DOCUMENT RESUME

ED 229 583 CE 035 855

TITLE	Cardiopulmonary Laboratory Specialist, 10-6. Military Curriculum Materials for Vocational and Technical Education.
INSTITUTION	Air Force Training Command, Sheppard AFB, Tex.; Ohio State Univ., Columbus. National Center for Research in Vocational Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C.
PUB DATE	75
NOTE	885p.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052) -- Guides - Classroom Use - Materials (For Learner) (051)
EDRS PRICE	MF06/PC36 Plus Postage.
DESCRIPTORS	*Allied Health Occupations Education; Anatomy; Behavioral Objectives; *Cardiovascular System; Course Descriptions; *Heart Disorders; *Inhalation Therapists; Lesson Plans; *Medical Laboratory Assistants; Physiology; Postsecondary Education; Programed Instructional Materials; Textbooks; Workbooks
IDENTIFIERS	Cardiology; *Cardiopulmonary Technicians; Military Curriculum Project; *Respiratory Therapy

ABSTRACT

These instructor and student materials for a postsecondary level course for cardiopulmonary laboratory specialist training comprise one of a number of military-developed curriculum packages selected for adaptation to vocational instruction and curriculum development in a civilian setting. The purpose stated for the course is to train students to assist cardiologists and pulmonary physiologists in examining, evaluating, diagnosing, and treating cardiopulmonary diseases and injuries. Basic math skills and background in biology and chemistry are required for this specialty course for students with basic medical laboratory training and experience. The two blocks of instruction are Cardiology and Pulmonary Medicine. Skills taught include diagnostic and therapeutic procedures, such as administering electrocardiograms, phonocardiograms, vectorcardiograms, stress tests, and blood gas analysis. Anatomy, physiology, medical terminology, care of cardiovascular disorders, and inhalation therapy are among the major areas of study. Instructor materials consist of a course chart and a plan of instruction detailing the units of instruction, criterion objectives, lesson duration, and support materials needed. Student materials for blocks 1 and 2 are 16 study guides, 16 programed texts, and three handouts. Several commercial texts and audiovisual aids are recommended but are not provided. (YLB)

MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

THE NATIONAL CENTER
FOR RESEARCH IN VOCATIONAL EDUCATION

Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

Agriculture	Food Service
Aviation	Health
Building & Construction Trades	Heating & Air Conditioning
Clerical Occupations	Machine Shop
Communications	Management & Supervision
Drafting	Meteorology & Navigation
Electronics	Photography
Engine Mechanics	Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

CARDIOPULMONARY LABORATORY SPECIALIST

Table of Contents

CARDIOPULMONARY LABORATORY SPECIALIST

(Table of Contents cont'd)

Developed by:

United States Air Force

Development and Review Dates:

April 23, 1975

D.O.T. No.:

070.108

Occupational Area:

Health

Target Audiences:

Grades 13-adult

Print Pages:

737

Cost:

Availability:

Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

Contents:	Type of Materials: Lesson Plans:	Programmed Text:	Student Workbook:	Handouts:	Text Materials:	Audio-Visuals:	Instructional Design: Performance Objectives:	Tests:	Review Exercises:	Additional Materials Required:	Type of Instruction: Group Instruction:	Individualized:
			No. of pages									
Block I – *Cardiology*	●	●	64	●	●	★	●	★		★	●	●
Block II – *Pulmonary Medicine*	●	●	45	●	●	★	●	★		★	●	●
Block III – *Introduction to Respiratory Therapy*	●		★		★	★	●	★		★	●	

★ Materials are recommended but not provided.

Expires July 1, 1978

Course Description

This course is designed to train students to assist cardiologists and pulmonary physiologists in examining, evaluating, diagnosing, and treating cardiopulmonary diseases and injuries. Students are taught to perform a wide range of diagnostic and therapeutic procedures, such as administering electrocardiograms, phonocardiograms, vectorcardiograms, stress tests, and blood gas analysis. Anatomy, physiology, medical terminology, care of cardiovascular disorders, and inhalation therapy are among the major areas of study. This course requires basic math skills, and background in biology and chemistry. It was designed as a specialty course for students with basic medical laboratory training and experience, however it does present refresher material and contains several programmed texts on math skills. This course is divided into three blocks containing 98 hours of instruction.

Block I — *Cardiology* contains eleven lessons covering 118 hours of instruction. Printed materials include nine study guide/workbooks, eight programmed texts, and two handouts. Lesson topics and hours follow:

Cardiovascular Anatomy and Physiology (7 hours classroom, 2 hours laboratory)
Cardiovascular Diseases (14 hours classroom, 4 hours laboratory)
Basic Physics and Electronics (6 hours classroom, 2 hours laboratory)
Electrocardiography I (3 hours classroom)
Electrocardiography II (10 hours classroom, 4 hours laboratory)
Cardiac Drugs (8 hours classroom, 4 hours laboratory)
Cardiac Vectors (6 hours classroom)
Phonocardiography and Heart Sounds (4 hours classroom)
Arrhythmia Interpretation (22 hours classroom, 10 hours laboratory)
Treatment of Arrhythmias (9 hours classroom, 2 hours laboratory)
Cardiac Catheterization (1 hour classroom)

Block II — *Pulmonary Medicine* contains eleven lessons covering 106 hours of instruction. Printed materials include seven study guides/workbooks, eight programmed texts, and one handout.

Respiratory Anatomy and Physiology (14 hours classroom, 4 hours laboratory)
Respiratory Disorders (9 hours classroom, 4 hours laboratory)
Respiratory Drugs (3 hours classroom, 2 hours laboratory)
Gas Laws (7 hours classroom, 2 hours laboratory)
Slide Rules and Nomograms (4 hours classroom)
Spirometer (2 hours classroom)
Acid Base Balance I (10 hours classroom, 4 hours laboratory)
Pulmonary Function Studies (12 hours classroom, 4 hours laboratory)
Acid Base Balance II (10 hours classroom, 4 hours laboratory)
Blood Gas Studies (7 hours classroom, 2 hours laboratory)
Postural Drainage (2 hours classroom)

Block III — *Introduction to Respiratory Therapy* contains fifteen lessons covering 74 hours of instruction. Printed materials consist of lesson plans and references only.

Block III is not included in this document.

Introduction to Respiratory Therapy (1 hour classroom)
Safe Use of Medical Gases (3 hours classroom, 2 hours laboratory)
Humidification and Aerosol Therapy (3 hours classroom)
Intermittent Positive Pressure Breathing (IPPB) (5 hours classroom, 2 hours laboratory)
Pediatric Ventilation (1 hour classroom)
Indications for the Use of Oxygen (2 hours of classroom, 2 hours laboratory)
Oxygen Equipment (3 hours classroom)
Management of the Comatose Patient (1 hour classroom)
Respirators I (9 hours classroom, 4 hours laboratory)
Intubation (2 hours classroom)
Respirators II (8 hours classroom, 4 hours laboratory)
Post Operative Complications (2 hours classroom)
Sterilization of Equipment (4 hours classroom, 2 hours laboratory)
Prolonged Artifical Ventilation (4 hours classroom, 2 hours laboratory)
Respirator Maintenance (8 hours classroom)

This course contains both teacher and student materials. Printed instructor materials consist of a course chart; a Specialty Training Standard; and a plan of instruction detailing the units of instruction, criterion objectives, duration of the lesson, and support materials needed. The student materials provided are study guides/workbooks, handouts, and programmed texts. Some of the programmed texts were deleted because they contained copyrighted materials. Several commercial texts are recommended for use with this course, these are not provided in this package.

Various audiovisuals aids are also recommended for this course but they are not provided. The audiovisuals consist of slides, transparencies, filmstrips with tapes or cassettes, and sound tapes.

COURSE CHART

NUMBER 3ALR91630	PDS CODE PIV	DATE 23 January 1975
COURSE TITLE Cardiopulmonary Laboratory Specialist		
ATC OPR AND APPROVAL DATE SGHE, 17 February 1972	CENTER OPR Sheppard/SHCS/MSOXC	SUPERSEDES COURSE CHART 3ALR91630, 23 April 1975
DEPARTMENT OPR Department of Medicine		APPLICABLE TRAINING STANDARD STS 916X0, 19 February 1975
LOCATION OF TRAINING Sheppard AFB Texas 76311		COURSE SECURITY CLASSIFICATION UNCLASSIFIED
INSTRUCTIONAL DESIGN Group/Lock Step		TARGET READING GRADE LEVEL FOR PREPARATION OF TRAINING LITERATURE 11.2

LENGTH OF TRAINING (8 Weeks, 0 Days)

	Hours	
Technical Training		312
Classroom/Laboratory (C/L)	240	
Complementary Technical Training (CTT)	72	
Related Training		8
Local Conditions Course, Course II (AFR 50-24)	2	
Commander's Calls/Briefings	4	
End of Course Appointments; Predeparture Safety Briefing (ATCR 127-1)	2	
Total		320

REMARKS

Applicable safety is integrated throughout the course.

Effective date: 3 March 1976 with class 760303.

TABLE I - MAJOR ITEMS OF EQUIPMENT

Model 1500 Hewlett-Packard Electrocardiographs
Collins Spirometers
Bird Mark 7 Respirators
Arrhythmia Resusci-Anne
Segmental Lung Models
Heart Models
EKG Tables
Bird Regulators
Bird Mark 8 Respirator
Patient Monitoring System
Mobile Cardiac Resuscitation System
Ultrasonic Nebulizers
Endotracheal Intubation Manikin
Bennett Respirators

ATC FORM DEC 74 449 REPLACES PREVIOUS EDITIONS AND ATC FORM 449 B, NOV 72

COURSE CHART – TABLE II – TRAINING CONTENT 3ALR91630

NOTE: Include time spent on technical training (TT) (classroom/laboratory (C/L) and complementary technical training (CTT)) and related training (RT). Exclude time spent on individual assistance (remedial instruction). A single entry of time shown for a unit is C/L time. When a double entry is shown, the second entry is CTT time.

WK OF TNG / HRS PER DAY	1 2 3 4 5 6	7 8
	Course Material - UNCLASSIFIED 124 Hours TT BLOCK I - Cardiology	2 Hours RT
1 2 3 4(.8/5)	Welcome and Orientation (2 hrs); Cardiovascular Anatomy and Physiology (7/2 hrs); Cardiovascular Diseases (14/4 hrs); Basic Physics and Electronics (6/2 hrs); Electrocardiography I (3 hrs); Electrocardiography II (10/4 hrs); Cardiac Drugs (8/4 hrs); Cardiac Vectors (6 hrs); Phonocardiography and Heart Sounds (4 hrs); Arrhythmia Interpretation (22/10 hrs); Treatment of Arrhythmias (9/2 hrs); Cardiac Catheterization (1 hr); Measurement Test and Test Critique (4 hrs) 96 Hours C/L	28 Hours CTT
	Course Material - UNCLASSIFIED 110 Hours TT BLOCK II - Pulmonary Medicine	2 Hours RT
4(4.2/5) 5 6(4.8/5)	Respiratory Anatomy and Physiology (14/4 hrs); Respiratory Disorders (9/4 hrs); Respiratory Drugs (3/2 hrs); Gas Laws (7/2 hrs); Slide Rules and Nomograms (4 hrs); Spirometer (2 hrs); Acid Base Balance I (10/4 hrs); Pulmonary Function Studies (12/4 hrs); Acid Base Balance II (10/4 hrs); Blood Gas Studies (7/2 hrs); Postural Drainage (2 hrs); Measurement Test and Test Critique (4 hrs) 84 Hours C/L	26 Hours CTT
	Course Material - UNCLASSIFIED 78 Hours TT BLOCK III - Introduction to Respiratory Therapy	
6(.2/5) 7 8	Introduction to Respiratory Therapy (1 hr); Safe Use of Medical Gases (3/2 hrs); Humidification and Aerosol Therapy (3 hrs); Intermittent Positive Pressure Breathing (IPPB) (5/2 hrs); Pediatric Ventilation (1 hr); Indications for the Use of Oxygen (2/2 hrs); Oxygen Equipment (3 hrs); Management of the Comatose Patient (1 hr); Respirators I (9/4 hrs); Intubation (2 hrs); Respirators II (8/4 hrs); Post Operative Complications (2 hrs); Sterilization of Equipment (4/2 hrs); Prolonged Artificial Ventilation (4/2 hrs); Respirator Maintenance (8 hrs); Measurement Test and Test Critique (3 hrs); Course Critique and Graduation (1 hr) 60 Hours C/L	18 Hours CTT 4 Hours RT

DEPARTMENT OF THE AIR FORCE
Headquarters, US Air Force
Washington DC 20330

CARDIOPULMONARY LABORATORY SPECIALIST AND CARDIOPULMONARY LABORATORY TECHNICIAN

1. Purpose of this Specialty Training Standard (STS). As prescribed in AFR 8-13, this STS:

a. States in column 1 of attachment 1 the tasks, knowledges, and study references (SR) necessary for airmen to perform duties in the Cardiopulmonary Laboratory ladder of the Airman Medical Career Field. These are based on Specialty Descriptions effective 1 March 1970 in AFM 39-1.

b. Indicates in columns 2A and 4A of attachment 1 the minimum proficiency recommended for each task or knowledge for qualification at the 3 and 7 skill levels of AFSCs. AFM 50-23 is the authority to change the proficiency level during JPG development when the local requirement is different from the skill level shown in this STS.

c. Shows in column 2A of attachment 1 the proficiency attained in Courses 3ALR91630 (PDS Code P1V) and 5AL091630-1 (PDS Code P1W) described in AFM 50-5. Proficiency code for the minimum proficiency recommended for the 3 skill level AFSC and the proficiency attained in the courses are the same except when dual codes are entered. When dual codes are entered the second code shows the proficiency attained in the courses. The task knowledge levels in column 2A of paragraph 8 are attained in course 3ALR91630 while the task performance levels are attained in course 5AL091630-1.

d. Provides basis for supervisors to plan and conduct individual OJT programs.

e. Provides a convenient record of on-the-job training completed when inserted in AF Form 623, "On-The-Job Training Record," and maintained in accordance with AFM 50-23.

f. Defines the knowledge requirements covered by Specialty Knowledge Tests in the Weighted Airman Promotion System.

2. Proficiency Code Key. Attachment 1 contains the Proficiency Code Key used to show proficiency level.

3. Career Development Channel of OJT. Personnel training to AFSC 91670 will obtain knowledge training by using applicable study references listed in this STS and fulfill management training requirements specified in AFM 50-23. (See ECI Catalog and Guide, chapter 3, paragraph 3-5, for current CDC identification number for ordering purposes.)

4. Study Guidance for Weighted Airman Promotion System (WAPS). Specialty Knowledge Tests (SKTs) for promotion to E-5 are based on 5 skill level knowledge requirements. SKTs for promotion to E-6 and E-7 are based on 7 skill level knowledge requirements. SKT questions are based primarily on Career Development Courses (CDCs). However, some questions may be drawn from other references listed in this Specialty Training Standard. The CDCs for SKT study are maintained in the WAPS Study Reference Library. Other references listed should be available in the work area. Individual responsibilities are outlined in AFM 35-8, chapter 19, paragraph 19-3g.

5. Recommendations. Report to ATC/SG unsatisfactory performance of individual graduates or inadequacies of this STS. Refer to specific paragraphs of this STS. See AFR 50-38.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

DAVID C. JONES, General, USAF
Chief of Staff

JACK R. BENSON, Colonel, USAF
Director of Administration

1 Attachment
Qualitative Requirements

Supersedes STS 916X0, 21 July 1972, and Change 1, 20 March 1974.

STS 916X0

THIS BLOCK IS FOR IDENTIFICATION PURPOSES ONLY		
TRAINEE		
NAME	INITIALS *(In Writing)*	GRADE
ORGANIZATION		
IMMEDIATE SUPERVISOR'S NAME AND INITIALS *(In Writing)*		
N I	N/I	
N I	N/I	

QUALITATIVE REQUIREMENTS

PROFICIENCY CODE KEY		
	SCALE VALUE	DEFINITION: The Individual
TASK PERFORMANCE LEVELS	1	Can do simple parts of the task. Needs to be told or shown how to do most of the task. (EXTREMELY LIMITED)
	2	Can do most parts of the task. Needs help only on hardest parts. May not meet local demands for speed or accuracy. (PARTIALLY PROFICIENT)
	3	Can do all parts of the task. Needs only a spot check of completed work. Meets minimum local demands for speed and accuracy. (COMPETENT)
	4	Can do the complete task quickly and accurately. Can tell or show others how to do the task. (HIGHLY PROFICIENT)
* TASK KNOWLEDGE LEVELS	a	Can name parts, tools, and simple facts about the task. (NOMENCLATURE)
	b	Can determine step by step procedures for doing the task. (PROCEDURES)
	c	Can explain why and when the task must be done and why each step is needed. (OPERATING PRINCIPLES)
	d	Can predict, identify, and resolve problems about the task. (COMPLETE THEORY)
** SUBJECT KNOWLEDGE LEVELS	A	Can identify basic facts and terms about the subject. (FACTS)
	B	Can explain relationship of basic facts and state general principles about the subject. (PRINCIPLES)
	C	Can analyze facts and principles and draw conclusions about the subject. (ANALYSIS)
	D	Can evaluate conditions and make proper decisions about the subject. (EVALUATION)

– EXPLANATIONS –

* A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task. (Examples: b and 1b)

** A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

– This mark is used alone instead of a scale value to show that no proficiency training is provided in the course, or that no proficiency is required at this skill level.

X This mark is used alone in course columns to show that training is not given due to limitations in resources.

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill Level		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
NOTE 1: Users may annotate lists of SRs to identify current references pending STS revision.									
NOTE 2: The 3 skill level proficiency for items of this STS marked with an asterisk (*) is attained through field experience and in prerequisite AFSC 90230. No additional training is provided in Courses 3ALR91630 and 5AL091630-1.									
1. DISASTER PREPAREDNESS MEDICAL CARE AND FIRST AID PROCEDURES									
SR: AFMs 160-12 (chap 1), 160-34 (chap 5 and 9), 160-37									
a. Manage shock	*2b						3c		
b. Maintain effective respiration	*2b						3c		
c. Control hemorrhage	*2b						3c		
d. Perform emergency treatment of wounds	*2b						3c		
e. Manage fractures, burns, and injuries from chemical agents	*2b						3c		
f. Perform methods of hand and litter carries	*2b						3c		
g. Load and unload vehicles utilized for transportation of patients	*2b						3c		
h. Maintain military sanitation	*a						2b		
2. AIRMAN CARDIOPULMONARY LABORATORY CAREER SPECIALTY								NO ADVANCED COURSE	
SR: AFM 39-1; AFVA 39-1									
a. Progression in career ladder 916X0	B						C		
b. Duties of AFSs 91630/70	B						C		
3. COMMUNICATIONS SECURITY (TRANSMISSION SECURITY)									
SR: AFRs 205-1, 205-7									
a. Identify information as classified, unclassified, or of possible intelligence value	*2b						3c		
b. Identify official information as Top Secret, Secret, Confidential, or For Official Use Only	*2b						3c		
c. Select and recommend mode of transmission dictated by security and expediency required	*2b						3c		
d. Observe security precautions involved in communications	*2b						3c		

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	2. 3 Skill Level A AFSC/Crs	3 Skill Level B Date OJT Started	3 Skill Level C Date Completed & Trainee's Supervisor's Initials	3. 5 Skill Level A AFSC	5 Skill Level B Date OJT Started	5 Skill Level C Date Completed & Trainee's Supervisor's Initials	4. 7 Skill Level A AFSC/Crs	7 Skill Level B Date OJT Started	7 Skill Level C Date Completed & Trainee's Supervisor's Initials
4. CARDIOPULMONARY LABORATORY SAFETY									
SR: AFM 127-101									
a. Hospital safety practices									
(1) Handle and care for patient	*2b						3c		
(2) Operate equipment	2b						3c		
(3) Maintain personal safety standards	*2c						3c		
b. Plan and direct the section safety program including the establishment and maintenance of sanitary standards for safe housekeeping	*2b						3c		
5. CARDIOPULMONARY LABORATORY PUBLICATIONS									
SR: AFM 168-4 (para 1-12); AFR 5-31									
a. Maintain publication files	*2b						3b		
b. Locate and interpret information related to care of patient and to management of personnel	*2b						3c		
c. Recommend changes in publications including local medical policies	*2b						3c		
6. CARDIOPULMONARY LABORATORY MATERIEL									
SR: AFMs 57-1, 167-1; AFR 67-10									
a. Use supply catalogs	*2b						3c	NO ADVANCED COURSE	
b. Issue and turn-in supplies and equipment	*2b						3c		
c. Property responsibility	*B						C		
d. Clean and maintain diagnostic and therapeutic equipment	2b/b						3c		
e. Establish and maintain procedures for storing, inventorying, and inspecting property items	*2b						3c		
f. Perform duties of a property custodian	*2b						3c		
7. SUPERVISION AND TRAINING									
a. Supervision									
(1) Evaluate performance of subordinate personnel	*2b						3c		
SR: AFMs 39-1 (atch 52, vol II), 39-62; AFR 39-6									

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	2. 3 Skill Level A AFSC/Crs	3 Skill Level B Date OJT Started	3 Skill Level C Date Completed & Trainee's Supervisor's Initials	3. 5 Skill Level A AFSC	5 Skill Level B Date OJT Started	5 Skill Level C Date Completed & Trainee's Supervisor's Initials	4. 7 Skill Level A AFSC/Crs	7 Skill Level B Date OJT Started	7 Skill Level C Date Completed & Trainee's Supervisor's Initials
7a(2) Plan and schedule work assignments and priorities	*2b						3c		
SR: AFM 50-20 (unit 2 and 3); AFR 39-6									
(3) Prepare correspondence, reports, and records	*2b						3c		
SR: AFM 10-1									
(4) Establish work methods, controls, and performance standards	*2b						3c		
SR: AFM 50-20 (unit 2 and 3)									
(5) Recommend policy changes on utilization of personnel and equipment	*2b						3c		
SR: AFMs 26-1, 26-2									
(6) Resolve technical problems encountered by subordinates	*2b						3c		
SR: AFR 39-6									
(7) Counsel personnel and resolve individual problems	*1a						3c		
SR: AFM 39-12; AFRs 35-32, 39-6, 39-30									
(8) Supervise the use of therapeutic equipment	1a/a						3c	NO ADVANCED COURSE	
b. Training									
(1) Orient newly assigned personnel on standard operating procedures	*2b						3c		
SR: AFMs 39-1, 50-20 (unit 4), 50-23; AFR 39-4									
(2) Recommend personnel for training	1a						3c		
SR: AFMs 39-1, 50-5, 50-20 (unit 4), 50-23; AFRs 39-4, 50-9									
(3) Plan and conduct OJT programs and refresher training	*2b						3c		
SR: AFMs 39-1, 50-20 (unit 4), 50-62									
(4) Maintain OJT records	*2b						3c		
SR: AFM 50-23									

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	2. 3 Skill Level A AFSC/Crs	2. 3 Skill Level B Date OJT Started	2. 3 Skill Level C Date Completed & Trainee's Supervisor's Initials	3. 5 Skill Level A AFSC	3. 5 Skill Level B Date OJT Started	3. 5 Skill Level C Date Completed & Trainee's Supervisor's Initials	4. 7 Skill Level A AFSC/Crs	4. 7 Skill Level B Date OJT Started	4. 7 Skill Level C Date Completed & Trainee's Supervisor's Initials
8. CARE OF PATIENT WITH SPECIFIC NEEDS AND PROBLEMS									
NOTE: The task knowledge levels in column 2A of this paragraph are attained in course 3ALR91630 while the task performance levels are attained in course 5AL091630-1.									
SR: AFMs 160-34, 168-4; Medical Dictionary; Dale Dubin, _Rapid Interpretation of EKGs_, Cover Publishing Company, 1970; Michael C. Ritota, _Diagnostic Electrocardiography_, J. B. Lippincott Company, 1969; Ross C. Kory, _A Primer of Cardiac Catheterization_, Charles C. Thomas Company, 1965; Arthur C. Guyton, _Functions of the Human Body_, Saunders 1974; N. Balfour Slonim, _Cardiopulmonary Laboratory Basic Methods and Calculations_, Charles C. Thomas, 1972; Donald F. Eagan, _Fundamentals of Inhalation Therapy_, C. V. Mosby, 1969; Lawrence E. Meltzer, _Intensive Coronary Care - A Manual for Nurses_, R. J. Brady, 1970									
a. Care of cardiovascular disorders									
(1) Definition of common terms	B						C		
(2) Related anatomy and physiology	C						C		
(3) Make and report observations	2b						3c		
(4) Common forms of heart disease	C						C		
(5) Nursing care of patient									
(a) Identify problems and needs									
1 Physical	2b						3c	NO ADVANCED COURSE	
2 Personal, cultural and social	2b						3c		
3 Emotional	2b						3c		
4 Rehabilitation	2b						3c		
(b) Perform nursing care to meet needs	2b						3c		
(6) Assist with or perform diagnostic therapeutic and special procedures									
(a) Cardiac catheterization	1a						3c		
(b) Treadmill	2b						3c		
(c) Master's two step	2b						3c		
(d) Recognition of abnormalities in electrocardiographic tracings	2b						3c		
(e) Interpretation of warning/lethal arrhythmias	2c						3c		
(f) Chest grid	2c						3c		
(7) Emergency procedures in cardiac arrest									
(a) Operate emergency equipment									
1 Pacemaker	2b						3c		

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	2. 3 Skill Level A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	3. 5 Skill Level A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	4. 7 Skill Level A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
8a(7)(a)2 Defibrillator	2b						3c		
3 Emergency cart	2b						3c		
(b) Set up special monitor	2b						3c		
(c) Assist physicians during emergency	2b						3c		
(d) Prepare pacemaker/defibrillator/electrodes	2b						3c		
(e) Defibrillate in an emergency	2b						3c		
(f) Perform closed cardiac massage	2b						3c		
(g) Perform mouth-to-mouth breathing and ambu breathing	2b						3c		
(8) Perform specialized procedures by operating									
(a) Electrocardiograph	2b						3c		
(b) Phonocardiograph	2b						3c		
(c) Vectorcardiograph	2b						3c		
(d) Multichannel recorder	2b						3c		
(e) Pressure transducers	1a						3c	NO ADVANCED COURSE	
(f) Multitrack tape recorder	2b						3c		
(g) Polaroid camera	2b						3c		
(h) Cardiac telemetry system	2b						3c		
(i) Cardiac multichannel scope	2b						3c		
(9) Cardiac drugs									
(a) Safety factors in giving medications	B						C		
(b) Expected actions, complications, and contraindications	B						C		
(10) Other									
(a) Perform calculations on data collected	2b						3c		
(b) Perform related darkroom procedures	1a						2b		
(c) Use automatic processors for cine X-ray and tracings	1a						2b		
(d) Basic physics and electronics pertaining to heart actions	B						C		
(e) Cut, mount, and process cardiograms	2b						3c		
b. Care of pulmonary disorders									
(1) Definition of common terms	B						C		

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill Level		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
8b(2) Related anatomy and physiology	B						C		
(3) Common pulmonary diseases	B						C		
(4) Make and report observations	2b						3c		
(5) Nursing care of patients									
(a) Identify problems and needs									
1 Physical	2b						3c		
2 Personal, cultural, and social	2b						3c		
3 Emotional	2b						3c		
4 Rehabilitational	2b						3c		
(b) Perform nursing care to meet needs	2b						3c		
(6) Diagnostic, therapeutic and special procedures									
(a) Perform tests and calculations									
1 Tidal volume	2b						3c		
2 Vital capacity	2b						3c		
3 Timed vital capacity	2b						3c		
4 Maximum expiratory flow rate	2b						3c		
5 Mid-maximal expiratory flow	2b						3c NO ADVANCED COURSE		
6 Maximum breathing capacity/maximum voluntary ventilation	2b						3c		
7 Walking ventilation	2b						3c		
8 Residual volume	2b						3c		
9 Helium wash-in	2b						3c		
10 Nitrogen wash-out	2b						3c		
11 Single breath diffusion capacity carbon monoxide	2b						3c		
12 Steady state diffusion capacity carbon monoxide	2b						3c		
13 Arterial punctures	2b						3c		
14 Blood gas analysis	2b						3c		

TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION								
1.	2. 3 Skill Level			3. 5 Skill Level			4. 7 Skill Level		
	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
8b(6)(b) Operate equipment									
1 PO^2, PCO^2 and PH meters	2b						3c		
2 Electronic blood gas oximeters	2b						3c		
3 Scholander	2b						3c		
4 Barometer (mercury and aneroid)	2b						3c		
5 Pulmotester/ pulmoanalyzer	2b						3c		
6 Calculator, slide rule, and nomograms	2b						3c		
7 Steady state diffusion apparatus	2b						3c		
8 Single breath diffusion apparatus	2b						3c		
9 Nitrogen meter	2b						3c		
10 Tissot	2b						3c		
11 9/10/13.5 liter spirometers	2b						3c		
12 Oxygen and carbon dioxide analyzers	2b						3c		
c. Respiratory therapy (inhalation therapy)									
(1) Operate oxygen therapy equipment									
(a) Tent	2b						3c		
(b) Mask (oral, nasal venturi)	2b						3c		
(c) Catheter, cannula	2b						3c		
(d) Hood, face tent	2b						3c		
(2) Operate intermittent positive pressure (IPPB) breathing apparatus									
(a) Pressure cycled respirators	2b						3c		
(b) Volume cycled apparatus	2b						3c		
(c) Hot and cold humidifiers	2b						3c		
(d) Aerosol generators	2b						3c		
(e) Nebulizers									
1 Hot	2b						3c		
2 Cold	2b						3c		

NO ADVANCED COURSE

1. TASKS, KNOWLEDGES AND STUDY REFERENCES	PROFICIENCY LEVEL, PROGRESS RECORD AND CERTIFICATION 2. 3 Skill Level A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	3. 5 Skill Level A AFSC	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials	4. 7 Skill Level A AFSC/Crs	B Date OJT Started	C Date Completed & Trainee's Supervisor's Initials
8c (3) Exercise safety precautions with use of medical gases	2b						3c		
(4) Operate medical regulators and flowmeters	2b						3c		
(5) Operate compressors.	2b						3c		
(6) Sterilize equipment									
(a) Heat	2b						3c		
(b) Cold	2b						3c		
(c) Gas	2b						3c		
(7) Perform preventive maintenance on equipment	2b						3c		
(8) Administer respiratory therapy drugs									
(a) Safety factors in giving medications	2b						3c		
(b) Expected actions, complications, and contraindications								NO ADVANCED COURSE	
1 Bronchodilators	2b						3c		
2 Mucolytics	2b						3c		
3 Isotonic solutions	2b						3c		
(9) Perform intubation procedures									
(a) Indications	1a						2b		
(b) Side effects	1a						2b		
(c) Procedure	1a						2b		
(10) Perform sputum induction									
(a) Acid fast bacillus	2b						3c		
(b) Fungi	2b						3c		
(c) Cytology	2b						3c		
(11) Teach patient principles of bronchial hygiene	2b						3c		

15

POI 3ALR91630

(PDS Code P1V)

PLAN OF INSTRUCTION

(Technical Training)

CARDIOPULMONARY LABORATORY SPECIALIST

SHEPPARD TECHNICAL TRAINING CENTER

23 April 1975 - Effective 15 May 1975 with Class 750515

10-6

16

DEPARTMENT OF THE AIR FORCE
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas 76311

PLAN OF INSTRUCTION 3ALR91630
(PDS Code P1V)
23 April 1975

FOREWORD

1. PURPOSE. This plan of instruction prescribes the qualitative requirements for Course Number 3ALR91630, Cardiopulmonary Laboratory Specialist, in terms of criterion objectives presented by units/modules of instruction, and shows duration, correlation with the training standard, support materials and instructional guidance. It was developed under the provisions of ATCR 50-5, Instructional System Development, and ATCR 52-7, Plans of Instruction.

2. COURSE DESCRIPTION. This 8-week course provides lateral training necessary to qualify selected airmen and NCOs in the 902X0 career specialty for assignment as a Cardiopulmonary Laboratory Specialist to perform duties in the Cardiopulmonary Ladder of the Airman Medical Career Field as outlined in AFM 39-1. It includes training to provide assistance to cardiologists and pulmonary physiologists in examination, evaluation, diagnosing, and treating cardiopulmonary diseases and injuries by performing a broad spectrum of diagnostic and therapeutic procedures such as administering electrocardiograms, phonocardiograms, vectorcardiograms, stress tests, defibrillation techniques, pulmonary function studies, intermittent positive pressure breathing, blood gas analysis, cardiac catheterization, and operation and maintenance of diagnostic equipment. Major areas of study are anatomy, physiology, medical terminology, care of cardiovascular disorders, care of pulmonary disorders, inhalation therapy, and related diagnostic processes and equipment. This course is Phase I of a two-phase training program; Course 5AL091630-1 (Phase II), provides 20 weeks of hospital training. In addition, related training consists of a Local Conditions Course, Commander's Call/Briefings, End of Course Appointments and a Traffic Safety Predeparture Briefing.

3. EQUIPMENT ALLOWANCE AND AUTHORIZATION. Training equipment required to conduct this course and for which accountability must be maintained, is found in the Medical and Non-Medical In-Use Equipment and is listed under custody account number 28553H.

NOTE: Group size is shown in parentheses after equipment listed in column 3 of numbered pages of this POI.

4. MULTIPLE INSTRUCTOR REQUIREMENTS. Units of instruction which require more than one instructor per instructional group are identified in the multiple instructor annex to this POI.

MODIFICATIONS

Lesson 1 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
2. Cardiovascular Anatomy and Physiology	9 (7/2)	Column 1 Reference / STS Reference 2a — 8a(1), 8a(2) 2b — 8a(1), 8a(2)
a. Describe the flow of blood and topical anatomy through the circulatory system.	(4)	
b. Compare the hemodynamic and electrical conduction principles of the cardiovascular system.	(3)	Instructional Materials Psychological Consultants, Inc., Human Physiology - A Programmed Text Dubin, Rapid Interpretation of EKGs Audio Visual Aids Slides, Cardiac Anatomy and Physiology Set Slides and Tape, Physiology of the Heart, by Research Medical Company (30 min) Filmstrip and Tape, The Cardiovascular System, by Brady (50 min) Training Equipment Heart Model (2) Training Methods Lecture/Discussion (7 hrs) Outside Assignments (2 hrs) Instructional Environment/Design Classroom (7 hrs) Home Study (2 hrs) Group/Lock Step Instructional Guidance Use slides and heart models to illustrate key points. Use one heart model per two students.
3. Cardiovascular Diseases	18 (14/4)	Column 1 Reference / STS Reference 3a, 3b, 3c — 8a(3), 8a(4), 8a(5)(a)1, 8a(5)(a)2, 8a(5)(a)3, 8a(5)(a)4; 8a(5)(b)
a. Describe the clinical features and treatment of common cardiovascular diseases.	(4)	3d — 8a(3), 8a(4), 8a(5)(a)1, 8a(5)(a)2, 8a(5)(a)3, 8a(5)(a)4, 8a(5)(b)
b. Describe the signs, symptoms, and treatment of congenital heart defects.	(4)	3e — 8a(6)(f), 8a(8)(a)

PLAN OF INSTRUCTION NO. 3ALR91630 | DATE 23 APR 1975 | BLOCK NO. I | PAGE NO. 2

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
c. Explain the signs, symptoms, and treatment of acute myocardial infarction.	(2)	**Instructional Materials** SG 3ALR91630-I-3a(1), Introduction to Cardiovascular Disease SG 3ALR91630-I-3a(2), Rheumatic Fever and Rheumatic Heart Disease SG 3ALR91630-I-3a(3), Arteriosclerosis and Arteriosclerotic Heart Disease SG 3ALR91630-I-3a(4), Forms of Heart Disease (Miscellaneous) SG 3ALR91630-I-3b, Congenital Cardiovascular Disease ROCOM Learners Workbook, Intensive Coronary Care Multimedia Learning System Dubin, Rapid Interpretation of EKGs
d. Describe the clinical features and treatment of circulatory failure disorders.	(3)	**Audio Visual Aids** Slides, Cardiovascular Disorder Set ROCOM Films: No. 1 - Concepts of Intensive Coronary Care (14 min) No. 2 - The Heart: Acute Myocardial Infarction (12 min) No. 7 - Congestive Heart Failure and Cardiogenic Shock (24 min) No. 6 - The Patient Not in Acute Distress - Admission, Care and Discharge (25 min) ROCOM Filmstrips: No. 1 - The Clinical Picture of Acute Myocardial Infarction - Part I, The History (11 min) No. 2 - The Clinical Picture of Acute Myocardial Infarction - Part 2, The Physical Examination (6 1/2 min) No. 3 - The Clinical Picture of Acute Myocardial Infarction - Part 3, The Hospital and Convalescent Phase (7 1/2 min) No. 4 - The Clinical Picture of Acute Myocardial Infarction - Part 4, The Post-Convalescent Phase (6 1/4 min) No. 13 - Treatment of Left Ventricular Heart Failure (8 1/4 min) No. 14 - The Use of Digitalis (6 min) No. 15 - Monitoring Central Venous Pressure...Technique...Theory (7min) No. 19 - Signs of Cardiogenic Shock (6 min) No. 20 - Treatment of Cardiogenic Shock (8 3/4 min) No. 21 - Metabolic Acidosis (9 3/4 min) No. 23 - Less Common Complication Following Acute Myocardial Infarction (9 3/4 min) No. 29 - The Diagnosis of Myocardial Infarction, Electrocardiography... Enzyme Studies (13 1/4 min) No. 31 - Electrical Hazards in the CCU (15 3/4 min)
e. Describe the electrical hazards involved with intensive coronary care.	(1)	

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Audio Visual Aids (Continued) ROCOM Audiotape: No. 4 - The Heart: Acute Myocardial Infarction (10 min) Training Equipment Heart Model (2) Training Methods Lecture/Discussion (14 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (14 hrs) Home Study (4 hrs) Group/Lock Step Instructional Guidance Have students prepare case presentation of a cardiovascular disorder, excluding those presented by the instructor as outside assignment. Cases will include etiology, signs, symptoms, treatment, and prognosis. Cases will be discussed at the end of Block I for 2 hours after additional information concerning cardiac drugs and arrythmias has been furnished.
4. Basic Physics and Electronics	8 (6/2)	Column 1 Reference: 4a, 4b, 4c STS Reference: 8a(8)(a), 8a(8)(b), 8a(8)(c), 8a(8)(d), 8a(8)(e), 8a(8)(f), 8a(8)(g), 8a(8)(h), 8a(8)(i)
a. Describe molecular structure and basic atomic theory.	(2)	
b. Analyze the relationship between current, resistance, and voltage as described in Ohm's law.	(2)	Instructional Materials SW 3ALR91630-I-4a(1), Basic Atomic Theory PT 3ALR91630-I-4a(2), Physics - Work, Power, and Energy (Mechanical) PT 3ALR91630-I-4a(3), Elements of Physics - Matter PT 3ALR91630-I-4a(4), Basic Physics - Matter
c. Describe the principles of magnetism and electromagnetism.	(2)	PT 3ALR91630-I-4a(5), Basic Physics - Atomic Structure and Static Electricity PT 3ALR91630-I-4a(6), Basic Physics - Work, Power, and Energy (Electrical) SW 3ALR91630-I-4b, Energy, Ohm's Law, and Basic Circuits SW 3ALR91630-I-4c, Magnetism and Electromagnetism

PLAN OF INSTRUCTION NO. 3ALR91630	DATE 23 APR 1975	BLOCK NO. I	PAGE NO. 4

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
		<u>Audio Visual Aids</u> <u>Sound-on-Slide:</u> Basic Atomic Structure Energy, Ohm's Law and Basic Circuits Magnetism and Electromagnetism <u>Training Methods</u> Discussion (1 hr) Performance (5 hrs) Outside Assignments (2 hrs) <u>Instructional Environment/Design</u> Classroom (1 hr) Laboratory (5 hrs) Home Study (2 hrs) Group/Lock Step <u>Instructional Guidance</u> Have students complete programmed texts as home study assignment. Introduce and summarize subject and answer any questions about the subjects. Conduct introduction and summary in the classroom. Performance hours are designed to reinforce knowledge and not develop proficiency.
5. <u>Electrocardiography I</u> a. Describe the procedure for operating a 12-lead EKG machine.	3	<u>Column 1 Reference</u> 5a <u>STS Reference</u> 4a(2), 6d, 7a(8), 8a(8)(a), 8a(10)~~(d)~~ <u>Instructional Materials</u> Meltzer, Penneo, Kitchell, <u>Intensive Coronary Care - A Manual for Nurses</u> ROCOM Learners Workbook, <u>Intensive Coronary Care Multimedia Learning System</u> <u>Audio Visual Aids</u> Transparencies, Electrocardiography Set ROCOM Film No. 4., Electrocardiography and the Arrhythmias (13 min) ROCOM Filmstrip, No. 7, The 12-Lead Electrocardiogram (9 3/4 min)

PLAN OF INSTRUCTION NO. 3ALR91630	DATE 23 APR 1975	BLOCK NO. I	PAGE NO. 5

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES (1)	DURATION (HOURS) (2)	SUPPORT MATERIALS AND GUIDANCE (3)
		Training Methods Lecture/Discussion (3 hrs) Instructional Environment/Design Classroom (3 hrs) Group/Lock Step
6. Measurement Test and Test Critique a. Measurement Test b. Test Critique	1	
7. Electrocardiography II	14 (10/4)	Column 1 Reference / STS Reference 7a — 4a(2), 6d, 7a(8), 8a(6)(f), 8a(8)(a), 8a(10)(d) 7b — 8a(6)(b), 8a(6)(c), 8a(10)(e) 7c — 8a(6)(b), 8a(6)(c) 7d — 8a(6)(d), 8a(6)(e), 8a(8)(a), 8a(10)(a)
a. Describe the procedure for performing a routine EKG.	(3)	
b. Describe the processing of electrocardiography tracings.	(3)	Instructional Materials HO 3ALR91630-I-7c, Masters Test PT 3ALR91630-I-7d, Basic Mathematics - Decimals Meltzer, Pinneo, Kitchell, Intensive Coronary Care-A Manual for Nurses Dubin, Rapid Interpretation of EKGs Rocom, Learners Workbook, Intensive Coronary Care Multimedia Learning System
c. Describe two types of stress tests.	(2)	
d. List the steps in interpreting EKGs.	(2)	Audio Visual Aids Transparencies, Electrocardiography Set Rocom Filmstrips: No. 6, The Format for Interpreting Electrocardiograms (13 min) No. 8, The Classification of Arrhythmias (14 1/4 min) Training Equipment Electrocardiographs (3) Treatment tables (3) Paper cutters (3) Mounting tape and boards (3)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Training Methods Lecture/Discussion (3 hrs) Demonstration (2 hrs) Performance (5 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (5 hrs) Laboratory (5 hrs) Home Study (4 hrs) Group/Lock Step Instructional Guidance Performance hours support knowledge requirements only and do not develop any proficiency. Have students complete programmed text during home study.
8. Cardiac Drugs	12 (8/4)	Column 1 Reference: 8a, 8b — STS Reference: 8a(9)(a), 8a(9)(b)
a. Describe the pharmacology of stimulants, depressants, and antiarrhythmics.	(3)	Instructional Materials SG 3ALR91630-I-8a(1), Cardiovascular Drugs SG 3ALR91630-I-8a(2), Major Antiarrhythmic Drugs
b. Describe the pharmacology of diuretics and anticoagulants.	(5)	PT 3ALR91630-I-8b, Current Concepts and Applications of Anticoagulant Therapy Rocom Learners Workbook, Intensive Coronary Care Multimedia Learning System Audio Visual Aids Rocom Filmstrips: No. 17, Diuretic Therapy (9 1/2 min) No. 22, Sympathomimetic Drugs (9 min) No. 24, Anticoagulant Therapy (13 3/4 min) Filmstrips and Cassettes, Trainex: Lidocaine Hydrochloride (50 min) Heparin Sodium and Warfarin Sodium (50 min) Atropine and Isoproterenol Hydrochloride (50 min)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Audio Visual Aids (Continued) Filmstrips and Cassettes, Trainex: Epinephrine and Isoproterenol Hydrochloride (50 min) Cardiac Glycosides and Quinidine Derivatives (50 min) Training Methods Lecture/Discussion (8 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (8 hrs) Home Study (4 hrs) Group/Lock Step Instructional Guidance Relate drug therapy to specific diseases covered in previous lesson on Cardiovascular diseases. Students may use computer program in Learning Resource Center to review these hours.
9. Cardiac Vectors a. Explain Einthoven's triangle. b. Predict Q R S Vectors.	6	Column 1 Reference — STS Reference 9a — 8a(8)(c), 8a(8)(h) 9b — 8a(8)(c), 8a(8)(h) Instructional Materials PT 3ALR91630-I-9a, Vectors and Trigonometric Functions PT 3ALR91630-I-9b, Basic Mathematics - Graphs Bowen, ZAO Vector Indicator Dubin, Rapid Interpretation of EKGs Audio Visual Aids Transparencies, Vector Set Slide, Ciba, No. 1555 Training Methods Lecture/Discussion (3 hrs) Performance (3 hrs)

PLAN OF INSTRUCTION NO.	DATE	BLOCK NO.	PAGE NO.
3ALR91630	2 0 APR 1975	I	8

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		<u>Instructional Environment/Design</u> Classroom (3 hrs) Laboratory (3 hrs) Group/Lock Step <u>Instructional Guidance</u> Use chalkboard to plot QRS vectors and have students work sample problems. Answer any questions about programmed texts. Complete PT 3ALR91630-I-9a as home study; PT 3ALR91630-I-9b in class. Performance hours are designed to reinforce student knowledge and not develop proficiency.
10. <u>Phonocardiography and Heart Sounds</u> a. Compare the action of the four heart valves with their related hemodynamic physiology.	4	<u>Column 1 Reference</u> 10a <u>STS Reference</u> 8a(8)(b) <u>Audio Visual Aids</u> Phono Simulator Transparencies, Heart Sounds Set <u>Training Methods</u> Lecture/Discussion (4 hrs) <u>Instructional Environment/Design</u> Classroom (4 hrs) Group/Lock Step <u>Instructional Guidance</u> Duplicate specific heart sounds with the phono simulator. Students should not listen to phono simulator for long periods of time because sounds will become difficult to distinguish.
11. <u>Measurement Test and Test Critique</u> a. Measurement Test b. Test Critique	1	

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
12. Arrhythmia Interpretation	32 (22/10)	Column 1 Reference — STS Reference 12a, 12b, 12c — 8a(3), 8a(4), 8a(6)(d), 8a(6)(e) 12d — 8a(3), 8a(4), 8a(6)(d), 8a(6)(e)
a. Interpret arrhythmias in the sinoatrial node.	(5)	Instructional Materials Meltzer, Penneo, Kitchell, Intensive Coronary Care-A Manual for Nurses Meltzer, Intensive Coronary Care Student Workbook
b. Interpret arrhythmias in the atria.	(5)	ROCOM EKG Workbook, Intensive Coronary Care Multimedia Learnino Systems
c. Interpret arrhythmias in the atrioventricular node.	(6)	ROCOM Learner's Workbook, Intensive Coronary Care Multimedia Learning Sys Ritota, Diagnostic Electrocardiography
d. Interpret arrhythmias in the ventricle.	(6)	Goldman, Clinical Electrocardiography Audio Visual Aids Rocom Films: No. 8, Warning Arrhythmias (22 min) No. 9, Lethal Arrhythmias (19 min) Rocom Filmstrips: No. 11, Types of Premature Ventricular Contractions and Their Treatment (6 3/4 min) No. 30a, Interpretation of Arrhythmias Originating in the S-A Node (12 min) No. 30b, Interpretation of Arrhythmias Originating in the Atria (13 1/2 min) No. 30c, Interpretation of Arrhythmias Originating in the A-V Junction (15 1/4 min) No. 30d, Interpretation of Arrhythmias Originating in the Ventricles (14 1/2 min) Slides, Arrhythmia Set Training Equipment Arrhythmia Reproducer (10) Monitor Scope (10) EKG Rulers (1) Training Methods Lecture/Discussion (16 hrs) Performance (6 hrs) Outside Assignments (10 hrs)

PLAN OF INSTRUCTION NO. 3ALR91630	DATE 23 APR 1975	BLOCK NO. I	PAGE NO. 10

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS)	SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (16 hrs) Laboratory (6 hrs) Outside Assignments (10 hrs) Group/Lock Step Instructional Guidance Have students use workbook after each set of Arrhythmias. Assign exercises in learner's workbook as homework assignments. An arrhythmia workshop will be presented for 6 hours after additional information concerning treatment of arrhythmias has been furnished. Arrhythmia reproducer and defibrillator will be used. Students will be required to diagnose selected arrhythmias and initiate treatment as needed, in order to reinforce knowledge of subject matter; skill will not be developed.
13. Treatment of Arrhythmias a. Explain cardiopulmonary resuscitation. b. Analyze the electrical treatment of arrhythmias. c. Determine the drug therapy of specific arrhythmias. d. Given a manikin, simulate precordial shock. Correctly completing five out of seven items on check list 3ALR91630-I-13d.	11 (9/2) (3) (3) (2) (1)	Column 1 Reference — STS Reference 13a — 8a(7)(c), 8a(7)(f), 8a(7)(g) 13b — 4a(2), 7a(8), 8a(7)(a)1, 8a(7)(a)2, 8a(7)(a)3, 8a(7)(b), 8a(7)(c), 8a(7)(d), 8a(7)(e), 8a(8)(f) 13c — 8a(9)(a), 8a(9)(b) 13d — 4a(2) Instructional Materials Meltzer, Pinneo, Kitchell, Intensive Coronary Care - A Manual for Nurses Rocom Learners Workbook, Intensive Coronary Care Multimedia Learning System Audio Visual Aids Slides, Cardiopulmonary Resuscitation Set Film, Rocom No. 5, Interpretation of Arrhythmias and Their Treatment (13 min) Filmstrips, Rocom: No. 9, Drug Therapy of Arrhythmias (12 1/2 min) No. 10, The Treatment of Specific Arrhythmias (7 1/4 min) No. 25, The Concepts of Cardiac Pacing (7 3/4 min) No. 26, Transvenous Pacing (13 1/2 min) No. 27, The Nursing Role in Cardiac Pacing (6 min) No. 28, The Electrical Treatment of Arrhythmias (11 1/2 min) No. 32, Cardiopulmonary Resuscitation (15 min)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Training Equipment Defibrillator (10) Resusci-Anne Manikin (10) Monitor Scope (10) Arrhythmia Reproducer (10) Training Methods Lecture/Discussion (7 hrs) Demonstration/Performance (2 hrs) Outside Assignments (2 hrs) Instructional Environment/Design Classroom (7 hrs) Laboratory (2 hrs) Home Study (2 hrs) Group/Lock Step Instructional Guidance Demonstrate procedures and point out hazards. Allow students to defibrillate the manikin. Use only a maximum of 50/watt/seconds on defibrillator.
14. Cardiac Catheterization a. Explain the duties of the cardiopulmonary laboratory specialist in assisting with a cardiac catheterization.	1	Column 1 Reference 14a STS Reference 8a(6)(a), 8a(8)(d), 8a(8)(e), 8a(8)(f), 8a(8)(g), 8a(10)(a), 8a(10)(b), 8a(10)(c) Training Equipment Transducers (5) Training Methods Lecture/Discussion (1 hr) Instructional Environment/Design Classroom (1 hr) Group/Lock Step

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION HOURS	SUPPORT MATERIALS AND GUIDANCE
		<u>Instructional Guidance</u> Emphasize that the primary responsibility is that of monitoring the electrical activity of the heart.
15. <u>Related Training</u> (identified in course chart).	2	
16. <u>Measurement Test and Test Critique</u> a. Measurement Test b. Test Critique	2	

PLAN OF INSTRUCTION NO. 3ALR91630	DATE 23 APR 1975	BLOCK NO. I	PAGE NO. 13

PLAN OF INSTRUCTION	COURSE TITLE: Cardiopulmonary Laboratory Specialist	
BLOCK TITLE: Pulmonary Medicine		
UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
1. Respiratory Anatomy and Physiology a. Describe the gross anatomy of the respiratory tract. b. Explain the mechanics of respiration. c. Describe gas exchange and transportation.	18 (14/4) (5) (4) (5)	Column 1 Reference — STS Reference 1a, 1b — 8b(1), 8b(2) 1c — 8b(1), 8b(2) Instructional Materials SW 3ALR91630-II-1, Respiratory Anatomy and Physiology SW 3ALR91630-II-1c(1), Gas Exchange and Transportation SW 3ALR91630-II-1c(2), Control of Respiration SW 3ALR91630-II-1c(3), Hyperbaric and Hypobaric Physiology SG 3ALR91630-II-1a(1), Respiratory Physiology - Part I SG 3ALR91630-II-1a(2), Respiratory Physiology - Part II Psychological Consultants Inc. Programmed Text, Human Physiology Brady, Respiratory Therapy Grenard, Beck, Rich, Introduction to Respiratory Therapy Grenard, Beck, Rich, Schapira, Advanced Studies in Respiratory Therapy Audio Visual Aids Transparencies, Respiratory A and P Set Slides, Respiratory A and P Set Filmstrip and Tape, Brady, The Respiratory System (50 min) Training Equipment Segmental Lungs (5) Training Methods Lecture/Discussion (14 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (14 hrs) Home Study (4 hrs) Group/Lock Step
PLAN OF INSTRUCTION NO. 3ALR91630	DATE 23 APR 1975	BLOCK NO. II — PAGE NO. 14

31

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance Use slides and transparencies to illustrate key points. Answer questions students have regarding workbook assignments.
2. Respiratory Disorders	13 (9/4)	Column 1 Reference / STS Reference
a. Describe the clinical features and treatment of pulmonary diseases.	(5)	2a, 2b — 8b(3), 8b(4), 8b(5)(a)1, 8b(5)(a)2, 8b(5)(a)3, 8b(5)(a)4, 8b(5)(b) 2c — 8b(3), 8b(4), 8b(5)(a)1, 8b(5)(a)2, 8b(5)(a)3, 8b(5)(a)4, 8b(5)(b)
b. Explain the signs and symptoms of respiratory dysfunction.	(2)	
c. Describe the causes of inadequate alveolar ventilation.	(2)	Instructional Materials Comroe, Forster, Dubois, Briscoe, Carlsen, The Lung Audio Visual Aids Slides, Respiratory Disorder Set Transparencies, Respiratory Disorder Set Filmstrips and Cassettes, Trainex: The Pathophysiology of Emphysema (50 min) Care of the Patient with Emphysema (50 min) Training Equipment Segmental Lungs (5) Training Methods Lecture/Discussion (9 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (9 hrs) Home Study (4 hrs) Group/Lock Step Instructional Guidance Have students prepare a case presentation of a pulmonary disorder, excluding those presented during the lecture/discussion. Cases will be prepared outside the classroom and include signs, symptoms, etiology, treatment, and prognosis. Cases will be discussed for 2 hours at the

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS) 2	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance (Continued) end of Block II after information concerning respiratory drugs and pulmonary function studies have been furnished. Presentation of case is designed to reinforce knowledge and not develop proficiency.
3. Respiratory Drugs a. Explain the pharmacology of bronchodilators. b. Explain the pharmacology of mucolytics. c. Explain the pharmacology of isotonic solutions.	5 (3/2)	Column 1 Reference: 3a, 3b — STS Reference: 8c(8)(a), 8c(8)(b)1, 8c(8)(b)2, 8c(8)(b)3 Column 1 Reference: 3c — STS Reference: 8c(8)(a), 8c(8)(b)1, 8c(8)(b)2, 8c(8)(b)3 Instructional Materials Grenard, Beck, Rich, Schapira, Advanced Studies in Respiratory Therapy Training Methods Lecture/Discussion (3 hrs) Outside Assignments (2 hrs) Instructional Environment/Design Classroom (3 hrs) Home Study (2 hrs) Group/Lock Step Instructional Guidance Correlate drugs with specific diseases presented in earlier lectures/discussion.
4. Measurement Test and Test Critique a. Measurement Test b. Test Critique	1	
5. Gas Laws a. Explain the procedure for converting temperature from one scale to another using the fahrenheit, centigrade, and Kelvin scales.	9 (7/2) (2)	Column 1 Reference: 5a, 5b, 5c — STS Reference: 8b(6)(a)1, 8b(6)(a)2, 8b(6)(a)3, 8b(6)(a)4, 8b(6)(a)5, 8b(6)(a)6, 8b(6)(a)7, 8b(6)(a)8, 8b(6)(a)9, 8b(6)(a)10, 8b(6)(a)11, 8b(6)(a)12

PLAN OF INSTRUCTION NO. 3ALR91630	DATE 23 APR 1975	BLOCK NO. II	PAGE NO. 16

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
b. Explain five gas laws related to pulmonary function studies. c. Explain the procedure for solving gas law problems involving temperature, pressure, and volume.	(2) (3)	Instructional Materials SW 3ALR91630-II-5, Gas Laws PT 3ALR91630-II-5c(1), Basic Mathematics - Fractions PT 3ALR91630-II-5c(2), Algebraic Expressions PT 3ALR91630-II-5c(3), Basic Mathematics - Algebraic Equations Grenard, Beck, Rich, Introduction to Respiratory Therapy Audio Visual Aids Transparencies, Gas Laws Set Training Methods Lecture/Discussion (4 hrs) Performance (3 hrs) Outside Assignments (2 hrs) Instructional Environment/Design Classroom (4 hrs) Laboratory (3 hrs) Home Study (2 hrs) Group/Lock Step Instructional Guidance Give examples of gas laws and work out sample problems. Have the students work gas law problems in SW 3ALR91630-II-5. Programmed text will be completed as home study. Performance hours are designed to reinforce knowledge but no proficiency is developed.
6. Slide Rules and Nomograms a. Explain how mathematical problems are solved with a slide rule. b. Explain the use of nomograms. c. Explain the use of the Collins Pulmonary Function computer.	4	Column 1 Reference — STS Reference 6a, 6b — 8b(6)(b)6 6c — 8b(6)(b)6 Instructional Materials SG 3ALR91630-II-6b, Nomograms Slonim, Bell, Christensen, Cardiopulmonary Laboratory, Basic Methods and Calculations

PLAN OF INSTRUCTION NO.	DATE	BLOCK NO.	PAGE NO.
3ALR91630	22 APR 1975	II	17

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Training Equipment Slide Rules (1) Pulmonary Function Computers (1) Training Methods Lecture/Discussion (1 hr) Demonstration (1 hr) Performance (2 hrs) Instructional Environment/Design Classroom (2 hrs) Laboratory (2 hrs) Group/Lock Step Instructional Guidance Performance hours are limited to working sample problems to insure students have a working knowledge of slide rules and computers.
7. Spirometer a. Explain the operational check of a Collins Spirometer.	2	Column 1 Reference: 7a STS Reference: 4a(2), 6d, 7a(8), 8b(6)(b)5, 8b(6)(b)11 Instructional Materials Slonim, Bell, Christensen, Cardiopulmonary Laboratory Basic Methods and Calculations Training Equipment Spirometers (3) Training Methods Lecture/Discussion (1 hr) Demonstration (1 hr) Instructional Environment/Design Classroom (2 hrs) Group/Lock Step

35

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance Have students feel the difference in resistance with the soda lime cannister in and out.
8. Acid Base Balance I a. Explain the signs and symptoms of respiratory acid base disturbances. b. Explain the signs and symptoms of metabolic acid base disturbances. c. Describe the method of obtaining logarithms from a slide rule.	14 (10/4) (4) (4) (2)	Column 1 Reference — STS Reference 8a — 8b(3), 8b(4) 8b — 8b(3), 8b(4) 8c — 8b(6)(a)14 Instructional Materials SG 3ALR91630-II-8c, Common Logarithms Grenard, Rich, Beck, Introduction to Respiratory Therapy Winters, Engel, Dell, Acid Base Physiology in Medicine Audio Visual Aids Filmstrips and Cassettes, Trainex: Compensation of Imbalances (50 min) Respiratory Acidosis and Alkalosis (50 min) Metabolic Acidosis and Alkalosis (50 min) Training Equipment Slide Rules (1) Training Methods Lecture/discussion (8 hrs) Performance (2 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (8 hrs) Laboratory (2 hrs) Home Study (4 hrs) Group/Lock Step Instructional Guidance Review use of the slide rule and basic mathematics. Performance hours are limited to converting whole numbers to logarithms to insure that students have a working knowledge of the conversion process.

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
9. Measurement Test and Test Critique	1	
a. Measurement Test		
b. Test Critique		
10. Pulmonary Function Studies	16 (12/4)	Column 1 Reference / STS Reference
a. Explain the performance and calculations of volume studies.	(3)	10a — 8b(6)(a)1, 8b(6)(a)2, 8b(6)(a)8, 8b(6)(a)9, 8b(6)(a)10, 8b(6)(b)9, 8b(6)(b)10, 8b(6)(b)11,
b. Explain the performance and calculation of flow rate studies.	(3)	10b — 8b(6)(a)3, 8b(6)(a)4, 8b(6)(a)5, 8b(6)(a)6, 8b(6)(a)7, 8b(6)(b)11
c. Describe diffusion studies.	(1)	10c — 8b(6)(a)11, 8b(6)(a)12, 8b(6)(b)7, 8b(6)(b)8
d. Using a 9 liter spirometer, perform and calculate routine spirometry studies. Correctly perform all items on checklist 3ALR91630-II-10d. Instructor assistance permitted.	(5)	10d — 4a(2)

Instructional Materials
PT 3ALR91630-II-10a(1), Basic Mathematics Percentage
PT 3ALR91630-II-10a(2), Review of Arithmetic and Whole Numbers
PT 3ALR91630-II-10a(3), Mathematics Review Volume I
Slonim, Bell, Christensen, Cardiopulmonary Laboratory Basic Methods and Calculations

Audio Visual Aids
Transparencies, Pulmonary Function Set
Slides and Tapes, Monaghan:
Medical Aspects of Pulmonary Function Testing (60 min)
Theory and Operation of Monaghan Pulmonary Function Analyzers (60 min)

Training Equipment
Slide Rules (1)
Pulmonary Function Computers (1)
Spirometers (3)

Training Methods
Lecture/Discussion (5 hrs)
Demonstration (1 hr)
Performance (6 hrs)
Outside assignments (4 hrs)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (6 hrs) Laboratory (6 hrs) Home Study (4 hrs) Group/Lock Step Instructional Guidance Have students pair off and perform studies on each other.
11. Acid Base Balance II	14 (10/4)	Column 1 Reference: 11a, 11b, 11c STS Reference: 8b(6)(a)14
a. Describe arterial blood gas values associated with acid base disturbances.	(2)	Instructional Materials PT 3ALR91630-II-11c(1), Powers of Ten PT 3ALR91630-II-11c(2), Mathematics Review Grenard, Rich, Beck, Introduction to Respiratory Therapy Winters, Engel, Dell, Acid Base Physiology in Medicine
b. Explain the Henderson-Hasselbalch equation.	(2)	
c. Describe the use of the Henderson-Hasselbalch equation in verifying blood gas values.	(6)	Audio Visual Aids Filmstrip and Cassette, Trainex: Body's Regulation of pH (50 min) Training Equipment Slide Rules (1) Training Methods Lecture/Discussion (4 hrs) Demonstration/Performance (6 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (4 hrs) Laboratory (6 hrs) Home Study (4 hrs) Group/Lock Step

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance Review basic mathematics. Performance hours are limited to working sample problems to insure students have a working knowledge of the Henderson-Hasselbalch equation. Programmed texts 3ALR91630-II-11c(1) and 3ALR91630-II-11c(2) are completed during home study.
12. **Blood Gas Studies**	9 (7/2)	**Column 1 Reference** / **STS Reference** 12a, 12b, 12c — 4a(2), 6d, 8b(6)(a)13, 8b(6)(a)14, 8b(6)(b)1, 8b(6)(b)2, 8b(6)(b)3, 8b(6)(b)4, 8b(6)(b)12 12d — 4a(2), 6d, 8b(6)(a)13, 8b(6)(a)14, 8b(6)(b)1, 8b(6)(b)2, 8b(6)(b)3, 8b(6)(b)4, 8b(6)(b)12
a. Match the arteries used with the types of studies performed.	(1)	
b. Describe the types of diagnostic equipment.	(2)	**Instructional Materials** SG 3ALR91630-II-12d, Arterial Punctures
c. Explain the collection and storage of samples.	(2)	**Audio Visual Aids** Filmloop, Rocom, Arterial Puncture (20 min) Filmstrip and Cassette, Trainex: Arterial Samples for Blood Gas Analysis (50 min) Transparencies, Blood Gas Set
d. List the steps in performing a single arterial puncture.	(2)	**Training Equipment** Treatment Tables (3) Sodium Heparin (10) 5cc Syringes (1) 21 gauge needles (1) Alcohol sponges (1) Band aids (1) **Training Methods** Lecture/Discussion (4 hrs) Demonstration/Performance (3 hrs) Outside Assignments (2 hrs)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (4 hrs) Laboratory (3 hrs) Home Study (2 hrs) Group/Lock Step Instructional Guidance Conclude lecture with Rocom filmstrip and then demonstrate a "single stick" using the radial artery. Have students pair up and perform the procedure on each other. Proficiency is not required. Performance of procedure is to allow students to get the feel of the puncture in a controlled environment.
13. Postural Drainage a. Explain three methods of performing postural drainage.	2	Column 1 Reference 13a STS Reference 8c(10)(a), 8c(10)(b), 8c(10)(c), 8c(11) Instructional Materials Grenard, Rich, Beck, Schapira, Advanced Studies in Respiratory Therapy Audio Visual Aids Filmstrip and Cassette, Trainex: Postural Drainage, Clapping and Vibration (50 min) Training Equipment Treatment tables (3) Training Methods Lecture/Discussion (1 hr) Demonstration/Performance (1 hr) Instructional Environment/Design Classroom (1 hr) Laboratory (1 hr) Group/Lock Step

PLAN OF INSTRUCTION (Continued)		
UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
		Instructional Guidance Illustrate lecture by demonstrating postural drainage on a student. Have students practice positions on each other. The performance hour is designed to reinforce knowledge requirements only and not to develop proficiency.
14. Related Training (identified in course chart).	2	
15. Measurement Test and Test Critique a. Measurement Test b. Test Critique	2	

PLAN OF INSTRUCTION NO. 3ALR91630	DATE 23 APR 1975	BLOCK NO. II	PAGE NO. 24

PLAN OF INSTRUCTION	COURSE TITLE Cardiopulmonary Laboratory Specialist

BLOCK TITLE Introduction to Respiratory Therapy

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
1. Introduction to Respiratory Therapy a. Describe the organization of a respiratory therapy department. b. List the services offered by a respiratory therapy department.	1	Column 1 Reference — STS Reference 1a — 2a, 2b, 7b(2) 1b — 2a, 2b, 7b(2) Instructional Materials Egan, Fundamentals of Respiratory Therapy AART Application Forms Training Methods Lecture/Discussion (1 hr) Instructional Environment/Design Classroom (1 hr) Group/Lock Step
2. Safe Use of Medical Gases a. Explain the safety systems used with medical gases. b. Describe the use of regulators and flowmeters.	5 (3/2)	Column 1 Reference — STS Reference 2a — 8c(3) 2b — 4a(2), 8c(4) Instructional Materials Brady, Respiratory Therapy Grenard, Beck, Rich, Introduction to Respiratory Therapy Bennett, Flow Regulator Punchout Audio Visual Aids Transparencies, Medical Gases Set Training Equipment Gas Regulators (5) Training Methods Lecture/Discussion (3 hrs) Outside Assignments (2 hrs)

PLAN OF INSTRUCTION NO. 3ALR91630	DATE 23 APR 1975	BLOCK NO. III	PAGE NO. 25

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (3 hrs) Home Study (2 hrs) Group/Lock Step Instructional Guidance Ask students to give examples of improper uses of medical gases from personal experiences.
3. Humidification and Aerosol Therapy a. Describe the conditioning of inspired air by humidity and aerosol. b. Explain the operation of jet nebulizers c. Explain the operation of ultrasonic nebulizers. d. Describe three types of humidifiers.	3	Column 1 Reference — STS Reference 3a — 4a(2), 8c(2)(c), 8c(2)(d), 8c(2)(e)1, 8c(2)(e)2 3b, 3c — 4a(2), 6d, 7a(8), 8c(2)(c), 8c(2)(d), 8c(2)(e)1, 8c(2)(e)2 3d — 4a(2), 6d, 7a(8), 8c(2)(c), 8c(2)(d), 8c(2)(e)1, 8c(2)(e)2 Instructional Materials Brady, Respiratory Therapy Grenard, Beck, Rich, Introduction to Respiratory Therapy Grenard, Beck, Rich, and Schapira, Advanced Studies in Respiratory Therapy Audio Visual Aids Transparencies, Humidification and Aerosol Set Sound Tapes, Monaghan: Medical-Phsyical Aspects of Humidity and Aerosol Therapy (50 min) Theory and Operation of Monaghan Ultrasonic Nebulizers (50 min) Filmstrip and Cassette, Trainex: Ultrasonic Nebulizers (50 min) Training Equipment Devilbiss Ultrasonic Nebulizer (10) Training Methods Lecture/Discussion (3 hrs)

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES 1	DURATION (HOURS) 2	SUPPORT MATERIALS AND GUIDANCE 3
		Instructional Environment/Design Classroom (3 hrs) Group/Lock Step Instructional Guidance Relate the use of humidity and aerosol therapy to specific pulmonary disorders.
4. Intermittent Positive Pressure Breathing (IPPB) a. Describe the indications for the use of IPPB. b. Explain the technique for IPPB therapy. c. State the hazards of IPPB therapy.	7 (5/2)	Column 1 Reference — STS Reference 4a, 4b — 7a(8), 8c(2)(a), 8c(2)(b), 8c(3), 8c(4), 8c(5) 4c — 7a(8), 8c(2)(a), 8c(2)(b), 8c(3), 8c(4), 8c(5) Instructional Materials Brady, Respiratory Therapy Grenard, Beck, Rich and Schapira, Advanced Studies in Respiratory Therapy Audio Visual Aids Transparencies, IPPB Set Slide Tape, Monaghan, Medical-Physical Aspects of Positive Pressure Breathing (60 min) Training Equipment Respirator, Bird Mark 7 (2) Training Methods Lecture/Discussion (4.5 hrs) Demonstration (.5 hrs) Outside Assignments (2 hrs) Instructional Environment/Design Classroom (5 hrs) Home Study (2 hrs) Group/Lock Step

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance Emphasize that this lesson is to give the student basic understanding of the therapy and not the mechanics of the operation.
5. Pediatric Ventilation a. Describe the problems and limitations of pediatric ventilation.	1	Column 1 Reference 5a STS Reference 8c(2)(a), 8c(2)(b) Instructional Materials Brady, Newborn Respiratory Tract Audio Visual Aids Slides, Brady, Newborn Respiratory Tract Training Methods Lecture/Discussion (1 hr) Instructional Environment/Design Classroom (1 hr) Group/Lock Step Instructional Guidance Point out specific problems in this area that are not found in adult ventilation.
6. Indications for the Use of Oxygen a. Describe the indications for the use of oxygen therapy.	4 (2/2)	Column 1 Reference 6a STS Reference 8c(1)(a), 8c(1)(b), 8c(1)(c), 8c(1)(d) Instructional Materials Brady, Respiratory Therapy Audio Visual Aids Transparencies, Indications for the Use of Oxygen Set Training Methods Lecture/Discussion (2 hrs) Outside Assignments (2 hrs)

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Instructional Environment/Design Classroom (2 hrs) Home Study (2 hrs) Group/Lock Step **Instructional Guidance** Discuss malfunctions of the cardiopulmonary system that lead to the use of O_2. Emphasize the cause of the malfunction by using selected transparencies.
7. Oxygen Equipment a. Describe the use of nasal catheters/ cannula. b. Explain the operation of oxygen masks. c. Explain the use of oxygen tents.	3	**Column 1 Reference** / **STS Reference** 7a — 4a(2), 6d, 7a(8), 8c(1)(c) 7b — 4a(2), 6d, 7a(8), 8c(1)(b) 7c — 4a(2), 6d, 7a(8), 8c(1)(a), 8c(1)(d) **Instructional Materials** Brady, Respiratory Therapy Egan, Fundamentals of Respiratory Therapy Grenard, Beck, and Rick, Introduction to Respiratory Therapy **Audio Visual Aids** Transparencies, Oxygen Equipment Set **Training Equipment** Catheters/Cannula (10) Oxygen Mask (10) **Training Methods** Lecture/Discussion (3 hrs) **Instructional Environment/Design** Classroom (3 hrs) Group/Lock Step **Instructional Guidance** Pass around examples of O_2 equipment after the lecture.

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS) 2	3 SUPPORT MATERIALS AND GUIDANCE
8. Management of the Comatose Patient a. Describe the technique of dealing with the unconscious patient.	1	Column 1 Reference 8a STS Reference 8c(1)(c), 8c(2)(a), 8c(2)(b) Audio Visual Aids Film, TF8-3224, Emergency Airway Maintenance (26 min) Training Methods Lecture/Discussion (1 hr) Instructional Environment/Design Classroom (1 hr) Group/Lock Step Instructional Guidance Conclude with the film on airway maintenance. Watch class closely for students passing out.
9. Respirators I a. Explain the operation of Bird respirators. b. Describe special breathing assemblies.	13 (9/4)	Column 1 Reference 9a, 9b STS Reference 4a(2), 8c(2)(a) Instructional Materials SW 3ALR91630-III-9a, Bird Respirators Bird Catalog Grenard, Beck, and Rich, Introduction to Respiratory Therapy Audio Visual Aids Transparencies, Bird Respirators, Set Slides, Bird Respirators Set Filmstrips and Cassettes, Trainex: IPPB-I-Bird Mark VII (50 min) IPPB-II-Bennett Pr-1 (50 min) Slide Tape: Theory and Operation of Monaghan Positive Pressure Breathing Machines Training Equipment Bird Respirators (5)

PLAN OF INSTRUCTION NO.	DATE	BLOCK NO.	PAGE NO.
3ALR91630	23 APR 1975	III	30

PLAN OF INSTRUCTION (Continued)

1 UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Training Methods Lecture/Discussion (7 hrs) Demonstration (2 hrs) Outside Assignments (4 hrs) Instructional Environment/Design Classroom (9 hrs) Home Study (4 hrs) Group/Lock Step
10. Intubation a. Explain the indications and side effects of intubation. b. Describe the types of endotracheal tubes. c. Describe the steps in intubating a patient.	2	Column 1 Reference — STS Reference 10a — 8c(9)(a), 8c(9)(b) 10b — 8c(9)(c) 10c — 4a(2), 8c(9)(c) Instructional Materials Grenard, Beck and Rich, Advanced Studies in Respiratory Therapy Brady, Respiratory Therapy Audio Visual Aids Transparencies, Intubation Set Film Loop, Rocom, Endotracheal Intubation (20 min) Training Equipment Intubation manikins (5) Endotracheal tubes (5) Laryngoscopes (5) Training Methods Lecture (1 hr) Demonstration/Performance (1 hr) Instructional Environment/Design Classroom (1 hr) Laboratory (1 hr) Group/Lock Step

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS) 2	3 SUPPORT MATERIALS AND GUIDANCE
		<u>Instructional Guidance</u> Demonstrate oral and nasal intubation and allow students to perform procedure. Check for positioning of the tubes and inflated cuff. The performance time is designed to reinforce knowledge and not develop proficiency.
1. <u>Measurement Test and Test Critique</u> a. Measurement Test b. Test Critique	1	
2. <u>Respirators II</u>	12 (8/4)	<u>Column 1 Reference</u> / <u>STS Reference</u> 12a — 4a(2), 8c(2)(a) 12b — 4a(2), 8c(2)(b)
a. Describe the operation of Bennett ressure limited ventilators.	(4)	<u>Instructional Materials</u> Bennett Training Manual Grenard, Beck and Rich, <u>Introduction to Respiratory Therapy</u>
b. Explain the operation of volume imited ventilators.	(4)	<u>Audio Visual Aids</u> Filmstrips and Cassettes, Trainex: IPPB - II - Bennett Pr-1 (50 min) <u>Training Equipment</u> Bennett Respirator (10) <u>Training Methods</u> Lecture/Discussion (7 hrs) Demonstration (1 hr) Outside Assignments (4 hrs) <u>Instructional Environment/Design</u> Classroom (8 hrs) Home Study (4 hrs) Group/Lock Step

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS)	SUPPORT MATERIALS AND GUIDANCE
		Instructional Guidance Present maintenance hours at the end of course in order to keep student interest the last two days.
13. Post Operative Complications a. Describe the pulmonary risks of surgery. b. Explain nine pulmonary complications of surgery.	2	**Column 1 Reference** / **STS Reference** 13a — 8c(2)(a), 8c(2)(b), 8c(10)(a), 8c(10)(b), 8c(10)(c), 8c(11) 13b — 8c(2)(a), 8c(2)(b), 8c(10)(a), 8c(10)(b), 8c(10)(c), 8c(11) **Instructional Materials** Brady, Respiratory Therapy Grenard, Beck, and Rich, Introduction to Respiratory Therapy **Audio Visual Aids** Transparencies, Post Operative Complications Set **Training Methods** Lecture/Discussion (2 hrs) **Instructional Environment/Design** Classroom (2 hrs) Group/Lock Step
14. Sterilization of Equipment a. Describe the protocol for a bacteriological check. b. Explain three types of heat disinfection. c. Select the advantages and disadvantages of gas sterilization. d. Describe the technique for cleaning and cold sterilization.	6 (4/2)	**Column 1 Reference** / **STS Reference** 14a — 6d, 7a(8) 14b — 6d, 7a(8), 8c(6)(a) 14c — 6d, 7a(8), 8c(6)(c) 14d — 6d, 7a(8), 8c(6)(b) **Instructional Materials** Grenard, Beck, and Rich, Introduction to Respiratory Therapy Brady, Respiratory Therapy **Audio Visual Aids** Transparencies, Sterilization Set

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	2 DURATION (HOURS)	3 SUPPORT MATERIALS AND GUIDANCE
		Training Methods Lecture/Discussion (4 hrs) Outside Assignments (2 hrs) Instructional Environment/Design Classroom (4 hrs) Home Study (2 hrs) Group/Lock Step Instructional Guidance Use discussion method as much as possible because of student background.
15. Prolonged Artificial Ventilation a. List five indications for prolonged artificial ventilation. b. Describe four types of respiratory dead space. c. Explain sighing and airway maintenance. d. Describe the problems involving infant ventilation.	6 (4/2)	Column 1 Reference: 15a, 15b, 15c; 15d STS Reference: 8c(2)(a), 8c(2)(b); 8c(2)(a), 8c(2)(b) Instructional Materials Brady, Respiratory Therapy Grenard, Beck, and Rich, Advanced Studies in Respiratory Therapy Audio Visual Aids Transparencies, Prolonged Artificial Ventilation Set Training Methods Lecture/Discussion (4 hrs) Outside Assignments (2 hrs) Instructional Environment/Design Classroom (4 hrs) Home Study (2 hrs) Group/Lock Step Instructional Guidance Point out that there may be some differences of opinion about whether a patient should be controlled or assisted with his ventilation. The examples given in the lesson are guidelines that can be followed. The ultimate decision rests with the physician.

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS)	SUPPORT MATERIALS AND GUIDANCE
16. <u>Respirator Maintenance</u>	8	<u>Column 1 Reference</u> / <u>STS Reference</u> 16a — 4a(2), 6d, 8c(7) 16b — 4a(2), 6d, 8c(7) 16c — 4a(2), 6d
a. Describe the preventive maintenance of Bird respirators.	(2)	<u>Instructional Materials</u> Bird Training Manual Bennett Training Manual Bird Catalog
b. Describe the preventive maintenance of Bennett respirators.	(2)	<u>Training Equipment</u> Bird respirators (5) Bennett respirator (10) Emerson respirator (10) Centerbody cutaways (2)
c. Given a tool kit satisfactorily dissassemble, calibrate, and reassemble respirator. Correctly perform all of the items on checklist 3ALR91630-III-16c. Instructor assistance permitted.	(4)	<u>Training Methods</u> Performance (8 hrs) <u>Instructional Environment/Design</u> Laboratory (8 hrs) Group/Lock Step <u>Instructional Guidance</u> Students will disassemble and reassemble the Mark 7 in order to better understand the mechanical operation of the respirator. Emphasize that inside maintenance should be done by qualified medical equipment repair personnel.
17. <u>Related Training</u> (identified in course chart).	4	
18. <u>Measurement Test and Test Critique</u>	2	
a. Measurement Test		
b. Test Critique		

PLAN OF INSTRUCTION NO.	DATE	BLOCK NO.	PAGE NO.
3ALR91630	[illegible]	III	35

PLAN OF INSTRUCTION (Continued)

UNITS OF INSTRUCTION AND CRITERION OBJECTIVES	DURATION (HOURS)	SUPPORT MATERIALS AND GUIDANCE
9. Course Critique and Graduation a. Course Critique b. Graduation	1	

10-6 53

Department of Medicine
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas

STUDY GUIDE 3ALR91630-I-3a(1)
March 1975

INTRODUCTION TO CARDIOVASCULAR DISEASE

OBJECTIVE

Using heart models, student will identify areas of the heart where abnormalities can occur.

INTRODUCTION

An understanding of heart disease will aid the cardiovascular pulmonary technician in the proper diagnosis and treatment of problems of the heart.

INFORMATION

1. Briefly introduce the subject of cardiac disease.

   a. The cardiovascular system

      (1) Heart

      (2) Blood vessels

      (3) Lymphatics

   b. Importance of heart disease

      (1) The leading cause of death in the U.S. - about 40 percent of deaths.

      (2) Due primarily to increasing age of population.

   c. Major cardiac disorders

      (1) Coronary heart disease, predominately atherosclerotic

      (2) Hypertensive cardiovascular disease

      (3) Rheumatic heart disease

      (4) Congenital heart disease

   d. Minor cardiac disorders

      (1) Syphilitic heart disease

      (2) Bacterial endocarditis

      (3) Myocarditis

      (4) Degenerative, endocrine, metabolic, electrolyte, etc. disorders

This supersedes SG 3ALR91630-I-3c, August 1973

2. Cardiac failure

a. Cardiac failure is a clinical state in which the heart is unable to maintain an adequate circulation for bodily needs.

b. Basic factors causing or contributing to heart failure

(1) Weakened heart muscle

(a) Loss of heart muscle

(b) Impairment of muscle contractility

(c) Heart muscle unable to function as an efficient pump

(d) Results from myocardial infarct or fibrosis, coronary artery insufficiency, myocarditis, metabolic disorders, etc.

(2) Mechanical overload which in time leads to myocardial failure:

(a) Increased resistance to ejection of blood such as due to valvular stenosis or hypertension.

(b) Excessive demand for increased cardiac output due to valvular insufficiency, or arteriovenous shunts, or increased tissue needs (as in thyrotoxicosis).

(3) Impaired cardiac filling of the heart chambers:

(a) Cardiac tamponade - a rapid accumulation of fluid or blood in the pericardial sac.

(b) Constrictive pericarditis - chronic scarring of the pericardium so that the heart cannot dilate normally to receive blood.

(4) A combination of these basic factors

c. Acute and chronic heart failure

(1) Acute failure - sudden onset

(a) Caused by myocardial injury due to coronary artery occlusion or by cardiac tamponade due to hemopericardium 2° rupture of heart.

(b) In acute failure there is a sudden reduction or cessation of cardiac output.

(2) Chronic heart failure - slow onset

(a) Most common in association with arteriosclerotic heart disease, hypertensive heart disease, and valvular abnormalities.

(b) It can occur as a result of any disease that weakens the heart directly or causes an increased demand on the myocardium.

d. Cardiac compensation and decompensation

(1) Compensation

(a) This is present when the cardiovascular system makes sufficient adjustments to maintain adquate output.

55

(b) The principle compensatory phenomena are

1 tachycardia - increased heart.

2 cardiac hypertrophy - increased heart mass.

3 cardiac dilatation - increased heart volume.

(2) Decompensation. When the adjustment just referred to are inadequate then cardiac decompensation is said to exist.

e. High and low output failure

(1) Low output failure

(a) In most cases of cardiac failure the cardiac output is reduced.

(b) Myocardial infarct, aortic valvular stenosis, constrictive pericarditis

(2) High output failure

(a) In some cases of cardiac failure, however, there is failures due to a high cardiac output.

(b) Arteriovenous fistulas, thyrotoxicosis, severe anemias

f. Left and right sided heart failure

(1) Heart failure may involve the entire heart or predominantly even exclusively the left or right side.

(2) Left heart failure

(a) Major clinical manifestations are associated with pulmonary edema and congestion.

(b) In severe cases pulmonary hypertension results leading to right heart failure.

(3) Right heart failure

(a) Often associated with left heart failure but does occur by itself

(b) Major clinical manifestations include

1 subcutaneous edema of dependent portions of body, e.g. ankles.

2 hydrothorax - pleural effusion.

3 ascites - fluid in abdominal cavity.

4 generalized venous congestion.

5 cyanosis.

6 increased blood volume (usually).

(4) Congestive heart failure - the clinical syndrome resulting from chronic (usually, but occasionally acute) heart failure.

10-6. 56

Department of Medicine
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas 76311

STUDY GUIDE 3ALR91630-I-3a(2)
March 1975

RHEUMATIC FEVER AND RHEUMATIC HEART DISEASE

OBJECTIVES

- List the parts of the body involved in rheumatic fever.
- Explain the pathophysiology of rheumatic fever.
- List the treatments of rheumatic fever and rheumatic heart disease.

INTRODUCTION

Rheumatic fever is a systemic (generalized) disease which varies greatly in severity and duration, therefore a knowledge of the signs, symptoms, and treatment of rheumatic fever and rheumatic heart disease is essential.

INFORMATION

1. Rheumatic fever and chronic rheumatic heart disease

a. General

(1) Rheumatic fever is a systemic (generalized) disease which varies greatly in severity and duration.

(2) Examples of parts of the body involved:

(a) Heart - A pancarditis - i.e., pericardium, myocardium, and endocardium are all affected.

(b) Joints

(c) Skin and subcutaneous tissues

(d) Blood vessels

(e) Central nervous system

(f) Lungs and pleura

(3) Jones criteria

(a) Major - 5

1 Carditis - heart

2 Polyarthritis - joints

3 Chorea minor - CNS

This supersedes SG 3ALR91630-I-3g, August 1973.

4 Subcutaneous nodules

5 Skin disease

(b) Minor

1 Fever

2 Arthralgia

3 Prolonged P-R interval on EKG

4 Abnormal lab studies, such as ↑ sed rate, +C- Reactive protein, leukocytosis

5 Evidence of preceding streptococcal, infection.

6 Previous history of rheumatic fever.

(4) Etiology (causation)

(a) Abundant evidence that beta hemolytic streptococci belonging to Group A are responsible.

(b) The first attack occurs 2 to 3 weeks following the strep infection.

(c) It is a hypersensitivity or allergic reaction to the streptococci.

(5) Incidence

(a) Marked decrease during 20th century even prior to sulfa and penicillin.

(b) More frequent in lower socioeconomic groups.

(c) No significant sex or racial predilection.

(d) Attack rate is 1-3 percent of strep infections.

(6) Age

(a) Onset most frequent in childhood from 4 to 15 years especially 6 - 10.

(b) Does occur outside of these age limits with a few even to adulthood.

(c) Chronic forms occur through adulthood.

b. Pathology

(1) A collagen disease. One of the diseases in which the collagenous connective tissues throughout the body are affected.

(2) Aschoff bodies (nodules). These are lesions of the connective tissues in the heart - not of the heart muscle.

(3) Pancarditis - all three heart layers are involved.

(4) Endocarditis

(a) Inflammation of the inner layer of the heart including the valves.

(b) There are small nodular lesions of the valves where they close on one another. These are called verrucae and are composed of degenerated collagen of the valves plus platelet thrombi.

(c) There are many more vegetations on the left side of the heart where the pressure is highest.

(d) Healing of the valvulitis occurs by fibrosis - scar formation. Blood vessels grow into the scar tissue thickening the valve leaflets. Also calcification which causes the valves to become rigid.

(e) As healing occurs adhesions occur between the lateral edges of the valve cusps.

(f) Thickening, shortening, and fusion of the chordae tendineae.

(g) Final result is valve deformities. The incidence of deformity of the valves singly and in combination.

1 Mitral

2 Mitral and aortic

3 Aortic

4 Mitral, aortic, and tricuspid

5 Mitral and tricuspid

6 Mitral, aortic, tricuspid and pulmonary

7 It is very rare for tricuspid or pulmonary valvulitis alone.

(h) The most characteristic type of deformity is mitral stenosis. Mitral insufficiency is not infrequently combined with mitral stenosis. Valvular insufficiency results from contraction of the scarred and deformed valves.

(5) Myocarditis

(a) Aschoff bodies

(b) Various types of inflammatory cells

(c) Foci of necrosis

(d) Any of these three types of lesions may affect the conduction system and be responsible for various EKG changes.

(e) The inflammation gradually subsides and the myocardium may be left with multiple small scars replacing the Aschoff bodies and small necrotic foci.

(6) Pericarditis

(a) The pericardium is almost invariably affected in rheumatic fever.

(b) The lesion is a fibrinous exudate - an outpouring of plasma high in fibrinogen from the vessels of the pericardium. The fibrinogen then clots on the pericardial surfaces.

(c) A serous exudate may be present with or without the fibrinous exudate.

(d) If much fluid is present recovery may occur without pericardial fibrous adhesions.

(e) Frequently, however, especially when the fibrin is abundant, organization of the exudate leads to fibrous thickening of the pericardial layers and pericardial adhesions leading to obliteration of the pericardial cavity. This is known as chronic adhesive pericarditis.

(7) Recurrent rheumatic carditis

(a) Once rheumatic fever has occurred in a patient, there is a likelihood of a recurrence of the disease with subsequent streptococcal infections.

(b) With the recurrence or exacerbation of the disease there is further damage to the valves and other parts of the heart leading to chronic rheumatic heart disease.

(c) This is the reason for taking sulfa or penicillin prophylactically for years following rheumatic fever. It prevents further strep infections which would result in further cardiac damage.

(8) Causes of death in rheumatic heart disease

(a) Cardiac failure

1 Most frequent cause of death.

2 Occurs during active rheumatic fever - in children.

3 Occurs in adults usually due to the valvular deformities.

(b) Bacterial endocarditis

1 Bacterial infection of a valve damaged by the disease.

2 Usually in young to middle aged adults.

3 Usually subacute in type.

(c) Embolism

1 Emboli to the brain are most frequent, followed by kidneys, spleen, and lungs.

2 Usually bland emboli, but some are septic from bacterial endocarditis.

3 Most emboli originate in the left artium or its appendage. This is almost always in association with mitral stenosis and atrial fibrillation.

4 Sudden death may occur as a result of obstruction of a stenotic mitral orifice by a ball thrombus in the left artium or by coronary insufficiency caused by severe aortic stenosis.

10-6 · 6

PREPARE. THE MAN. STUDY GUIDE 3ALR91630-I-3 (3)

Department of Medicine
School of Health Care Sciences

ARTERIOSCLEROSIS AND ARTERIOSCLEROTIC HEART DISEASE

August 1973

Sheppard Air Force Base, Texas

Designed For ATC Course Use

DO NOT USE ON THE JOB

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Department of Medicine
School of Health Care Sciences, USAF (ATC)
Sheppard Air Force Base, Texas

SG 3ALR91630-I-3a
August 1973

ARTERIOSCLEROSIS AND ARTERIOSCLEROTIC HEART DISEASE

1. The types of the blood vessels and their anatomy.
   a. Arterial - carry blood away from the heart.
   b. Venous - carry blood to the heart.
   c. Capillaries - small vessels between arteries and veins.
   d. Arterial blood vessels
      (1) Vary in size.
         (a) Large artery
         (b) Medium artery
         (c) Small artery
         (d) Arterioles
      (2) Layers
         (a) Tunica intima
            1. Innermost layer
            2. About 1/6th thickness of wall
            3. Endothelial layer of cells adjacent to the blood
         (b) Tunica media
            1. Middle layer
            2. About 1/2 thickness of wall
            3. Smooth muscle
            4. Elastic tissue

This SG supersedes SHO 3ALR91630-I-3e, dated November 1972

(c) Tunica adventitia

1. Outermost layer

2. About 1/3 thickness of wall

3. Fibrous connective tissue containing small blood vessels.

e. Venous blood vessels

(1) Vary in size

(a) Large vein

(b) Medium vein

(c) Small vein

(d) Venules

(2) Layers - same as arterial vessels

f. Capillaries

(1) Microscopic size

(2) Only an endothelial layer of cells. No media or adventitial layers.

2. Classify arteriosclerosis and describe the types.

a. Atherosclerosis

(1) Most common and important disease of arteries.

(2) Affects large and medium size arteries leaving small arteries relatively unaffected.

(3) Disease begins in the intima and media with accumulation of lipids including cholesterol.

(4) These lipids cause various degenerative changes in the wall of the arteries.

(a) Necrosis - death of cells in the intima and media.

(b) Fibrosis - scar formation.

(c) Calcific deposits

(d) Hemorrhage into the wall of the vessel.

(e) Ulceration - loss of the surface.

(f) Thrombosis on top of the ulcers or damaged intima.

(5) As a result narrowing leading to occlusion of the artery.

(6) Destruction of the intima and media by atherosclerosis may weaken the wall to the extent that an aneurysm may develop.

(7) Etiology and factors involved:

(a) The final answers are not yet known.

(b) Increases with age.

(c) Related to increased lipid levels in the blood - both cholesterol and triglycerides.

(d) Familial hyperlipidemias of 5 separate types - genetically inherited abnormalities of lipid metabolism. In 4/5 accelerated atherosclerosis.

(e) Diabetes mellitus - increased atherosclerotic disease.

(f) Sex related - females less atherosclerosis before menopause than males. After menopause about the same.

(g) High blood pressure - hypertension - accelerates the atherosclerotic process.

(8) Important blood vessels affected by atherosclerosis - examples:

(a) Cerebral arteries -

1. Senility

2. Stroke

(b) Renal arteries

1. Decreased renal function

2. Infarcts - death of tissue due to vascular insufficiency.

(c) Limbs - particularly lower.

1. Gangrene of toes

2. Cold, painful legs

(d) Coronary arteries

1. Coronary

2. Arrhythmias

3. Myocardial infarct

b. Monckeberg's medial sclerosis

(1) Less common and much less important than atherosclerosis.

(2) Found from middle age on.

(3) Deposits of calcium are found in the media of medium and large arteries. The intima is unaffected.

(4) The affected blood vessels can be recognized by palpation to be hardened (pipestem rigidity) and beaded.

(5) The vessels also elongate thus taking on a tortous course.

(6) The hardening of these arteries may cause systolic hypertension.

c. Arteriolar sclerosis (arteriolosclerosis)

(1) A widespread process affecting the arterioles.

(2) The arterioles are thickened by endothelial hyperplasia and intimal hypertrophy.

(3) Associated with hypertension, especially in the renal vessels.

(4) Associated with aging, vessels other than in the kidney.

3. Discuss coronary artery atherosclerosis and its complications.

a. Etiology - already listed many factors involved in atherosclerosis.

b. Complications in the arteries.

(1) Decrease in size of lumen of artery due to increased lipid scar, calcific deposits (atherosclerotic changes) in wall of artery.

(2) Hemorrhage into an atherosclerotic plaque (lesion) can cause sudden narrowing of a coronary artery.

(3) Thrombus formation is a common complication of atherosclerosis leading to partial or complete coronary artery occlusion.

(4) Embolism - rupture of an atheromatous plaque.

(5) Site of coronary artery occlusion. In a study of 1495 cases the distribution showed that the left coronary artery was most frequently involved particularly the left anterior descending branch.

Left main artery 71.
Left anterior descending branch 834.
Left circumflex branch 211.
Right coronary artery 379.

c. Complications in the heart muscle

(1) Myocardial infarct

(a) Acute stages

1. Death of heart muscle.

2. Inflammatory cells (neutrophils and macrophages) begin to enter the tissue at the end of the 1st day.

3. Removal of dead tissue by the cells begins at 3 or 4 days and persists until complete.

4. Fibrous repair begins at about 12-14 days and continues to completion by 4-6 weeks.

(b) Late stages

1. The left ventricular wall will be somewhat thinned as there is less fibrous scar remaining with healing than there was muscle originally.

2. If the area of scar is large in the left ventricle it may bulge and stretch due to the high pressure in the ventricle. With time a saclike bulge forms - a ventricular aneurysm.

3. Ten % or more of healed myocardial infarcts may give rise to ventricular aneurysm. These patients usually have congestive heart failure.

4. Paradoxical movement of the heart may occur with the aneurysm - the sac bulging outward on systole.

5. Thrombi (mural) are frequent in the left ventricular lumen attached to the endocardium in the area of the aneurysm. These may from time to time break loose and be ejected from the heart. These thromboemboli may lodge in any of a number of arteries or arterioles.

(c) Types of myocardial infarct

1. Full-thickness (transmural). The entire thickness of the myocardium is involved. Also the pericardium may be involved causing pericarditis. The endocardium is also involved. This is the type which usually leads to ventricular aneurysm. Also the type which may lead to rupture of the heart (1-3 weeks). This occurs in 8-15% of acute MI's.

2. Non transmural - These are often large but do not involve the entire thickness of the muscle.

3. Laminar - This type involves less than 1/2 of the thickness of the wall. Usually it is the inner 1/2, the subendocardial portion. These infarcts involve, then, the endocardium and subendocardial muscle.

(d) Location of myocardial infarcts

1. Almost all infarcts occur in the left ventricle and septum.

2. Most frequent site is the anterior region of left ventricle near the apex, usually including the anterior 2/3rd of the IV septum because of disease of the anterior descending branch of the left coronary artery.

3. Second most common site is the posterior left ventricle along with the posterior 1/3rd of the IV septum related.

4. Less commonly infarcts confined to the lateral left ventricular wall occur. These are due to disease of the left circumflex branch of the left coronary artery.

(2) Angina pectoris

(a) Not the appropriate place to discuss clinical features.

(b) Results from inadequate oxygenation of heart muscle usually resulting from

1. Significant atherosclerosis of the coronary vessels.

2. Associated reduction in blood supply to the heart (e.g., following heavy meal) or increase in O_2 requirement by the heart (e.g. exercise).

(3) Sudden death.

(a) This may occur during the course of a myocardial infarct.

(b) May occur in a person who has experienced anginal attacks without a myocardial infarct.

(c) May occur without either (a) or (b).

1. Some patients die with severe atherosclerosis or coronary arteries with or without an occlusion by thrombus, hemorrhage, etc.

2. These patients usually die of an arrhythmia - therminating as ventricular fibrillation.

3. Although there may be an arterial occlusion the patient died before the myocardial infarct had time to develop.

(4) Myocardial fibrosis

(a) Some patients who never had an obvious myocardial infarct either clinically or pathologically are found to have patchy foci of fibrosis of the myocardium.

(b) Some of the patients had anginal attacks.

(c) These patchy foci of fibrosis represent small foci of myocardial necrosis with subsequent fibrosis due to chronic progressive myocardial ischemia.

c. ASHD - arteriosclerotic heart disease - or atherosclerotic coronary heart disease.

This term is used for heart disease resulting from coronary atherosclerosis which includes such features as angina pectoris, myocardial infarct, myocardial fibrosis, congestive heart failure, etc.

6

DEPARTMENT OF MEDICINE

CARDIOPULMONARY LABORATORY SPECIALIST

FORMS OF HEART DISEASE (MISCELLANEOUS)

March 1975

SCHOOL OF HEALTH CARE SCIENCES, USAF
SHEPPARD AIR FORCE BASE, TEXAS

Designed For ATC Course Use

DO NOT USE ON THE JOB

68

Department of Medicine
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas

SG 3ALR91630-I-3a(4)
March 1975

FORMS OF HEART DISEASE (MISCELLANEOUS)

OBJECTIVE

Using heart models, identify areas of heart where diseases occur.

INTRODUCTION

An understanding of Forms of Heart Disease is essential in the diagnosis and treatment of a patient. This complex pump has many areas in which problems can arise, and as CP techs, we must be able to diagnose and treat these problems.

INFORMATION

The student will identify and categorize Forms of Heart Disease.

1. Congenital Heart Disease

a. There is a wide spectrum of anatomic malformations. We have already mentioned several and gone over the physiology of congenital aortic stenosis and pulmonic stenosis. Obstruction to left and right ventricular outflow tracts may be at several levels and what is really important is to realize that there is obstruction to ventricular emptying. Further evaluation of the exact level can then be worked out with the aid of the specialized diagnostic procedures.

b. There are two fairly frequent forms of congenital heart disease which you are apt to see, especially in the younger adults.

(1) Atrial septal defect

(a) Although the physiology of any type of ASD is the same, there are certain features, especially electrocardiographically, which help distinguish them. Physiologically, ASD imposes a volume overload on the right heart and pulmonary circuit without involving the left heart. To help clarify this, let's look at the circulatory pathway. Blood is returned from the periphery to the right atrium in the normal fashion through the superior and inferior venae cavae. During diastole the right ventricle receives the blood from the right atrium and during systole, ejects that volume of blood to the pulmonary arterial system. The blood is then returned via the pulmonary veins to the left atrium. It can either go through the mitral valve into the left ventricle or it can go across the ASD into the right heart. The major determinate of flow is the distensibility characteristic of the receiving ventricle. Since the right ventricle is thinner and more distensible than the left ventricle, its diastolic pressure is several mm Hg. less than that of the left ventricle and hence, some of the left atrial blood crosses the atrial septum and is delivered to the right ventricle. Therefore, there is a short circuit of blood which is simply going from RA to RV to PA to LA and back to the right heart again. Now we can see that the basic physiologic effect of ASD is left to right shunting at atrial level with consequent volume overloading of the right heart. Another physiologic effect of ASD is that the amount of left to right shunting (always diastolic) is exactly decreased by the same amount that venous return is increased by inspiration. Therefore, right ventricular volume is increased but constant and P_2 is delayed but does not have respiratory variation - fixed split of S_2.

This supersedes SG 3ALR91630-I-3i, July 1973

(b) The murmur of ASD has nothing to do with the defect in the atrial septum because, as we have said, left to right shunting occurs in diastole and the murmur of ASD is systolic and is recovered in the pulmonic trunk. Its genesis is that of "relative" obstruction to right ventricular emptying due to the greatly increased right ventricular volumes. The clinical signs of ASD therefore include:

1 Fixed splitting of S_2.

2 A mid-systolic murmur across the pulmonic valve.

3 Increased force of right ventricular contraction due to the increased volume. Consequently, you easily feel a right ventricular impulse at the lower left sternal border.

4 Also, because of increased flow, the pulmonary trunk dilates and it too is palpable, in the 2nd left intercostal space.

(c) X-ray would be expected to show an enlarged pulmonary arterial segment with increased pulmonary arterial markings (shunt vascularity). The right heart may be enlarged with crowding of the retrosternal space on lateral film.

(d) EKG may help to localize the defect but that will be discussed when we cover EKGs next semester.

(2) Ventricular septal defect.

(a) The physiological consequences of this lesion are quite different from ASD. The circulation is traced in the following statements. During systole blood is ejected into the pulmonary artery and returns to the left atrium via the pulmonary veins. During diastole, the left ventricle fills, but now, during the next systole, blood has two avenues of egress from the LV - out the aorta or through the VSD into the right ventricle. Since the pressure in the left ventricle is higher than the right, blood shunts across the septum (only during systole) into the right ventricle.

(b) Again, we have a short circuit, but now it involves the LA, LV, RV, and PA but not the RA. In each of these chambers we have volume overload and may have resultant hypertrophy. In addition, the PA now has both a pressure and volume overload, and pulmonary vascular changes resultant much more frequently with VSD than with ASD. Because the atrial septum is intact, there is no compensatory mechanism for handling increased venous return with inspiration and P_2 moves normally. The clinical signs of VSD therefore include:

1 A holosystolic murmur at the lower left sternal border - with normal pulmonary artery pressures. As PA pressure increases, the murmur shortens and may become early systolic with fixed pulmonary hypertension. The murmur is generated across the defect itself.

2 Normal respiratory variation of S_2.

3 Increased RV impulse and increased LV impulse - sustained left ventricular hypertrophy.

4 Pulmonary trunk may be palpable due to dilatation with increased flow.

5 May have clinical signs of pulmonary hypertension and if RV pressure is greater than LV, flow may be reversed (right to left) with resultant cyanosis. (Eisenmenger reation)

(c) X-ray would again show shunt vascularity and increased right heart but in addition may show left atrial and left ventricular dilatation.

(d) EKG may show biventricular hypertrophy plus left atrial hypertrophy.

(e) Many small VSDs close spontaneously as the ventricular septum grows. Therefore, we follow children with VSDs for many years (8-12 years of age) before subjecting them to operative closure. Evidence of progressive pulmonary hypertension would lead to much earlier operation.

Summary

VSD imposes volume and pressure overload to the PA while only a volume overload to the LA and LV.

Holosystolic murmur or early systolic depending on PA pressures.

Hyperdynamic RV plus LVH, normal splitting of S_2.

Pulmonary hypertension leads to RVH and reversed shunting - clinical cyanosis.

2. Pericardial Disease - before the pericardial disease, the anatomy of the normal pericardium is reviewed in the following statements. Basically, it consists of two thin membranes - one immediately surrounding the epicardium - the visceral pericardium, and one surrounding the entire heart and base of both great vessels - the parietal pericardium. Between these two layers of pericardium there is a potential space which is lubricated by approximately 5 cc. of straw colored pericardial fluid. In reviewing disease conditions of the pericardium several broad categories should be covered:

a. Inflammatory diseases of the pericardium covers the gamut of infectious and auto immune disease. Their clinical expressions are quite similar with respect to the pericardium although it may be very difficult to determine the exact etiologic agent in the laboratory. Several features of the clinical syndrome of pericarditis are quite specific and suggest the diagnosis which can then be confirmed by some of the special diagnostic studies. The patient is generally brought to your attention because of chest pain.

(1) It is a sharp, stabbing pain substernally or over the left precordium. It generally is localized, without radiation. It is constant but very characteristically is made worse by lying down and somewhat relieved by sitting up and leaning forward. If it is viral in origin, the patient may have had the prodromata or a recent URI of viral origin. On auscultation, there is a friction rub sounding similar to a pleural friction rub but not having respiratory variation. This is caused by the two pericardial membranes which are inflamed, rubbing together. The rub may be systolic, diastolic and/or presystolic - any of the three components may be present or all three may be heard simultaneously.

(2) Benign viral pericarditis is the most common etiology but others such as bacterial, fungal, tuberculosis, or metastatic must be considered. There are usually no immediate physiologic sequelae to the pericarditis and some types, associated with a systemic illness such as lupus erythematosis or uremia, carry the prognosis of the underlying disease process.

b. Constrictive pericarditis is a late complication of pericarditis and may or may not be calcific. Tuberculosis, as the prototype of constrictive pericarditis, calcifies as the years progress and healing takes place. Tight constriction of the pericardium may impose a great burden on the hemodynamics of circulation because it does not allow the normal distensibility of the cardiac chambers and intracardiac pressures rise secondary to external compression of the heart by the constricting pericardium. This is especially prominent during diastole when the ventricles normally distend with venous return. The clinical signs therefore include:

(1) Marked increased systemic venous pressures with hepatic engorgement, ascitis and pedal edema.

(2) Pulsus paradoxicus - fall in arterial systolic pressure with inspiration greater than 10 mm Hg.

(3) Kussmaul's sign - inspiratory increase of the JVP and cervical veins.

(4) X-ray may be helpful in demonstrating calcium in the pericardium.

c. Pericardial effusion may have very few clinical signs, especially if it has beer gradual in accumulation and has not caused hemodynamic changes by restriction of ventricular diastolic filling. The physical signs of pericardial effusion are:

(1) Quiet precordium with distant heart sounds.

(2) Marked increase in cardiac sullness, with dullness to the right of the sternum (Rotch's sign)

Multiple etiologies are also important to recognize when evaluating pericardial effusions but the most frequent ones are tuberculous, viral, neoplastic, uremic, or collagen vascular in origin. X-ray is quite helpful because the heart shadow (all water density) is very enlarged and globular. It is often symmetrically enlarged and water flask in shape. Treatment includes therapy of the underlying process and pericardial aspiration (pericardiocentesis) if hemodynamic changes occur or for diagnostic studies.

d. Cardiac tamponade is an acute medical emergency and combines the features of constrictive pericarditis and pericardial effusion. The etiology is that of sudden flu.d accumulation in the pericardial space with constriction and compression of the heart chambers - especially the ventricles. This results commonly from trauma - knife wounds, bullet wounds, ruptured aorta - with bleeding into the pericardium. It is also one of the mechanisms of sudden death in myocardial infarction secondary to ventricular rupture.

(1) Clinical signs are varied and the conditions surrounding the sudden vascular collapse tip you off to the possibility of tamponade:

(a) Clinical setting important - trauma, aortic dissection, several days post M.I. - especially if patient is in sinus rhythm.

(b) Cervical vein signs may be absent. Too sudden an appearance for systemic venous congestion.

(c) Quiet precordium with distant heart sounds.

(d) Marked fall in arterial B.P. and quite possibly shock.

(2) The therapy is two-fold, aspirate the pericardium and stop the bleeding. By leaving a tube in the pericardium blood cannot accumulate and although bleeding persists, pericardial tamponade is prevented.

3. Myocardial Disease. Primary myocardial disease or myocardiopathy is a nonspecific term used to generate the concept that the main problem is one of mycardial dysfunction becasue of intrinsic disease of heart muscle itself. It is unlike valvular heart disease where pressure and/or volume changes impose a burden on the myocardium because it is called upon to function at a higher level than it can sustain without failing. It is also distinct from coronary artery disease in which the basic problem is poor perfusion of the myocardium because of a disease process which is extramural in nature. Primary myocardial disease is a diffuse disease involving all four chambers of the heart in such

72

a manner that the distensibility characteristics of the chambers are altered. There are three broad categories the myocardial disease falls into obstructive, congestive, and infiltrative.

a. Obstructive cardiomyopathy is included in the classification of primary myocardial disease because the ventricular myocardial hypertrophy is the initiating change responsible for hemodynamic alterations. As previously discussed, IHSS is disproportionate septal hypertrophy causing obstruction to left ventricular emptying. Therefore, it imposes a pressure load on the left ventricle and all of the physiologic correlates that implies. Because of marked septal hypertrophy, the right ventricular outflow tract may also become obstructed, imposing a pressure gradient on the right ventricle, with all its physiologic correlates (Burnheim syndrome).

b. Congestive cardiomyopathy implies that because of the basic disease process involving the myocardium, the ventricular muscle has become nondistensible, compensation via the Starling mechanism has been exceeded and failure has ensued - usually biventricular failure.

(1) The physiology is that of combined ventricular failure with both pulmonary venous and systemic venous congestion. Because of biventricular failure, there then is a tendency to peripheral venous stasis and venous disease with consequent deep vein thrombosis and pulmonary emboli. Because the underlying process involves all chambers, including the atria, patients are prone to atrial arrhythmias, especially atrial fibrillation. With the loss of mechanical atrial contraction, stasis can develop with consequent atrial thrombi. Right atrial thrombus can lead to pulmonary emboli, while left atrial thrombus can lead to systemic emboli.

(2) Clinical findings in patients with primary myocardial disease of the congestive variety are those seen with any etiology of biventricular failure. The diagnosis is suggested in a patient with biventricular failure who does not have valvular heart disease or coronary artery disease. Sometimes this is not an easy distinction, especially seeing the patient for the first time, because the murmurs of mitral regurgitation and/or tricuspid regurgitation may be present due to ventricular dilatation. One of the more difficult differential diagnoses to make is that between PMD and coronary artery disease without clinical angina.

(3) The etiology of congestive myocardiopathy or primary myocardial disease is often quite difficult, if not impossible, to ascertain. There are many specific causes of PMD and it is most important to try and search out the inciting process so that specific therapy can be instituted.

(4) The general therapy of congestive PMD includes rest and the usual treatments of salt restriction, digitalis, and diuretics for CHF. If arrythmia is present, it should be treated and anticoagulants used for pulmonary or systemic emboli. Sometimes the anti-inflammatory effects of steriods are very helpful if there is an active, noninfectious, myocarditis.

c. Infiltrative myocardiopathy causes physiologic impairment by replacing myocardial cells with foreign substance. The common mechanism for all of these disease-causing problems revolves around the marked loss of normal distensibility of the cardiac chambers. In addition many of these processes involve the conduction system in such a manner as to cause marked conduction disturbances and high degree A-V blocks. Unfortunately, most of the infiltrative diseases are not amneiable to curative therapy but steriods are very effective in sarcoidosis and chemotherapy may be very effective in neoplastic infiltrative myocardiopathy.

73

ETIOLOGIC CLASSIFICATION OF ACUTE PERICARDITIS

1. Acute idiopathic or nonspecific
2. Specific infections:
   a. Bacterial (staphylococcal, meningococcal, streptococcal, pneumococcal, gonococcal)
   b. Fungal (histoplasmosis, actinomycosis, nocardiosis, toxoplasmosis)
   c. Viral (Coxsackie B, influenza, ECHO)
   d. Tuberculosis
   e. Miscellaneous (syphilitic gummatous pericarditis, parasitic disease, especially Echinococcus and Cysticercus)
3. Connective Tissue Disease - rheumatoid disease, rheumatic fever, Systemic Lupus Erythematosus, scleroderma, periarteritis nodosa.
4. Uremic Pericarditis
5. Primary or metastatic neoplasm including lymphoma, leukemia, melanoma
6. Post radiation pericarditis
7. Acute myocardial infarction
8. Post myocardial infarction syndrome
9. Post thoractomy syndrome
10. Trauma - penetrating or nonpenetrating
11. Aortic aneurysm - rupture of dissecting or nondissecting aneurysm into the pericardiac space
12. Drug associated - Hydralazine, Procaine amide, Isonizid

PRIMARY MYOCARDIAL DISEASE

Etiology

1. Idiopathic (unknown etiology)
2. Specific etiology
   a. Infectious (viral, bacterial, mycotic, parasitic, protozoal, rickettsial)
   b. Metabolic (hyperthyroid, hypothyroid, pheochromocytoma, nutritional, electrolyte imbalance, anemia)
   c. Toxic (emetine, carbon tetrachloride, bacterial toxins, others)
   d. Infiltrative (malignancy, sarcoid, hemachromatosis, amyloidosis, glycogen-storage disease)
   e. Collagen diseases
   f. Neuromuscular disorders (progressive muscular dystrophy, dystrophia myotonia, Friedreich's ataxia)
   g. Pregnancy and postpartum state
   h. Congenital or familial myocardial disease
   i. Miscellaneous - endocardial fibroelastosis, endomyocardial fibrosis, alcoholic myocardiopathy, hypertrophic muscular outflow, tract obstruction (obstructive cardiomyopathy), hypersensitivity, traumatic myocardial injury

DIFFERENTIATING FEATURES OF PRIMARY MYOCARDIAL DISEASE AND ARTERIOSCLEROTIC HEART DISEASE

Features	Primary Myocardial Disease	Arteriosclerotic Heart Disease
Age	Any age	Over 40
Sex	Equal	Predominantly males
Angina pectoris	Occasional	Frequent
Angina pectoris without CHF	Rare	Frequent
EKG infarction pattern	Occasional	Frequent
Infarction pattern with normal or slightly enlarged heart	Rare	Frequent

120

TREATMENT OF PRIMARY MYOCARDIAL DISEASE

1. Rest

2. Usual treatment for congestive heart failure

   a. Sodium restriction

   b. Digitalis

   c. Diuretics

3. Treatment for arrhythmia

4. Anticoagulants for pulmonary or peripheral emboli

5. Steriods

10-6 76

Department of Medicine
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HANDOUT 3ALR91630-I-3b
February 1976

CONGENITAL CARDIOVASCULAR DISEASE

1. The common congenital abnormalities of the great arteries.

   a. Patent ductus arteriosus (PDA)

      (1) The ductus arteriosus is a vessel in the fetus which shunts blood from the right side of the circulation (pulmonary artery) to the left side of the circulation (aorta) below the 3 great vessels of the arch.

      ( ) Normally, the ductus arteriosus begins to close soon after birth and is completely closed within a few weeks or months.

      (3) If the ductus is open past 3 months after birth it is know as a patent ductus arteriosus.

      (4) The ductus not being closed allows for a left to right shunt of blood. Aorta → pulmonary artery.

      (5) Therefore, there is increased blood flow through the lungs, left atrium, and left ventricle.

      (6) This results in increase in size of the left heart to accommodate the increased blood flow - volume hypertrophy.

      (7) The high pressure blood from the aorta reaching the low pressure pulmonary artery may lead to pulmonary hypertension.

      (8) Pulmonary hypertension causes hypertrophy of the right ventricle - a pressure hypertrophy.

      (9) Eventually, there may be a reversal of the direction of shunt from. L → R to R → L

      (10) At this point venous (unoxygenated) blood enters the arterial system causing cyanosis.

This supersedes SG 3ALR91630-I-3b, August 1973.

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b. Coarctation of the aorta

(1) Coarctation is a narrowing of the aorta.

(2) The area of importance is that of the left subclavian artery origin and the entrance of the ductus arteriosus.

(3) There are several types of coarctation:

(a) Fetal

(b) Transitional

(c) Adult - only type to be discussed here.

(4) Adult coarctation

(a) The point of narrowing is just proximal, at, or just distal to the ductus arteriosus.

(b) The ductus arteriosus may also be patent.

(c) Increased pressure in the segment of aorta proximal to the coarctation. There is hypotension distal to the coarctation.

(d) There is pressure hypertrophy of the left ventricle and sometimes also left atrium.

(e) Also, collateral blood flow by multiple anastomoses brings blood to the lower portion of the body via intercostal arteries, internal mammary arteries, and dorsal scapular arteries.

2. Common congenital abnormalities of the heart

a. Atrial septal defect. (ASD)

(1) At times there may be a defect or hole in the septum between the atria.

(2) There are three types of atrial septal defect related to the embryologic development of the heart. Only one will be discussed.

(3) ASD, fossa ovalis type.

(a) The shunt is left to right, i.e., left atrium to right atrium. This is because pressure in the left atrium is higher than in the right atrium.

(b) The right atrium and right ventricle show volume hypertrophy. There is enlargement (dilation) of the tricuspid and pulmonary valves and the pulmonary trunk.

(c) The left atrium and left ventricle may be smaller than normal, as may be the mitral and aortic valve orifices.

(d) Reversal of flow, i.e., right to left shunting is very uncommon.

b. Ventricular Septal Defect (VSD)

(1) Defects may occur anywhere in the interventricular septum but there is a predilection for the subaortic area.

(2) Many of the defects are in the subaortic area are in the membranous portion of the septum.

(3) Some defects are in the muscular portion of the septum.

(4) These begin as left to right shunts.

(5) Volume hypertrophy of the right ventricle, pressure hypertrophy of the right atrium, volume hypertrophy of the left atrium and left ventricle are present.

(6) Enlargement of the pulmonic and mitral orifices.

(7) There is frequently a reversal of the shunt to right to left as the right ventricle becomes very hypertrophic.

c. Aortic Stenosis

(1) There are three types:

(a) Valvular

(b) Subvalvular

(c) Supravalvular

(d) Several varieties of each of these types

(2) Without considering the types or their varieties - we will consider the affect produced by all of them.

(3) Pressure hypertrophy of the left ventricle.

d. Pulmonary stenosis

(1) Two types

(a) Valvular - most common

(b) Subvalvular - uncommon

(2) Pressure hypertrophy of the right ventricle.

(3) Often poststenotic dilitation of the pulmonary trunk.

(4) Here we are of necessity only discussing a valve which through stenotic allows enough blood flow to the left side to maintain life.

3. Common congenital anomalies of the great vessels and heart combined.

a. Total anomalous pulmonary venous drainage

(1) Numerous forms - here we will only consider the direct form without pulmonary venous obstruction.

(2) In this anomaly all the pulmonary veins enter the right atrium. The veins actually enter a pouchlike structure which then enters the right atrium.

(3) There is always an atrial septal defect of the fossa ovalis type with a right to left shunt.

(4) Pulmonary hypertension is usually found.

(5) Pressure and volume hypertrophy of right atrium and right ventricle.

(6) Enlargement of the tricuspid and pulmonary orifices and pulmonary trunk.

(7) The left atrium is small. The left ventricle may be normal or small.

b. Transposition of the arterial trunks.

(1) There are 4 basic common forms of transposition:

(a) Complete transposition

(b) Partial transposition with pulmonary stenosis

(c) Taussig-Bing complex

(d) Tetralogy of Fallot

(2) Transposition is an anomaly in which the aorta is abnormally placed with respect to the pulmonary trunk.

(3) Only the complete transposition and tetralogy of Fallot will be discussed here.

(4) Complete transposition

(a) The aorta emerges from the right ventricle

(b) The pulmonary trunk emerges from the left ventricle

(c) There must be and are various shunts available. VSD, ASD and patent ductus arteriosus are the usual shunts.

(d) An ASD if present is usually left to right

(e) PDA and VSD are variable in direction of shunting

(f) Pressure hypertrophy of the right atrium and right ventricle.

(g) May be volume hype-trophy of the left side.

c. Tetralogy of Fallot

(1) The tetralogy is

(a) Pulmonary stenosis

(b) Right ventricular hypertrophy

(c) Ventricular septal defect

(d) Overriding aorta

(2) The pulmonary stenosis is in the infundibulum and may also be in the valve.

(3) The overriding aorta refers to the aorta straddling the interventricular septum over a defect in the septum. The aorta actually emerges from both ventricles. The pulmonary trunk emerges from both ventricles. The pulmonary trunk emerges from the right ventricle.

(4) There are two types of complexes - a cyanotic type and an acyanotic type. The e types depend on the degree of pulmonic stenosis and size of the VSD.

(5) Cyanotic type

(a) Pulmonary stenosis is predominant

(b) Pressure hypertrophy of the right atrium and ventricle

(c) Decreased pulmonary blood flow

(d) Smaller than usual left atrium and ventricle

(e) A right-to-left shunt at the ventricular level

(6) Acyanotic type

(a) Pulmonary stenosis is relatively mild and the VSD predominates

(b) A left-to-right shunt at the ventricular level with increased pulmonary blood flow and increased volume on the left side.

82

(c) Pressure and volume hypertrophy of the right ventricle

(d) Pressure hypertrophy of the right atrium

(e) Volume hypertrophy of left atrium andvventricle

(f) Enlargement of mitral and aortic orifices

NOTES:

STUDY GUIDE AND WORKBOOK 3ABR90330-I-4

DEPARTMENT OF MEDICINE

RADIOLOGY SPECIALIST

BASIC ATOMIC THEORY

June 1975

SCHOOL OF HEALTH CARE SCIENCES, USAF
SHEPPARD AIR FORCE BASE, TEXAS

10-6

Designed For ATC Course Use

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84

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The PROGRAMMED TEXT (PT) presents information in planned steps with provisions for you to actively respond to each step. You are given immediate knowledge of the correctness of each response. PTs may either replace or augment SGs and WBs.

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Department of Medicine
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas

SW 3ABR90330-I-3
June 1975

BASIC ATOMIC THEORY

OBJECTIVES

a. Describe the structure of an atom.

b. Differentiate between a compound and a mixture.

c. Define the units of measurement of electric current.

d. Differentiate between an insulator, conductor, and semi-conductor.

e. Identify the heat, shock, and magnetic effects of electric current.

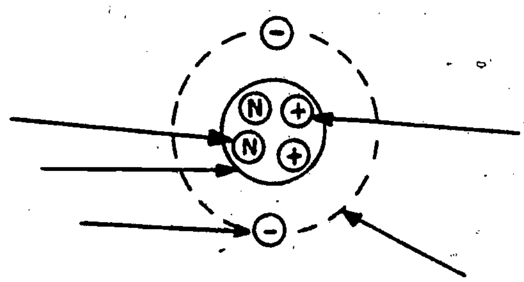
INTRODUCTION

This Study Guide/Workbook was prepared as part of a programmed lecture. Later in the course you will study, among other things, the interactions between atomic particles which result in the production of x-radiation; formation of an image on a radiographic film; radiation protection for patients and yourself. Basic atomic theory will assist you in understanding these and many other points.

INFORMATION

Exercise 1

1. Study the illustration below and identify the different parts of the atom.



This supersedes SW 3ABR90330-I-2, January 1974

2. Answer the questions below, True (T) or False (F).

_____ a. The structure of the atom is identical to the solar systems.

_____ b. The nucleus has a positive charge.

_____ c. Electrons are located within the nucleus of the atom.

_____ d. Electrons have a negative charge.

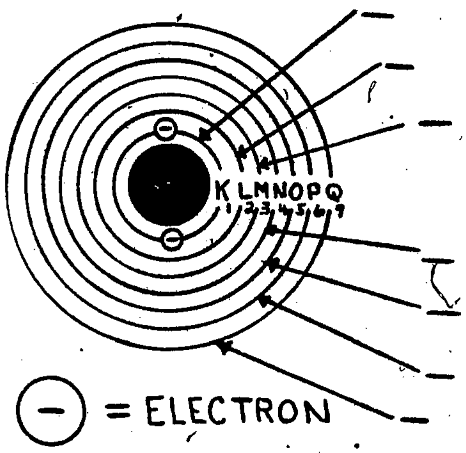
_____ e. Electrons revolve in fixed orbits around the nucleus of the atom.

_____ f. The nucleus is made up of protons and neutrons.

_____ g. Neutrons have a positive charge.

EXERCISE 2:

1. Study the illustration below and fill in the maximum number of electrons that each shell can hold.



2. Answer the questions below, True (T) or False (F).

_____ a. The hydrogen atom consists of 1 proton and 1 electron.

_____ b. The second shell on an atom is identified as the "L" shell.

_____ c. The maximum number of electrons in the next to the outermost shell is 8.

_____ d. The outermost shell is called the valence shell.

_____ e. The maximum number of electrons in the valence shell is 8.

EXERCISE 3:

1. Answer the questions below as, True (T) or False (F).

   _____ a. Unlike charges repel.

   _____ b. A neutral atom has an equal number of electrons and neutrons.

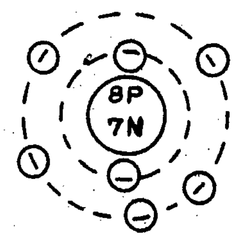
   _____ c. A positive ion has a surplus of electrons.

   _____ d. If an atom gains an electron it becomes a negative ion.

   _____ e. The number of protons in the nucleus of an atom determines its atomic number (Z).

   _____ f. The number of electrons and protons determines the atomic weight or mass (A) of an atom.

2. Study the illustration below, then answer the questions that follow.



   a. How many electrons are in this atom? __________

   b. Is this atom neutral? __________

   c. What is the atomic weight (A)? __________

   d. What is the atomic number (Z)? __________

   e. How many electrons are in the valence shell? __________

   f. Is this a negative or positive ion? __________

   g. Where is most of the weight of the atom? __________

EXERCISE 4:

1. Match each term in column A with the correct definition from column B.

A - Terms	B - Definitions
_____ a. Element	1. Anything which occupies space and has weight.
_____ b. Matter	2. A substance which is made up of the same kind of atoms.
_____ c. Atom	3. The smallest part of an element.

2. Answer the questions below, True (T) or False (F).

_____ a. The bones in the body are NOT made up of matter.

_____ b. All matter exists in a solid state.

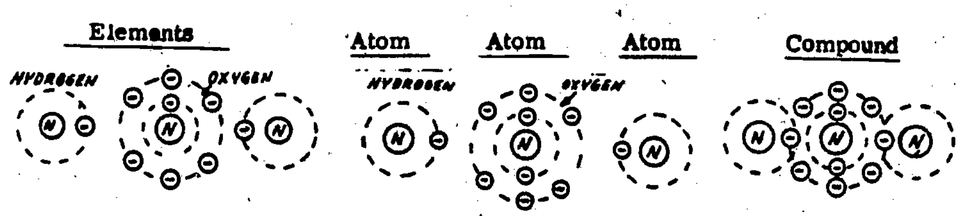
_____ c. Liquids are a form of matter.

_____ d. Matter made up from one type of atom is called an element.

_____ e. An element cannot be separated into different substances except by nuclear disintegration.

EXERCISE 5:

Study the illustration below and answer the questions, True (T) or False (F).



_____ a. A substance made up of one type of atom is called an element.

_____ b. One molecule of water is composed of 2 atoms of hydrogen and one atom of oxygen.

_____ c. Water is an element.

_____ d. An element is a combination of different atoms.

_____ e. A compound is composed of more than one element, chemically combined.

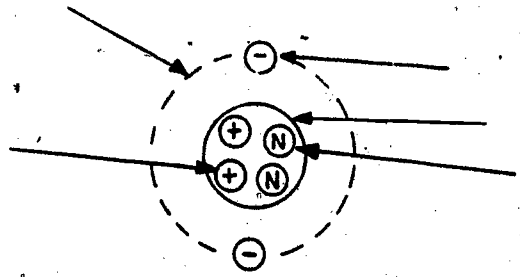
_____ f. A mixture can be separated into its elements by mechanical means.

_____ g. Water is an example of a compound.

_____ h. Sugar dissolved in water is an example of a mixture.

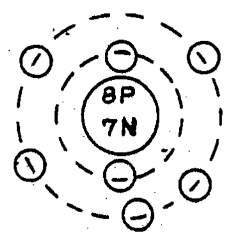
EXERCISE 6:

1. Study the illustration below and identify the different parts of the atom.



2. Study the illustration of the atom below. Then answer the questions that follow.

The "8P" and the "7N" represent the number of protons and neutrons in the nucleus.



a. How many shells are there in this atom? ____________________

b. The first shell is identified as the ____________________ shell.

c. The second shell is identified as the ____________________ shell.

d. Which shells are missing from this atom? ____________________

e. Does the number of protons in the nucleus equal the number of orbiting electrons? ____________________

f. Do the 7 neutrons have any effect on the electrical charge of the protons or the electrons? ____________________

g. Can the protons and neutrons be separated by ordinary means? __________

h. What particle of the atom rotates around the nucleus? __________

i. Where is most of the weight of the atom found? __________

j. Draw the symbol for a proton. ____________________

k. Draw the symbol for a neutron. ____________________

l. What particles are found in the nucleus? __________

m. What is the maximum number of electrons contained in the valence shell of any atom? ____________________

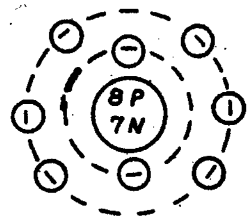
90

n. What is the atomic weight of an atom containing 8 neutrons, 9 protons, and 9 electrons? ____________________

o. What determines the atomic number of an atom? ____________________

____

3. Study the illustration below and answer the following questions, True (T) or False (F).



___ a. The atomic weight of this atom is eight (8).

___ b. The atom illustrated is a positive ion.

___ c. The "L" shell of this atom is called the valence shell.

___ d. The atomic number of this atom is 15.

4. Match each term in column A with the correct definition from column B.

A - Terms	B - Definitions
___ a. Element	1. The number of protons in the nucleus of an atom.
___ b. Matter	2. Anything that has weight and occupies space.
___ c. Compound	3. A substance composed of two or more elements.
___ d. Mixture	4. The number of protons and neutrons in the nucleus of an atom.
___ e. Molecule	5. A substance composed of two or more elements NOT chemically combined.
___ f. "Z" number	6. The smallest part of a compound that can be identified as that compound.
___ g. "A" number	7. A substance made up of one type of atom.

EXERCISE 7:

1. Answer the questions below, True (T) or False (F).

____ a. An atom must have 5 or more valence electrons to be considered chemically stable.

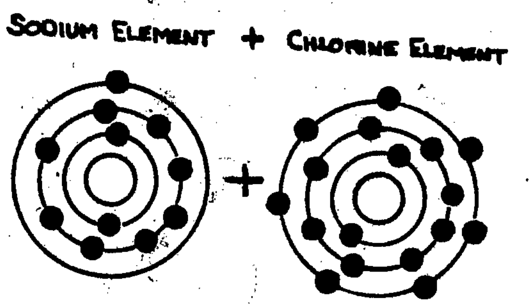
____ b. An atom with an atomic number of 2 must have 8 valence electrons in order to be considered chemically stable.

____ c. An atom with 8 valence electrons is chemically stable.

____ d. The maximum number of valence electrons cannot exceed 8.

____ e. Two unstable atoms can form a stable compound if the valence electrons add up to a total of 8.

2. Study the illustration below and answer the following questions, True (T) or False (F).



____ a. The atoms illustrated will readily combine to form a stable compound.

____ b. The "M" shell of the chlorine atom is called the valence shell.

____ c. The "L" shell of the sodium atom is called the valence shell.

EXERCISE 8:

1. Answer the questions below, True (T) or False (F).

____ a. Loosely bound electrons can easily become free electrons.

____ b. An atom that has 5 electrons in the valence shell gives up its electrons easily.

____ c. If the movement of free electrons is controlled by an outside force, an electric current is produced.

____ d. Electrons are attracted by positive polarity.

____ e. An electric current is caused by a chain of ionization.

____ f. An electron has a positive elemental charge.

____ g. It takes a very large number of elemental charges to make one coulomb.

____ h. One elemental charge is equal to one coulomb.

EXERCISE 9:

1. The definition of an electron current is the
   a. movement of electrical force through a conducting material.
   b. flow of water through a pipe.
   c. movement of free electrons through a conducting material.
   d. electromotive force within a material.

2. When we measure electrical current, we determine the
   a. strength of each electrical charge.
   b. flow rate of the current.
   c. charge that is carried by the electron.
   d. charge remaining on the proton.

3. When we measure current, the unit charge used to determine the flow rate per second is the
   a. coulomb.
   b. elemental charge.
   c. electron.
   d. proton.

4. The unit of measure for current flow is the
   a. elemental charge.
   b. proton.
   c. ampere.
   d. electron.

5. The movement of electrons through a conducting material is the result of
   a. the elemental charges.
   b. a difference of potential.
   c. two positively charged atoms.
   d. Two negatively charged atoms.

6. The pressure or force that causes current to flow is called
   a. the elemental charge.
   b. electromotive force.
   c. electron flow.
   d. a deficiency of electrons.

7. The unit of measurement for electromotive force is the

a. ampere.

b. coulomb.

c. volt.

d. ohm.

EXERCISE 10:

1. Study the table below and answer the questions on the following page, True (T) or False (F).

NOTE: The outermost shell of an atom is its valence shell.

ELECTRON STRUCTURE OF ATOMS

ATOMIC NUMBER	ATOM	SHELL 1	2	3	4	5
1	Hydrogen H	1				
2	Helium He	2				
3	Lithium Li	2	1			
4	Beryllium Be	2	2			
5	Boron B	2	3			
6	Carbon C	2	4			
7	Nitrogen N	2	5			
8	Oxygen O	2	6			
9	Fluorine F	2	7			
10	Neon Ne	2	8			
11	Sodium Na	2	8	1		
12	Magnesium Mg	2	8	2		
13	Aluminum Al	2	8	3		
14	Silicon Si	2	8	4		
15	Phosphorous P	2	8	5		
16	Sulphur S	2	8	6		
17	Chlorine Cl	2	8	7		
18	Argon A	2	8	8		
19	Potassium K	2	8	8	1	
20	Calcium Ca	2	8	8	2	
21	Scandium Sc	2	8	9	2	
22	Titanium Ti	2	8	10	2	
23	Vanadium V	2	8	11	2	
24	Chromium Cr	2	8	13	1	
25	Manganese Mn	2	8	13	2	
26	Iron Fe	2	8	14	2	
27	Cobalt Co	2	8	15	2	
28	Nickel Ni	2	8	16	2	
29	Copper Cu	2	8	18	1	
30	Zinc Zn	2	8	18	2	
31	Gallium Ga	2	8	18	3	
32	Germanium Ge	2	8	18	4	
33	Arsenic As	2	8	18	5	
34	Selenium Se	2	8	18	6	
35	Bromine Br	2	8	18	7	
36	Krypton Kr	2	8	18	8	
37	Rubidium Rb	2	8	18	8	1
38	Strontium Sr	2	8	18	8	2
39	Yttrium Y	2	8	18	9	2
40	Zirconium Zr	2	8	18	10	2
41	Niobium Nb	2	8	18	12	1
42	Molybdenum Mo	2	8	18	13	1
43	Techetium Te	2	8	18	14	1
44	Ruthenium Ru	2	8	18	15	1
45	Rhodium Rh	2	8	18	16	1
46	Palladium Pd	2	8	18	18	0
47	Silver Ag	2	8	18	18	1
48	Cadmium Cd	2	8	18	18	2
49	Indium In	2	8	18	18	3

ATOMIC NUMBER	ATOM	SHELL 1	2	3	4	5	6	7
50	Tin Sn	2	8	18	18	4	0	0
51	Antimony Sb	2	8	18	18	5		
52	Tellurium Te	2	8	18	18	6		
53	Iodine I	2	8	18	18	7		
54	Xenon Xe	2	8	18	18	8		
55	Cesium Cs	2	8	18	18	8	1	
56	Barium Ba	2	8	18	18	8	2	
57	Lanthanum La	2	8	18	18	9	2	
58	Cerium Ce	2	8	18	19	9	2	
59	Praseodymium Pr	2	8	18	20	9	2	
60	Neodymium Nd	2	8	18	21	9	2	
61	Promethium- Pm	2	8	18	22	9	2	
62	Samarium Sm	2	8	18	23	9	2	
63	Europium Eu	2	8	18	24	9	2	
64	Gadolinium Gd	2	8	18	25	9	2	
65	Terbium Tb	2	8	18	26	9	2	
66	Dyspresium Dy	2	8	18	27	9	2	
67	Holmium Ho	2	8	18	28	9	2	
68	Erbium Er	2	8	18	29	9	2	
69	Thulium Tm	2	8	18	30	9	2	
70	Ytterbium Yb	2	8	18	31	9	2	
71	Lutetium Lu	2	8	18	32	9	2	
72	Holmium Hf	2	8	18	32	10	2	
73	Tantalum Ta	2	8	18	32	11	2	
74	Tungsten W	2	8	18	32	12	2	
75	Rhenium Re	2	8	18	32	13	2	
76	Osimium Os	2	8	18	32	14	2	
77	Iridium Ir	2	8	18	32	15	2	
78	Platinum Pt	2	8	18	32	16	2	
79	Gold Au	2	8	18	32	18	1	
80	Mercury Hg	2	8	18	32	18	2	
81	Thallium Tl	2	8	18	32	18	3	
82	Lead Pb	2	8	18	32	18	4	
83	Bismuth Bi	2	8	18	32	18	5	
84	Polonium Po	2	8	18	32	18	6	
85	Astitine At	2	8	18	32	18	7	
86	Radon Rn	2	8	18	32	18	8	
87	Francium Fr	2	8	18	32	18	8	1
88	Radium Ra	2	8	18	32	18	8	2
89	Actinium Ac	2	8	18	32	18	9	2
90	Thorium Th	2	8	18	32	19	9	2
91	Protactinium Pa	2	8	18	32	20	9	2
92	Uranium U	2	8	18	32	21	9	2
93	Neptunium Np	2	8	18	32	22	9	2
94	Plutonium Pu	2	8	18	32	23	9	2
95	Americium Am	2	8	18	32	24	9	2
96	Curium Cm	2	8	18	32	25	9	2
97	Berkelium Bk	2	8	18	32	26	9	2
98	Californium Cf	2	8	18	32	27	9	2

94

___ a. Gold (atomic number 79) is a good conductor.

___ b. Lead (atomic number 82) is an insulator.

___ c. Molybdenum (atomic number 42) is a semiconductor.

___ d. Bromine (atomic number 35) is an insulator.

___ e. Tungsten (atomic number 74) is a better conductor than gold.

___ f. Carbon (atomic number 6) is a semiconductor.

___ g. Copper (atomic number 29) is a better conductor than tungsten.

EXERCISE 11:

1. The opposition to current flow in a conducting material is known as

   a. resistance.

   b. electromotive force.

   c. amperes.

   d. conductance.

2. The unit of measure for resistance is the

   a. volt.

   b. ampere.

   c. watt.

   d. ohm.

3. The four factors affecting the resistance of a material are the

   a. type of material, applied voltage, proton movement, and heat.

   b. length, chemical action, current, and insulation.

   c. electromotive force, temperature, cross-sectional area, and diameter.

   d. type of material, cross-sectional area, length, and temperature.

4. Match each term in column A with the appropriate definition in column B.

A - Terms	B - Definitions
___ a. Volt	1. A unit of measurement for electromotive force.
___ b. Ohm	2. A unit of measurement for current flow.
___ c. Amperes	3. A unit of measurement for resistance.
___ d. Conductor	4. A path through which electrons can move.
___ e. Resistance	5. Opposition to current flow.

5. Conductors are constructed from materials having

   a. tightly held valence electrons.

   b. a large number of atoms.

   c. high resistance.

   d. low resistance.

6. If the conductor has a low resistance it will have a large number of

   a. molecules.

   b. atoms.

   c. protons.

   d. free electrons.

7. Materials with extremely high resistance are used as

   a. insulators.

   b. conductors.

   c. fuses.

   d. ohms.

8. Materials having very few free electrons make good

   a. atoms.

   b. conductors.

   c. molecules.

   d. insulators.

EXERCISE 12:

1. Two effects of an electron current are

   a. heat and electromotive force.

   b. resistance and shock.

   c. heat and magnetism.

   d. magnetism and high resistance.

2. Complete the following statements.

   a. Electric light is made possible by the ______________ effect of an electron current.

   b. An electron current produces a ______________ ____________ around the conductor.

   c. Electrocution is caused by the ____________ effect of an ____________, ____________ through the body.

SUMMARY OF THE BASIC ATOMIC THEORY

Introduction. In order to discuss the fundamentals of x-ray production, interaction of x-rays with matter and radiation protection, we must first discuss the structure of matter. Many theories have been advanced but it was not until the beginning of the 19th century that Dalton, Avogadro and Prout laid the foundation of the atomic theory of matter. The work of Rutherford in 1911 and further development by Bohr in 1913 led to a concept which explains the structure and behavior of the atom satisfactorily. This concept is called the Rutherford-Bohr concept, or in short, Bohr's atomic theory.

Bohr's Theory. In 1913, a Danish physicist, Neils Bohr, advanced the theory that the structure of the atom resembles that of a miniature solar system. According to this theory, an atom consists of the central nucleus with a positive electrical charge and tiny, negatively charged particles, called electrons revolving around the nucleus in fixed orbits, in much the same way that planets revolve around the sun.

Structure Of The Atom. This includes the nucleus, proton, neutron, and electron.

NUCLEUS. The nucleus accounts for almost all of the weight and mass of the atom. It furnishes the force that causes other particles to spin around the nucleus. The nucleus contains protons and neutrons.

PROTON. The proton has a positive charge. Every atom must have at least one proton. On the atomic model, protons are represented by the symbol P or +

NEUTRON. Another particle found in most atoms is the neutron. It has approximately the same mass and weight as the proton but it has no electrical charge - it is neutral. The neutron is required to stabilize the atomic structure of the more complex atoms.

ELECTRON. The third particle of the atom is the electron. It has a negative electrical charge and it is represented by a circle with a minus sign − . The electron revolves about the nucleus in paths called shells, or energy levels.

Simple Atoms. Two simple atoms are the hydrogen atom and the helium atom.

HYDROGEN. The structure of the hydrogen atom is very simple - it consists of one proton in the nucleus and one electron in orbit around it. Since the two charges + − cancel out, the atom is electrically neutral.

HELIUM. The helium atom has two protons and two neutrons in its nucleus. The protons give the nucleus an electrical charge of + 2. Therefore, we need a charge of - 2 or two electrons orbiting around the nucleus to make this a balanced neutral atom. Since the neutrons have no charge, they do not affect the electrical balance of this atom.

Shells Or Energy Levels. The levels of energy surrounding the nucleus.

ELECTRONS PER SHELL. There is a limit to the number of electrons that a shell can hold. The maximum number held by the different shells are: K - 2; L - 8; M - 18; N - 32; O - 32; P - 18; Q - 8.

98

ADDITIONAL LIMITATIONS. Regardless of how many shells a particular atom has, the outermost shell can never exceed 8 electrons and the next to the outermost shell can never exceed 18 electrons.

VALENCE SHELL. The outermost shell of an atom is called the valence shell and the number of electrons in this shell determines the chemical stability and the electrical characteristics of that atom.

Static Electricity. One of the fundamental laws of electricity states that like charges repel and unlike charges attract. This law explains the bond that exists in the atom between the positively charged protons and the negatively charged orbiting electrons. Since the two particles, (electrons and protons) have unlike charges, they will be drawn toward each other until the positive charge exactly balances the negative charge. This balanced condition holds the electrons in the various orbits around the nucleus.

NEUTRAL ATOM. Under normal conditions the number of electrons in the orbital shells of an atom will be the same as the number of protons in the nucleus. Therefore, if the sum of the positive charges is equal to the sum of the negative charges, the atom will be electrically neutral.

ION. If the negative and positive charges within an atom are not equal, the atom becomes an ion. As an x-ray technician, you are very much concerned with ions, because the biological damage to the body, caused by x-rays, is due to ionization.

NEGATIVE ION. If a neutral atom gains an electron it becomes negatively charged. Since it has a surplus of electrons it is a negative ion.

POSITIVE ION. If a neutral atom looses an electron it becomes positively charged. Since it has more protons than electrons it is a positive ion.

Atomic Number. The number of protons or positive charges in the nucleus of an atom.

Atomic Weight (Mass Number). The total number of protons and neutrons in the nucleus of an atom.

Matter. Matter is anything that has weight and occupies space. The three states of matter are solid, liquid and gas. Certain types of matter can exist in all three states; for example, water, ice and steam represent the same matter in different states.

Element. Any substance that cannot be separated into different substances except by nuclear disintegration. It is made up of only one type of atom. The smallest part of an element is the atom. If you would break down gold to its smallest part, you would end up with one (1) atom of gold.

Compound. A compound is a substance composed of two or more elements chemically combined. Water is a combination of hydrogen and oxygen atoms.

Mixture. A mixture is made up of two or more elements NOT chemically combined. This means that the constituents of a mixture can be separated by machanical means. A mixture of iron shavings and sand could be separated by removing the iron particles with a magnet.

Molecule. The smallest part of a compound that still can be identified as that particular compound. One molecule of water (H_20) will consist of 2 atoms of hydrogen and one atom of oxygen. If you reduce this molecule any further, you would have the elements, hydrogen and oxygen.

Stable Atom. An atom is chemically stable if its valence shell is completely filled. An atom with only one shell will be stable if it contains two (2) electrons while all other valence shells require eight (8) electrons to be stable.

Unstable Atom. If the valence shell is not completely filled, the atom is chemically unstable. An atom that has its valence shell more than half full (5 or more electrons) tends to take on additional electrons and will refuse to give them up. If the valence shell is less than half full (3 or less electrons) the atom tends to give up electrons. The less valence electrons there are in the valence shell, the easier it is to free them.

Chemical Combinations. Two unstable atoms can form a stable compound if the valence electrons add up to a total of eight (8). Sodium with one (1) valence electron and chlorine with seven (7) valence electrons chemically combine to make the compound Sodium Chloride (table salt).

Electrical Characteristics. If an orbital electron is removed from an atom, it is called a free electron. The valence electrons of certain metals are so loosely bound to the nucleus that a small outside force can move the electrons from the atom. Even the small amount of energy created by room temperature can cause an electron to be removed from the atom and become a free electron. This free electron may move in any direction through the metal in search of a positively charged atom.

ELECTRIC CURRENT. If the movement of the free electrons is controlled by an external force we have an electric current. Since the electron has a negative charge it will be attracted to a positive charge. Therefore, if we place a positive potential on one end of a wire and a negative potential on the other end, electrons are repelled by the negative potential and attracted to the positive potential, constituting an electric current. Actually the electrons do not move from one end of the wire to the other end, but their effects move through a chain of ionization. Just imagine a row of closely spaced standing dominoes. If the first one falls, all of them will fall; therefore the effect of falling is passed from the first domino to the last one.

ELEMENTAL CHARGE. Now that we know that free electrons can be moved from point to point in a conducting material, there must be a unit of measurement. The charge of one electron is called one (1) negative elemental charge. The charge of one proton is called one (1) positive elemental charge.

COULOMB. The elemental charge is too small as a practical unit of measurement. The coulomb is the unit quantity, or unit charge. It takes 6,280 million billion elemental charges to make one coulomb. The coulomb does not specify whether the electrons are moving or static.

Ampere or Rate of Current Flow. The rate at which water flows through a pipe may be expressed as a certain number of gallons per second. In the same way, a current of electricity may be expressed as a certain quantity of charge flowing past a certain point in one second. If one coulomb of electrons flows past a given point each second, then we have a current of one <u>ampere</u>.

Potential Difference. Just as there must be pressure to cause the flow of water, there must be pressure to cause the flow of electrons. If we connect a wire between a point with an excessive number of electrons and another point with a deficiency of electrons we will have a potential difference resulting in a flow of electrons. The greater the difference in the number of electrons, the greater the electrical pressure and the resulting electron flow.

ELECTROMOTIVE FORCE (EMF). When two bodies have unequal charges, a difference of potential exists between them. This difference of potential causes an electron current. The force needed to move the electrons is called electromotive force (EMF).

VOLT. The unit of measurement for EMF is the volt. When the EMF of a battery is mentioned, it is referred to as having a certain number of volts. The same is true of a wall plug in your house. When we measure the EMF of the plug, we say that there are 110 volts available.

ELECTRICAL RESISTANCE

Introduction. Since an electric current is dependent on moving electrons, any collision with other electrons will tend to oppose the flow of current. In other words, when electrons are forced through a conducting material, there is a certain amount of opposition.

Resistance. The opposition to the flow of current is called resistance. The amount of resistance depends on the number of valence electrons that can be detached from the atoms and become free electrons.

INSULATOR. An atom is stable if its valence shell contains 8 electrons. Since this atom will not readily give up any of its electrons, this material would make an excellent electrical insulator. Substances made of atoms with 5 to 8 valence electrons are considered insulators. Since it would be easier to remove an electron from an atom having 5 valence electrons than from one having 6, 7 or 8, the quality of the insulating material depends on the number of valence electrons.

CONDUCTOR. Atoms which have one valence electron readily give up this electron. Substances made of atoms with 1 to 3 valence electrons are considered to be conductors of electricity. The best conductors are silver and copper having only one valence electron.

SEMICONDUCTOR. Atoms which have 4 valence electrons are neither good conductors nor good insulators. Semiconductor materials are used in solid state devices such as transistors and silicon diodes.

OHM. The unit of measurement for resistance is the ohm. We have 1 ohm of resistance if an EMF of 1 volt produces a current of 1 ampere.

LENGTH OF CONDUCTOR. The longer the conducting material, the higher the resistance. This resistance to moving electrons depends on the number of collisions with other electrons and atoms. If a conductor 1 foot long has a resistance of 5 ohms, then a conductor 2 feet long would have a resistance of 10 ohms.

DIAMETER OF CONDUCTOR. If the cross-section or diameter of a conductor is increased, the resistance of the conductor decreases. If a conductor 1 foot long and 1/4 inch in diameter has a resistance of 10 ohms, then a conductor made of the same material, 1 foot long but 1/2 inch in diameter would have a 2.5 ohm resistance. The larger the cross-sectional area, the larger the space for the electrons to move and, therefore, there will be less collisions which reduces the resistance.

TEMPERATURE. The temperature of a conductor will affect its resistance. However, this type of resistance is of no importance to you at this time, therefore, we will not discuss it in detail.

Effects of Current Flow. In our modern-day life, it would be rather difficult to get along without electricity. Although we cannot see electricity, its effects can be felt and seen. You will be primarily concerned with the effects of heat, shock, and magnetism; therefore, we will limit our discussion to these areas.

HEAT EFFECT. The opposition to the movement of electrons within a material results in the production of heat. The heat produced by a given amount of current depends on the resistance of the conducting material. Since there is more opposition when the resistance is high it becomes obvious that more heat is produced in a high resistive material than in one having a low resistance.

FILAMENTS. The filaments of light bulbs are usually made from tungsten. Tungsten has two valence electrons and is therefore classified as a conductor. However, by reducing the diameter of tungsten wire, its resistance becomes relatively high. With the proper amount of current the filament can then be heated to a white hot condition to give off light.

ELECTRICAL FIRES. Even good conductors have some resistance. If the current through a conductor exceeds the maximum value for which it was designed it will become red-hot and cause an electrical fire.

MAGNETIC EFFECT. When current flows through a wire, a circular magnetic field is set up around the wire. The direction and strength of the magnetic field is determined by the direction and strength of the current. We will discuss the importance of this magnetic field in detail in a later lesson.

SHOCK EFFECT. This very undesirable effect is caused by the passage of current through the body or a portion of the body. The results are burns and a paralizing effect on the heart and chest muscles. A current of only a small fraction of an ampere can be fatal.

PREPARE THE MAN PROGRAMMED TEXT 3ALR91630-I-4(2) 102

Department of Medicine
School of Health Care Sciences

CARDIOPULMONARY LABORATORY SPECIALIST

PHYSICS - WORK, POWER AND ENERGY
(Mechanical)

July 1973

10-6

Sheppard Air Force Base, Texas

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by
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Designed For ATC Course Use

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ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by page)	REVIEW QUESTIONS (by No)

WORK, POWER AND ENERGY

(MECHANICAL)

OBJECTIVES:

1. Define potential energy.
2. Define kinetic energy.
3. State the formula for work.
4. Solve for work when given values of force and distance.
5. Define mechanical power
6. Define mechanical horsepower.
7. Solve for power in terms of horsepower when given work and time.

SUGGESTED READING TIME 50 MINUTES

Formulae for Work, Power and Energy

PART (A)

1. Work = force x distance

2. Power = $\frac{\text{work}}{\text{time}}$

3. Mechanical power = $\frac{\text{work (ft. lbs.)}}{\text{time}}$

4. Mechanical horsepower = 550 foot-pounds per second

2A

You should understand, by now, that as technicians, we make a point of specifically defining all terms that we use. This is very necessary, because we use so many technical terms in explaining our work. With a good working knowledge of such terms as energy, work, power, emf, current, and resistance, you will be far more savvy about your work. Too, you will want to be sure, so that you can shoot the breeze about your job. Knowing exactly what certain words mean helps a lot.

You often hear the word "energy". But, you use energy far more often than you hear the word. When you lift something, you use energy. Every time you move, you use energy.

Energy is defined by Webster as "The capacity for doing work and overcoming resistance."

Is a rock sitting on the edge of a cliff a source of energy?

Yes, it is. page 6A

No, it isn't. page 4A

2B

YOUR ANSWER: 27 foot-pounds.

No, that is not correct.

The correct formula for solving how much work has been done is this: Work = force x distance.

With this in mind, return to page 4B and solve for the correct answer.

3A

YOUR ANSWER: Kinetic energy.

Not quite right. A pendulum does possess kinetic energy, but only while it is moving. It has potential energy as it rests momentarily at the end of its swing.

As you pull the bob to one side, you are storing potential energy by lifting the bob against gravity. As the bob swings downward and forward, the potential energy becomes kinetic. The kinetic energy released is sufficient to carry the bob upward again on the opposite side, thus storing up more potential energy.

Refer to figures 1 and 2 below.

Figure 1 Potential or stored energy.

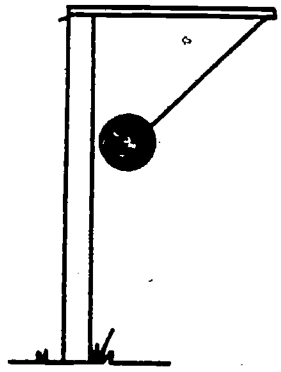
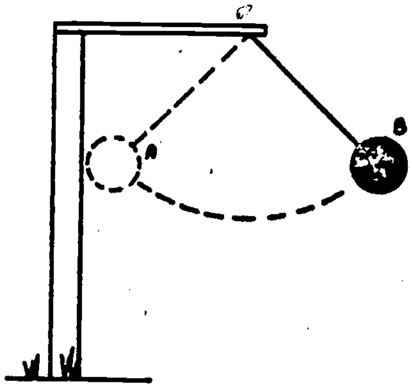
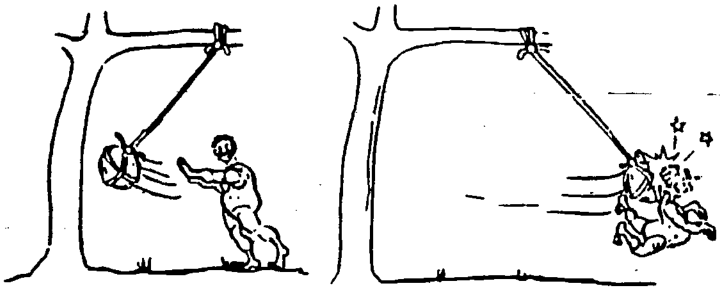


Figure 2





As the pendulum swings, the potential energy becomes kinetic energy, but at point "A" the kinetic energy is changed back to potential energy. As it swings back toward point "B", the potential energy again becomes kinetic energy.

Return to page 6A and select the correct answer.

4A

YOUR ANSWER: No, it isn't.

Wrong. A rock sitting on the edge of a cliff would have what we call "energy of position." It is energy waiting to happen, or it is a form of potential energy. Move one small grain of sand, and the rock would start tumbling down the cliff, perhaps even starting an avalanche.

We have already defined energy as the capacity to do work. Flowing water has energy because the pull of gravity has given it velocity. Wind is a similar example. Waves and tides, too, have energy. A motionless body has the capacity to do work; all we have to do is put it in motion, or give it velocity.

In our example, work was done when we moved the grain of sand, not very much perhaps, but enough to give the rock velocity as it tumbled down the cliff.

Now, return to page 2A and select the correct answer.

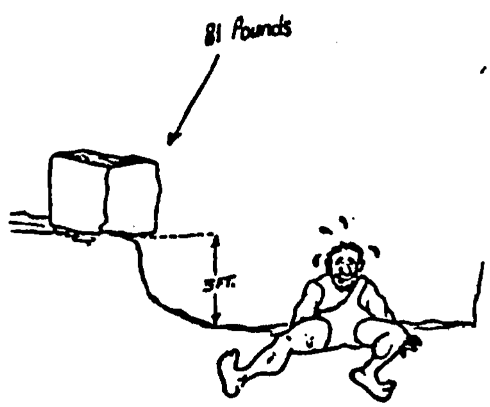
4B

YOUR ANSWER: 800 foot-pounds.

Very good. Now, let's try another problem of the same type.

A man is required to lift an 81-pound crate onto a loading dock, which is 3 ft. high. How much work did this man do?

27 foot-pounds	page 2B
243 foot-pounds	page 11A



5A

YOUR ANSWER: Yes.

Come, come now. Our definition of work was a force acting through a distance. True, you exerted a force on the bulkhead, but chances are you did not move the bulkhead through a distance or space.

Keep this in mind: To do work, you must exert a force on an object and the object must be moved a distance.

Now, return to page 10A and select the correct answer.

5B

YOUR ANSWER: 50 foot-pounds.

Wrong.

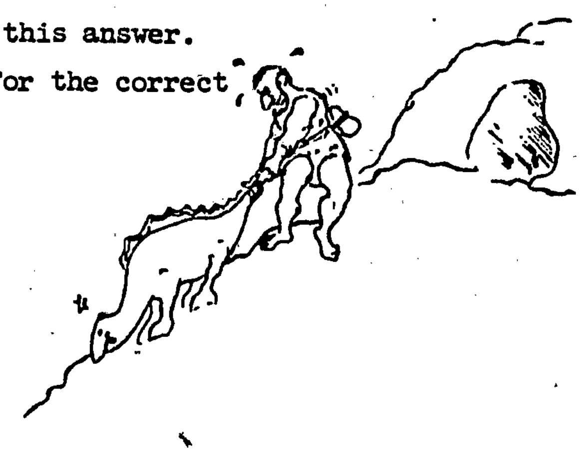
The formula for work is:

Work = force x distance or in short form.

W = f x d.

You must have divided to get this answer.

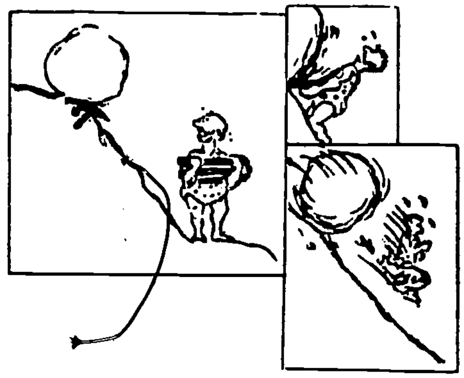
Return to page 7A and solve for the correct answer.



6A

YOUR ANSWER: Yes, it is.

Of course it is. This type of energy is known as potential energy. Just as we have potential energy in an automobile battery, the energy is stored until we put it in our car and hook it up.



We have two types of energy that we will discuss in this lesson. The first is kinetic energy, which is defined as energy in motion. For instance, a moving automobile, running water or current flow; these are all good examples of kinetic energy. The other type of energy is potential energy, which is defined as stored energy or energy of position. Our storage battery is a good example of stored energy. The rock on the edge of the cliff would be an example of energy of position.

It is possible to change potential energy to kinetic energy; also, it is possible to change kinetic energy to potential energy.

A pendulum would be a source of what type of energy?

Kinetic.	page 3A
Potential.	page 8A
Both of the above.	page 10A

7A

YOUR ANSWER: No.

Of course not. The definition said "a force acting through a distance." If you moved that steel bulkhead, you are a lot stronger than I had thought.

Before we get to the formula for solving the amount of work done, let's take a quick look at the word "force". Force is that which produces or tends to produce motion.

Note that work and force are quite different. Force is exerted whenever a body is pushed or pulled, but work is done only if that body moves.

The formula for solving how much work has been done is this:

Work = force x distance and is expressed in foot-pounds.

The force exerted to lift an object is exactly equal to the weight of the object. For example: If you lifted a 200-pound weight, you would have exerted a force of 200 pounds on the weight.

Work is measured in foot-pounds, because we are multiplying together two different quantities, distance (in feet) and force (in pounds). Thus: feet (distance) x pounds (force) = foot-pounds.

Now, suppose that you were required to lift a 200-pound shell to a shelf 4 feet high, how much work would you have to do?

800 foot-pounds. page 4B

50 foot-pounds. page 5B

I don't know. page 9A

 113

8A

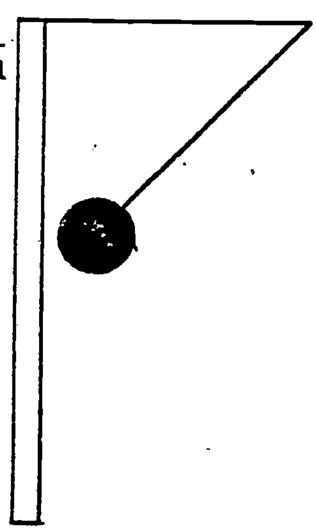
YOUR ANSWER: Potential energy.

Yes, this is true, but you missed half the picture. The pendulum possesses potential energy only as long as you are holding it to one side.

We have defined potential energy as stored energy, or energy of position. In the case of our pendulum, when you pull the pendulum bob to one side, you are storing potential energy by lifting the bob against the pull of gravity. As the bob swings downward and forward, the potential energy becomes kinetic. The kinetic energy released is sufficient to carry the bob upward again on the opposite side, thus storing up more potential energy.

Refer to figures 1 and 2 below.

Figure 1
Potential or stored energy.



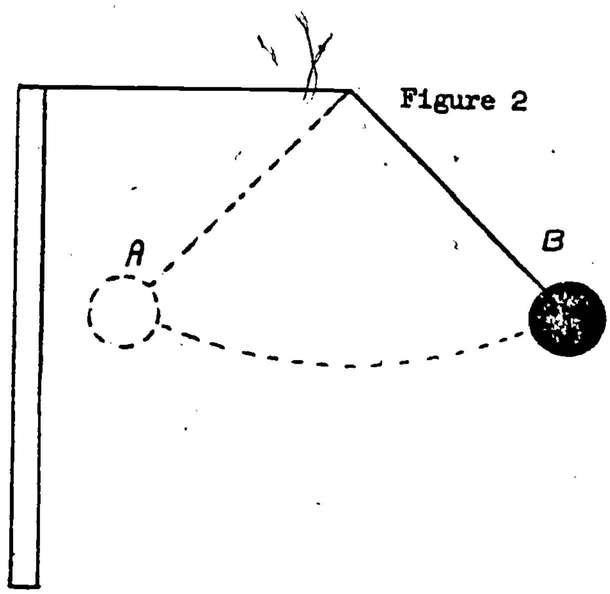


Figure 2

As the pendulum swings, the potential energy becomes kinetic energy, but at point "A" the kinetic energy is changed back to potential energy. As it swings back toward point "B", the potential energy again becomes kinetic energy.

Return to page 6A and select the more correct answer.

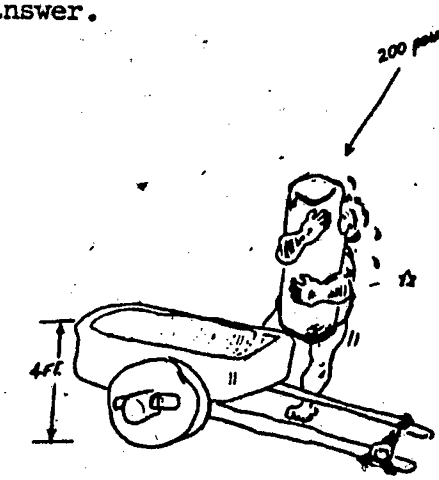
9A

YOUR ANSWER: I don't know.

My answer, to your answer, why not? We have stated the formula for doing work. Work = force x distance and the product is expressed in foot-pounds.

Now, let's take a look at our problem. You were asked, how much work did you do, when you lifted a 200-pound shell to a shelf 4 feet high? Substituting these values into our formula it now looks like this:

Work = 200 x 4; in other words, you exerted a 200-pound force through a distance of four feet. Now, we should be able to return to page 7A and select the correct answer.



9B

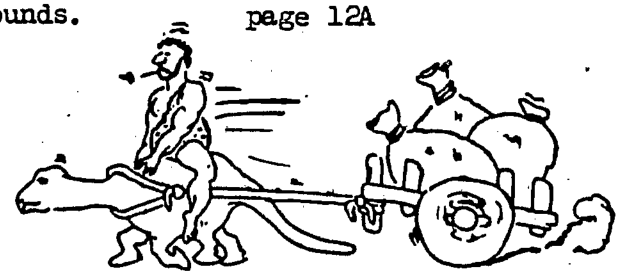
YOUR ANSWER: 300 feet.

Good. Just a little transposing of our original formula,

Work = force x distance.

Next problem. A man accomplishes 112,500 foot-pounds of work in moving an object 50 feet. How much did the object weigh?

2250 pounds.	page 11B
5,625,000 pounds.	page 12A



10A

YOUR ANSWER: Both the above.

Good for you. You can understand that by holding the pendulum to one side, you have stored potential energy. When you release the pendulum, starting energy to move, you have energy in motion or **kinetic** energy.

Energy has the ability to do work. Energy is expended when work is done.

So far, we have talked about the two types of energy. Kinetic energy, or energy in motion, and potential energy, or energy which is stored or at rest.

We could have all the energy in the world, but unless it accomplished something for us, it would be of little value. So, in electronics, we use the potential energy of a battery to make electrons move. This is kinetic energy, and with this type of kinetic energy, we can make neon bulbs light, T. V. sets operate, and radios play. We have energy doing work.

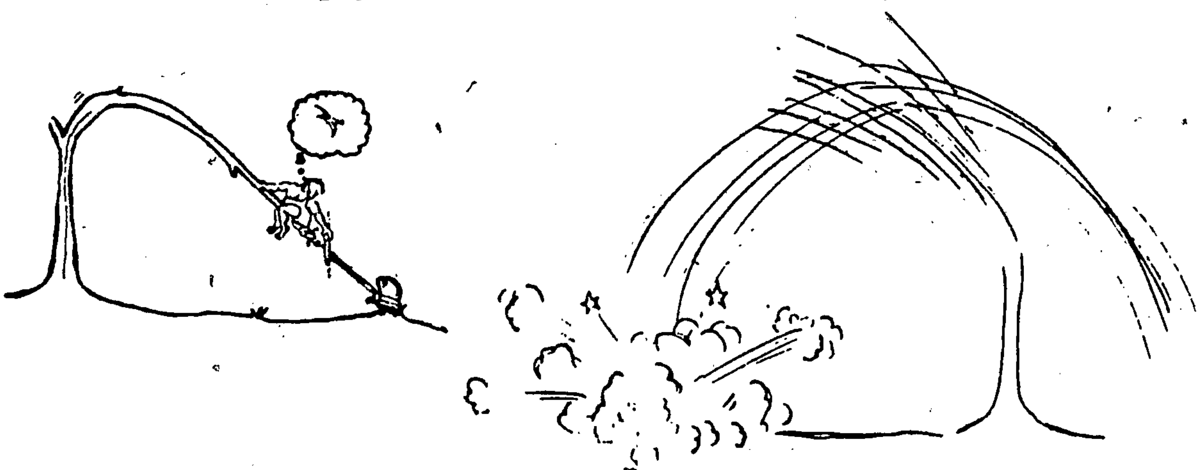
This brings us to our next topic for discussion, the word "ugh" work, and what it means to us in the field of electronics.

Work is defined as a force acting through a distance.

Now, with this definition firmly affixed in your mind, suppose you pushed against a steel bulkhead with all your strength; did you do work?

Yes. page 5A

No. page 7A



11A

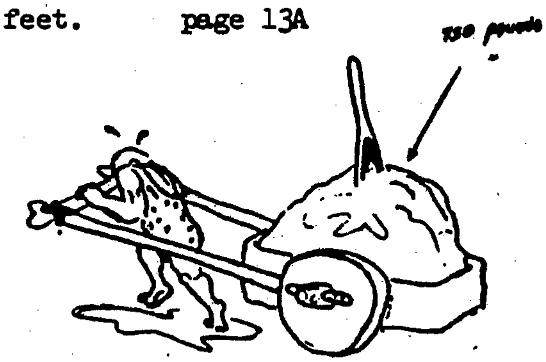
YOUR ANSWER: 243 foot-pounds.

You are right.

Now, let's give him a little more difficult job. The man is to move a pile of earth weighing 750 pounds. In moving this pile of earth, the man did 225,000 foot-pounds of work. How far did the man move the earth?

300 feet. page 9B

168,750,000 feet. page 13A



11B

YOUR ANSWER: 2250 pounds.

Correct. We are getting along just fine.

Suppose you were required to move 30 chairs, which weigh 11 pounds each, and a desk weighing 37 pounds to the next classroom, which is 46 feet away. How much work would you have to do?

15,180 foot-pounds. page 12B

1,702 foot-pounds. page 14A

16,882 foot-pounds. page 16A

12A

YOUR ANSWER: 5,625,000 pounds.

Not quite.

Our formula for work is: Work = force x distance. In our case, we were given the amount of work accomplished and the distance the object was moved. It would look like this:

$$112{,}500 \text{ (work)} = \text{force} \times 50 \text{ (distance)}$$

We must get the "force" to stand alone in our formula. So we divide both sides by the distance (50). Thus:

$$\frac{112{,}500}{50} = \text{force} \times \frac{50}{50}$$

The 50's on the right cancel and we end up with $\frac{112{,}500}{50}$ = force.

Now, return to page 9B and solve for the correct answer.

12B

YOUR ANSWER: 15,180 foot-pounds.

You are correct. As far as you have gone. But you forgot to take the desk into consideration.

So return to page 11B and solve for the correct answer. Don't forget the desk.

13A

YOUR ANSWER: 168,750,000 feet.

oooOOP's.

It looks like you made an error in your transposition of the original work formula.

To solve for work, we use the formula:

Work = force x distance.

In our case, we were given the amount of work accomplished and the force exerted to move the pile of earth. So it would look like this:

225,000 (work) = 750 (force) x distance.

We must get the distance to stand alone in the formula, so we divide both sides of the formula by 750. Thus:

$$\frac{225,000}{750} = \frac{750}{750} \text{ x distance}$$

The 750's on the right side cancel out and we end up with

$$\frac{225,000}{750} = \text{distance.}$$

Now, return to page 11A and solve for the correct answer.

13B

YOUR ANSWER: 36,000 foot-pounds per second.

No.

Your formula selection was very poor, or you did not check the formula page.

The formula for power again is:

$$\text{Power} = \frac{\text{work}}{\text{time}} \text{ not power = Work x time.}$$

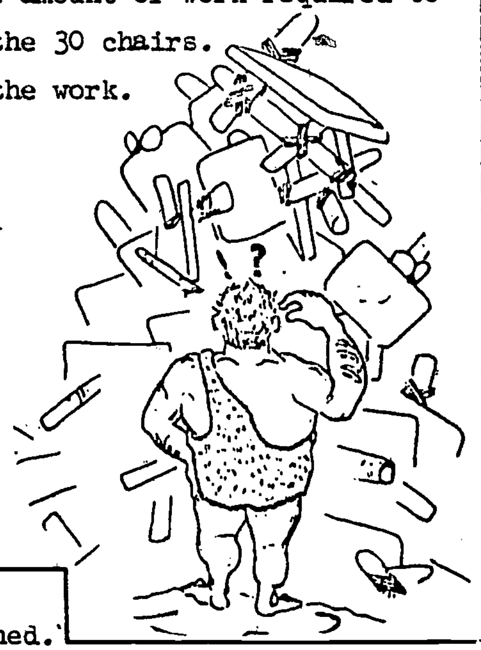
Now, return to page 17A and solve for the correct answer.

14A

YOUR ANSWER: 1,702 foot-pounds.

Partially correct. You solved for the amount of work required to move the desk. But you completely forgot the 30 chairs.

Return to page 11B and solve for all the work.



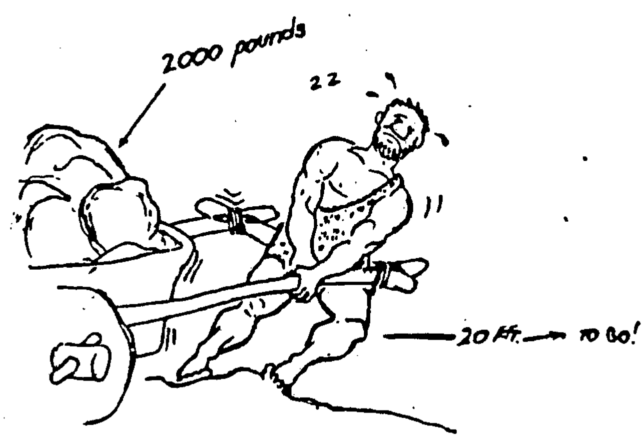
14B

YOUR ANSWER: The amount of work accomplished.

Again you are a little confused. We defined power as the time rate for doing work.

We could, for example, pull a 2000-pound object a distance of 20 feet, which would be 2000 x 20 or 40,000 foot-pounds of work; in other words, you accomplished 40,000 foot-pounds of work. But, if we never considered the time it took to pull this 2000-pound object through a distance of 20 feet, we would never know how much power we used.

Now, return to page 16A and select the correct answer.



15A

YOUR ANSWER: Less than.

Come now, how in the world did you ever become this confused? I can understand how you might have said that the work done by the steam shovel is greater than that done by the man, but not less than.

Let's look at our problem again: To raise 1000 pounds of earth to a height of 20 feet.

Work = force x distance = 1,000 x 20 = 20,000 foot-pounds.

So you see both the steam shovel and the man did the same amount of work, the only difference being that the steam shovel did this work much faster, and when we take the time factor into consideration, we are talking about power.

Let's return to page 18A and reconsider our answer.

15B

YOUR ANSWER: 1,780,200 foot-pounds per second.

Not even a good guess.

The formula for power is: Power = $\frac{\text{work}}{\text{time}}$.

You solved for work correctly, but you forgot to consider time, which is an important factor when solving for power.

Return to page 19A and solve for the correct answer. Don't forget the time.

16A

YOUR ANSWER: 16,882 foot-pounds.

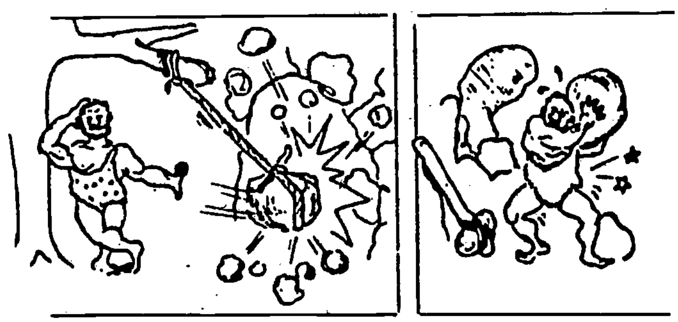
Very good.

The amount of work, then, is equal to the amount of force exerted on an object times the distance the object moved.

While it might be a nice thing to know how much work is to be done, it is of more interest to people as to HOW FAST the work will be accomplished. This brings in the element of TIME. One man might build a house in two months and another man build the same type of house in one year. Both have done the same amount of WORK, but which one would you hire? In electronics, we are always concerned with how much time it took to do a certain amount of work. The time rate for doing work is called POWER. Power, then, is:

The amount of work accomplished. page 14B

The rate of doing work. page 18A



16B

YOUR ANSWER: 5600 horsepower.

You are correct, as far as you have gone. You solved for power, but completely forgot to divide by the number of foot-pounds per second in one horsepower (550).

$$\text{Horsepower} = \frac{\text{foot-pounds per second}}{550} = \_\_\_\_\_\_\_\_\_\_ \text{ hp.}$$

Now, return to page 21A and solve for the correct answer.

17A

YOUR ANSWER: Equal to.

Right. They both moved the same amount of earth the same distance, so the work done was equal.

The formula for power once more is this:

$$\text{Power} = \frac{\text{work}}{\text{time}}$$

With the formula firmly in your mind, try this problem.

A steam shovel raised 5000 pounds of earth to a height of 12 feet in 6 seconds. How much power did the steam shovel use?

36,000 foot-pounds per second. page 13B

10,000 foot-pounds per second. page 19A

17B

YOUR ANSWER: 22,500 ft.-lbs per sec.

My goodness, no.

Remember that mechanical power is measured in foot-pounds per second (as we have covered it). You solved for power by dividing by minutes.

Return to page 19B and try again.

123

18A

YOUR ANSWER: The rate of doing work.

Exactly. You have learned that the amount of work done has nothing to do with the time it takes to do the work. But the amount of power depends on how fast that work can be done. The formula for work done again is:

Work = force x distance.

Now, let's look at the formula for power, which is:

$$\text{Power} = \frac{\text{work}}{\text{time}}.$$

We both know that a steam shovel has a great deal more power than a man. Both can do the same amount of work, but the steam shovel will do it a lot faster. For example, say that 1000 pounds of earth must be raised 20 feet. The work is:

Work = force x distance = 1000 x 20 = 20,000 foot-pounds.

The steam shovel does the job in one scoop, taking two seconds. The man does the job in twenty minutes (1200 seconds).

The steam shovel has:

$$\text{Power} = \frac{\text{work}}{\text{time}} = \frac{20{,}000}{2} = 10{,}000 \text{ foot-pounds per second power.}$$

The man has:

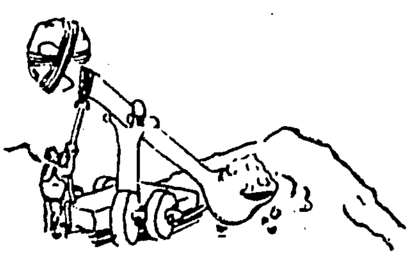
$$\text{Power} = \frac{\text{work}}{\text{time}} = \frac{20{,}000}{1200} = 16.7 \text{ foot-pounds per second power.}$$

The work done by the steam shovel is __________ __________ that done by the man.

Less than — page 15A

Equal to — page 17A

Greater than — page 20A



19A

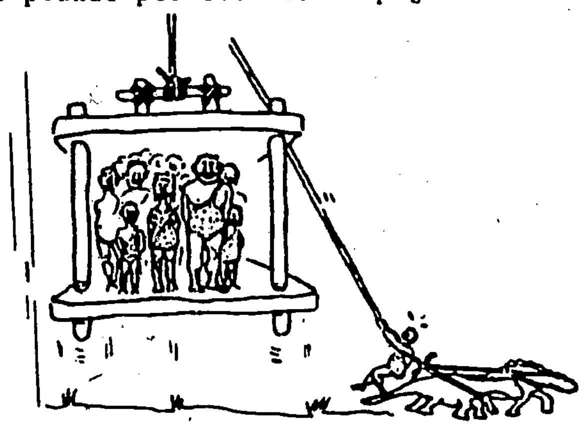
YOUR ANSWER: 10,000 foot-pounds per second. Good.

Let's look at another one.

An elevator in the Empire State Building makes the ascent to the 80th floor in 50 seconds. If the height is 989 feet, what power would be required in order to lift 12 persons averaging 150 pounds each to this floor?

1,780,200 foot-pounds per second. page 15B

35,604 foot-pounds per second. page 21A



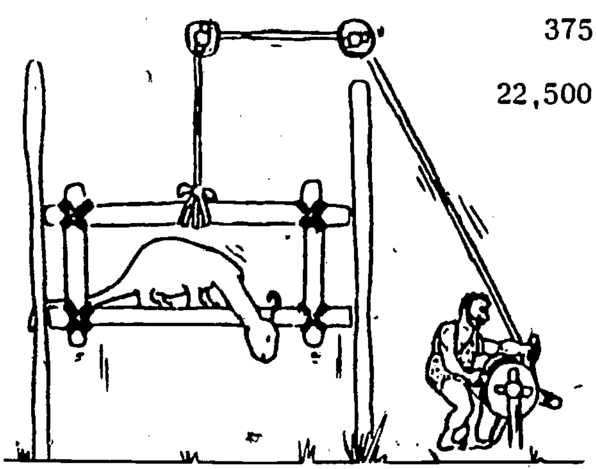
19B

YOUR ANSWER: 10 horsepower. Good, You are still with me.

An elevator in a garage can raise an automobile weighing 1500 pounds to a height of 30 feet in 2 minutes. What power is used?

375 ft.-lbs. per sec. page 20B

22,500 ft.-lbs. per sec. page 17B



20A

YOUR ANSWER: Greater than.

Maybe you didn't understand the question. So, let's start over again. Our problem was to raise 1000 pounds of earth 20 feet. The steam shovel accomplished this amount of work:

Work = force x distance = 1000 x 20 = 20,000 foot-pounds.

The man accomplished this amount of work:

Work = force x distance = 1000 x 20 = 20,000 foot-pounds.

The only difference between the work of the steam shovel and that of the man is the time factor, and when we consider the time rate of work, we are then talking about power.

Return to page 18A and select the correct answer.

20B

YOUR ANSWER: 375 foot-pounds per second.

Right you are.

Power, whether electrical or mechanical, pertains to the rate at which work is being done. Work is done whenever a force causes motion. If a mechanical force is used to lift or move a weight, work is done. However, force exerted without causing motion does not do work.

Would a spring compressed between two fixed objects be doing work?

Yes.	page 23B
No.	page 22A

21A

YOUR ANSWER: 35,604 foot-pounds per second.

Right.

This is a mechanical power, and as we have seen, it is measured in foot-pounds per second, which is too small for practical use. In the early days, power was generally supplied by horses, and experiments indicated that an average horse could do 550 foot-pounds of work per second. This led to the establishment of a larger unit of measurement; you guessed it, the horse-power (hp).

$$1 \text{ hp} = 550 \text{ foot-pounds per second.}$$

To solve for horsepower, we must first solve the amount of power in foot-pounds per second, then divide by 550 foot-pounds per second; the number of foot-pounds per second is one horsepower. For example, suppose we had an electric motor that could move a 2200-pound object 2 feet in 4 seconds. Our solution would look like this:

First, work = force x distance = 2200 x 2 = 4400 ft.-lbs.

Second, power $= \frac{\text{work}}{\text{time}} = \frac{4400}{4} = 1100$ ft.-lbs. per second.

Third, horsepower $= \frac{\text{foot-pounds per second}}{550 \text{ (foot-pounds per second(1 hp)}} = \frac{1100}{550} = 2$ hp.

Now, consider this problem.

An elevator with 6 passengers weighs 1400 pounds. How much horsepower would be required to raise the elevator 4 feet per second? ANSWER to the nearest whole horsepower.

10 horsepower.	page 19B
5600 horsepower.	page 16B

22A

YOUR ANSWER: No.

Quite right.

We have pretty well covered mechanical work, power, and energy. Before we go on to electrical power, let us review mechanical power and see just how much we have learned.

	1. The capacity to do work or overcome resistance is a definition of ______________.
energy	2. We said that energy in motion is __________ energy.
kinetic	3. Energy that is stored or energy of position is ______________ energy.
potential	4. There are two types of energy; list them. (a) ______________ (b) ______________.
potential kinetic	5. Energy is that which has the capacity to do work or overcome resistance. That which produces or tends to produce motion is a definition of ________
force	6. A force acting through a distance is the definition of ______________.
work	7. Work is equal to the product of a force acting through a ______________.
distance	8. The formula for solving how much work we have done is: Work = ____________ x ____________.

Continue on page 23A

23A force distance	9. We found that a steam shovel and a man could do the same amount of work. The steam shovel is much faster, however. When we consider the time rate for doing work, we are talking about ______________.
power	10. The time rate for doing work is a definition of________.
power	11. Power is equal to __________ divided by ______________.
work ÷ time	12. We found that power is measured in foot-pounds per second and a larger unit of measurement, the____________.
horsepower	13. One horsepower is equal to ____________ foot-pounds per second.
550	14. Power is the time rate for doing work. The formula for mechanical power is: Power = ______________________ divided by ____.
work ÷ time.	THE END

23B

YOUR ANSWER: Yes.

No.

A spring compressed between two fixed objects would be exerting a force on the objects. But chances are the spring is not moving the objects, and the force must cause motion, before work can be done.

Now, return to page 20B and select the correct answer.

REVIEW TEST FOR WORK, POWER, AND ENERGY

(Mechanical)

1. Write the definition of potential energy. ____________________

____

2. Write the definition of kinetic energy. ____________________

____

3. The formula for work is: work = ____________ x ____________.

4. How many foot-pounds of work are accomplished when lifting a 75-lb. transmitter onto a shop bench 3 feet high? ____________ ft.-lbs.

5. Mechanical power is equal to ____________ divided by ____________.

6. One mechanical horsepower is equal to ________ ft.-lbs. per second.

7. How much mechanical power is required for an elevator to lift a 20,000-pound aircraft 10 feet in 50 seconds?

   a. ____________ foot-pounds per second.

   b. ____________ horsepower.

8. A certain engine can move an 1100-pound object 2 feet in 2 seconds. What is the horsepower of this engine? ____________ horsepower.

9. Write the definition for power. ____________________

____

____

____

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Department of Medicine
School of Health Care Sciences

TECHNICAL TRAINING

CARDIOPULMONARY LABORATORY SPECIALIST

ELEMENTS OF PHYSICS - MATTER

July 1973

10-6

Sheppard Air Force Base, Texas

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Designed For ATC Course Use

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ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by page)	REVIEW QUESTIONS (by No)

ELEMENTS OF ELECTRICAL PHYSICS

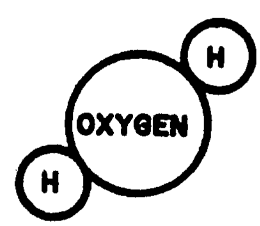
OBJECTIVES:

1. Define matter.
2. Define molecule.
3. Define an atom.
4. Define an element.
5. Define a compound.
6. Identify the 4 main parts of the atom and indicate the charge of each.
7. Calculate the atomic number of an atom when given specific conditions.
8. Figure a net charge given specified conditions.
9. Define valence electrons.
10. Describe electrical balance.
11. Describe the effects of electron excess and deficiency.
12. State the unit of electrical charge.
13. Define an ion.

SUGGESTED READING TIME 85 MINUTES

This lesson is on electrical physics. The material taught in this programmed lesson is essential material only. If you want to go deeper into the subjects taught and broaden your knowledge, you can do so on your own.

USE A FOLDED SHEET OF PAPER TO COVER THE ANSWER.

	1. All things which have weight and occupy space are matter. The pencil or pen you are writing with is classified as________________.
(Matter)	2. All things which have weight and occupy space are ______________.
(Matter)	3. A pencil or pen has__________and occupies________ so it is matter.
(Weight) (Space)	4. The smallest particle of any matter which has the properties of that matter is called a molecule. The smallest bit of glass that can be identified as glass is a glass______________.
(Molecule)	5. A water molecule is the________bit of water that can be identified as water.
(Smallest)	6. A drop of water is matter because it also has __________and occupies______________.
(Weight) (Space)	7. Molecules are made of atoms. This picture shows a water molecule with 3 atoms. This molecule has 2 hydrogen atoms and 1 oxygen______ 

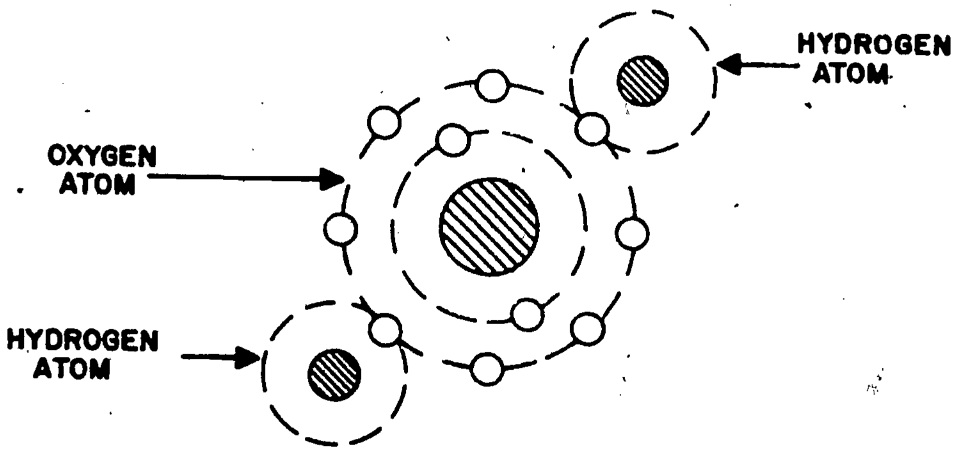
Continue on Page 3.

2A

YOUR ANSWER: The smallest particle to which matter can be broken down
(From P-7) is the molecule.

Wrong. You have been working with the basic building block of matter. It had electrons orbiting around a nucleus. I'm sure you recall now, that the atom is the smallest particle to which matter can be broken down. But before we go any further, let's get straight what a molecule is.

Atoms combine to make molecules. For example, a molecule of water is made up of 2 atoms of hydrogen and 1 atom of oxygen.



After thinking this over, go on to Page 4B and continue.

2B

YOUR ANSWER: Shoes, ships, and sealing wax, but not cabbages
(From P-4B) and kings.

You are incorrect.

Sometimes the word matter is used to mean simple substances or things that are not alive. But, in scientific usage, live things, animals and vegetables, as well as inanimate things such as shoes, ships, and sealing wax, are all forms of matter.

Now, return to Page 4B and select the correct answer.

 136

(Atom)	8. Matter made up of only one kind of atom is an element. Gold is matter that is made up of only one kind of atom, so gold is a/an________.
(Element)	9. A molecule of gold has only one kind of________.
(Atom)	10. A molecule is composed of two or more________.
(Atoms)	11. Oxygen is a gas that is composed of only one kind of atom. Oxygen is classified as a/an________. (molecule, element, atom)
(Element)	12. When two or more atoms of oxygen combine, a________ of oxygen is formed.
(Molecule)	13. An element is composed of________of only one kind.
(Atoms)	14. Two or more atoms combine to make a/an________.
(Molecule)	15. Matter consisting of only one kind of atom is a/an ________.
(Element)	16. The smallest part of an element is a/an________.
(Atom)	17. Two atoms of oxygen combine to form a/an________ of oxygen.
(Molecule)	18. When two or more elements chemically combine (a new substance is formed), a <u>compound</u> is produced. When the two elements, oxygen and hydrogen, chemically combine, a/an________is produced.
(Compound)	19. Water is a compound. Water is composed of two different________.

Continue on Page 5

4A

YOUR ANSWER: No, this stretches the definition too far.
(From P-6B)

Actually, the statement that air is matter doesn't stretch the definition in the least. Gases, such as those in air, are matter just as much as shoes and ships and kings.

Normally, you don't notice that air is around you. In the same way, a fish, if it could reason, probably would have difficulty in recognizing that water is matter. But, if you took the fish out of water, it would know that something is missing.

When you get up very high in an airplane, you need a supply of oxygen, because the higher up you get, the less air there is for you to breathe. Something is missing.

Now, return to Page 6B and select the correct answer.

4B

YOUR ANSWER: The smallest particle to which matter can be broken down is the atom.
(From P-7)

Correct. Atoms are the basic building blocks of all matter.

From "Alice in Wonderland" comes the quotation:

"The time has come, the Walrus said,
To talk of many things;
Of shoes and ships and sealing wax,
Of cabbages and kings."

Which of the things mentioned in the verse would you classify as matter?

Shoes, ships, and sealing wax, but not cabbages and kings. Turn to Page 2B

All of them. Turn to Page 6B

(Elements)	20. A molecule of water has 3 atoms chemically comb[illegible]ed: 2 hydrogen________ and 1 oxygen__________.
(Atoms) (Atoms)	21. Two elements chemically combine to form a/an________.
(Compound)	22. Two or more atoms combine to form a/an____________.
(Molecule)	23. A compound is formed when two or more____________ chemically combine.
(Elements)	24. A molecule is made up of two or more____________.
(Atoms)	25. The smallest part of an element is a/an__________.
(Atom)	26. Matter that is composed of only one kind of atom is a/an________________.
(Element)	27. Matter that is composed of atoms of two or more elements chemically combined is a/an____________.
(Compound)	28. Matter is all things that have________________ and occupy________________.
(Weight) (Space)	29. A molecule of an element contains two or more atoms of ____________________ kinds. (the same, different)
(The same)	30. A molecule of a compound contains two or more atoms of____________________ kinds. (the same, different)
(Different)	31. Sugar is a compound composed of three elements carbon, hydrogen, and oxygen. The smallest particle of sugar is a/an____________ of sugar.

Continue on Page 7.

6A

YOUR ANSWER: Compounds do retain the chemical characteristics
(From P-8) of the elements which are combined to produce them.

No, no. Give it some thought. We spoke of water as being a compound consisting of oxygen and hydrogen. Oxygen and hydrogen are both gases in their normal state, whereas water is a liquid.

Oxygen will support combustion and hydrogen will burn with a hot flame. What will water do to a fire? We can breathe oxygen, but can we breathe water?

Now, return to Page 8 and select the correct answer.

6B

YOUR ANSWER: All of them.
(From P-4B)

You are correct.

All things which have weight and occupy space are matter.

Can you decide whether the air we breathe is matter according to the above definition?

No, this stretches the definition too far.	Page 4A
Yes, air is matter.	Page 8
Doesn't possess weight, so it can't be matter.	Page 10A

(Molecule)	32. The smallest particle of any of the three <u>elements</u> in sugar is a/an____________of that element.
(Atom)	33. The smallest particle of a <u>compound</u> is a/an__________ of that compound.
(Molecule)	34. A molecule is to a compound as a/an____________is to an element.
(Atom)	35. An element is to a compound as an atom is to a/an ________________.
(Molecule)	36. Scientists have identified more than 100 different elements.

About 92 of these are found in nature; ten or more can be produced in an atomic pile. With nuclear energy, we can change many elements to others -- even lead to gold. The only trouble is that it costs more to make gold this way than it does to mine it from the earth!

Chemistry, which is concerned mainly with how elements are combined in compounds, was a well-developed science when its close relationship to electronics was discovered. Many of the basic terms in electronics come from chemistry.

In electronics, we are concerned with the characteristics of the atoms that make up the components in our electronic equipment. Why do some materials such as copper, silver, and gold make good conductors of electricity and other materials very poor conductors? This question is just one of the reasons you are starting out electronics with a basic physics lesson.

The smallest particle to which matter can be broken down is the __________________.

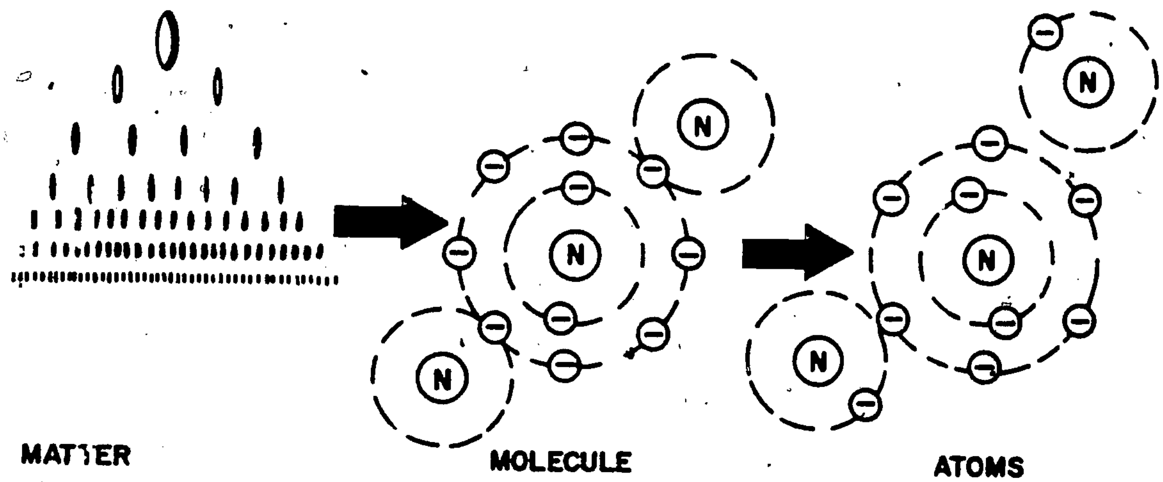
If you choose <u>molecule</u>, turn to Page 2A

If you choose <u>atom</u>, turn to Page 4B.

YOUR ANSWER: Air is matter.
(From P-6B)

Absolutely. Air can be weighed by compressing it in a tank such as skin divers use. Simply weigh the tank before and after filling it and you find that as more air is pushed into the tank, the more it will weigh. Air is matter.

Matter exists in three states, solid, liquid, and gaseous. All matter is made up of tiny particles called molecules. Molecules, when broken down into their smallest parts, are found to be composed of one or more kinds of atoms.



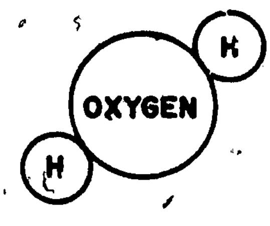
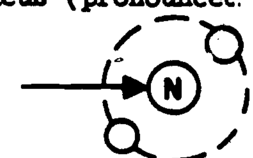
A substance which contains atoms of only one kind is called an element. Oxygen, hydrogen, copper, gold, silver, iron, sulfur, aluminum, carbon and uranium are some of the elements known to man.

By chemical action, we can combine elements to form completely new substances called <u>compounds</u>. Water is a compound. Water is composed of the elements hydrogen and oxygen, which are both gases in their normal state. Rust is another compound. It is produced when iron and oxygen combine.

Compounds ______________ retain the chemical characteristics of the elements which are combined to produce them.

Do	Page 6A
Do not	Page 10B

2F-73-9202

	1. Matter is all things that have ______________ and ______________ ______________.
(Weight occupy space)	2. The smallest bit of glass that can be identified as glass is a glass molecule. A water molecule is the __________ bit of water that can be identified as water.
(Smallest)	3. A drop of water can be continuously divided into smaller and smaller parts until the smallest identifiable bit of water left is a water ____________.
(Molecule)	4. Molecules are made of atoms. This picture shows a water molecule with 3 atoms. This molecule has 2 hydrogen atoms and 1 oxygen ________________. 
(Atom)	5. Atoms have two parts, a nucleus and one or more electrons. These parts make up an atom, just as atoms make up a ________________.
(Molecule)	6. In the center of an atom is the nucleus (pronounced NEW-klee-us). The arrow points to the __________. 
(Nucleus)	7. A molecule is made of ________________.
(Atoms)	8. Matter composed of only one type of atom is an/a ________________.
(Element)	9. Matter composed of two or more different atoms chemically combined is a/an ________________.

Continue on Page 11.

10A

YOUR ANSWER: Air doesn't possess weight, so it can't be matter.
(From P-6B)

You are incorrect.

Air does have weight, and it can be weighed. The barometer, besides being used by weather forecasters, can be used to measure altitude by measuring the weight of air.

The earth is surrounded by a layer of air many miles deep. On a mountain, there is less air above you to be weighed than is above you when you are at the seashore. This difference in the amount of air can be weighed by a barometer. From that measure, it is also possible to estimate your altitude.

Now, return to Page 6B and select the correct answer.

10B

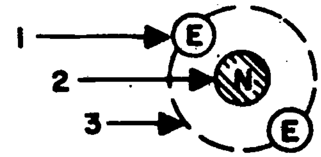
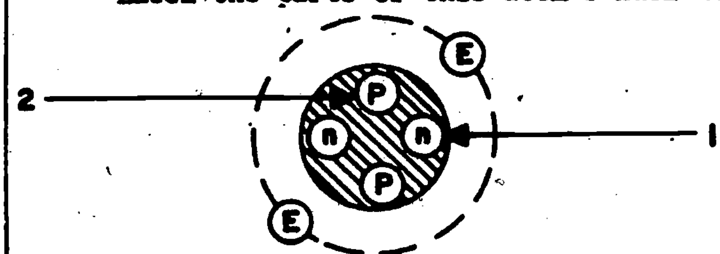
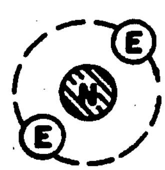
YOUR ANSWER: Compounds do not retain the chemical characteristics
(From P-8) of the elements which are combined to produce them.

You are correct.

The compound water, for example, will not burn; but the gases which are chemically combined to make up water will. We can breathe oxygen, but can we breathe water?

The chemists' name for the smallest part of an element that retains the chemical properties of the original element is "atom." The atom is the smallest particle of an element which can enter into chemical combination.

Now turn to the top of Page 9 and continue. Do not forget to cover your answers before you write your answer.

(Compound)	10. Electrons (E) are particles that travel in rings around the nucleus. Which number labels the electron ring of this atom? ( ) 
(3)	11. The nucleus of an atom contains two kinds of particles called protons (P) and neutrons (n) Label the parts of this atom's nucleus. 
(1. Neutron 2. Proton)	12. The symbol for an electron is (E). The symbol for a proton is (P). The symbol for a neutron is (n). Label these symbols. (P) ____________________ (E) ____________________ (n) ____________________
(P) Proton (E) Electron (n) Neutron	13. Several atoms may make up a ____________________.
(Molecule)	14. The nucleus of an atom contains two kinds of particles. The nucleus is made of (electrons and protons/protons and neutrons/electrons and neutrons).
(Protons and neutrons)	15. Atoms have two parts, a ________ and one or more ________. 

Continue on Page 13.

12A

YOUR ANSWER: False
(From P-16B)

No. No. We have just said that each element has an Atomic Number that corresponds to the number of protons in one of its atoms. All elements have different atomic numbers. It has also been stated that the normal atom of all elements is electrically balanced. So each must have a different amount of electrons -- right.

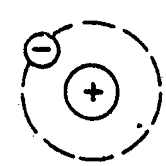
Think this over and go back to page 16A and continue.

12B

YOUR ANSWER: Ten protons.
(From P-21)

Right. For the normal atom to be electrically balanced, it must have the same number of protons as it has electrons.

The simplest of all atoms as far as the number of protons and electrons are concerned is hydrogen. The normal hydrogen atom contains one proton and one electron.

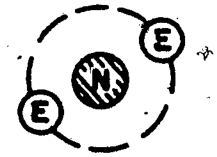
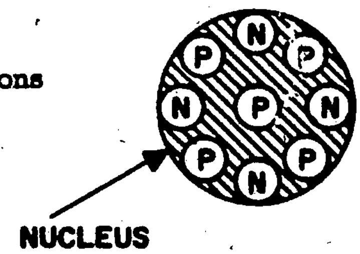


Every element is assigned an atomic number. This number is the number of protons the atom has. Hydrogen has 1 proton, so an atomic number of 1. Copper with its 29 protons is assigned an atomic number of 29.

In addition to electrons and protons, all atoms, except the hydrogen atom, have other particles called neutrons. They are electrically neutral and thus have no effect on electrons. They add weight but they do not change chemical or electrical qualities.

If an element has an atomic number of 17, how many electrons would this atom have in its balanced state?

Not enough information.	Page 14.
17 electrons	Page 16.

(Nucleus electrons)	16. Traveling around the nucleus are particles called electrons. This picture shows____________ traveling in a ring around the __________________. 
(Electrons) (Nucleus)	17. The nucleus of an atom is formed of protons and ______________________.
(Neutrons)	18. The electrons form rings around the (nucleus/proton/molecule/atom).
(Nucleus)	19. The nucleus of an atom contains both neutrons and protons. In this nucleus, how many protons and neutrons are there? ( )neutrons ( )protons 
(4) (5)	20. In an atom, the rings around the nucleus contain _________________________.
(Electrons)	21. The nucleus of an atom contains______________________ and___________________.
(Protons) (Neutrons)	22. A proton has a positive electric charge. The + sign stands for the positive charge. Which of these represents a proton?  A B C D

Continue on Page 15.

14A

YOUR ANSWER: Not enough information is given to tell how many electrons an element with an atomic number of 17 would have.
(From P-12B)

You are incorrect.

Yes, there is enough information given to determine how many electrons this element would have.

We said the element was electrically balanced, so we know there are as many electrons as protons. The atomic number is determined by the number of protons an atom has.

Now, return to Page 12B and try once more.

14B

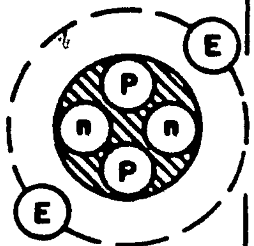
YOUR ANSWER: Ten neutrons.
(From P-21)

Perhaps you are confusing protons and neutrons. Protons are the particles with positive electrical charges. Neutrons are those particles with a neutral charge -- neutron, neutral.

What we said was not that the number of neutrons equals the number of electrons, but that the number of protons in the normal atom equals the number of electrons.

The number of neutrons in some atoms is equal to the number of protons or electrons, but in other atoms, the number of neutrons may be either more or less. So, if we are told the number of electrons in an atom, we cannot tell how many neutrons it has.

Now, return to Page 21 and try again.

(D)	23. Draw a picture of an atom. Show 2 electrons (E) in the ring around the nucleus and 2 protons (P) and 2 neutrons (n) in the nucleus.
	24. An electron has a negative electric charge. The - sign stands for the negative charge. Which of these represents an electron? (+) A (P) B (-) C (∞) D
(C)	25. In rings around the nucleus are particles called ________________
(Electrons)	26. If a particle has + charges and - charges, the net charge is the algebraic sum of the charges. If a particle has 3 (+) charges and 5 (-) charges, the net charge is (+3) + (-5) = ( ).
(-2)	27. Protons have a ________________ electric charge. The symbol for this kind of charge is ( ).
(Positive) (+)	28. What is the net charge on these particles? A (+2 -1) B (+4 -2) C (-3 +1) D (-5 +4)
(A +1 B +2 C -2 D -1	29. Protons and neutrons make up the ________________ of an atom.

Continue on Page 17.

149

16A

YOUR ANSWER: 17 electrons.
(From P-12B)

You are correct.

Since we said this element was electrically balanced, we know there are as many electrons as protons. The atomic number gave us the number of protons in this element.

Of the 100 or so elements that are known today, each has an atomic number. Example:

Element	Atomic Number	Element	Atomic Number
Hydrogen	1	Krypton	36
Helium	2	Silver	47
Carbon	6	Gold	79
Oxygen	8	Uranium	92
Copper	29	Mendelevium	101

A complete chart of the elements can be found in most chemistry and physics books.

Each of the 100 or so elements that have been identified has its own distinctive atom.

False Page 12A

True Page 18

16B

YOUR ANSWER: Five protons and five neutrons.
(From P-21)

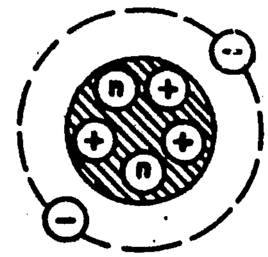
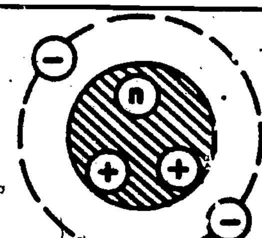
No. The principle behind this question is in the following statement:

In the normal atom, the number of protons equals the number of electrons.

This says nothing about neutrons. Some normal atoms have more neutrons than protons, some have the same number, and some have fewer. Simply knowing the number of protons or electrons tells us nothing about the number of neutrons.

Now, return to Page 21 and select the correct answer.

3F-73-9202

(Nucleus)	30. A neutral charge means a net charge of zero. Which of these has a neutral charge? A: (+2) (+3) B: (+1) (-2) C: (+2) (-2) D: (-3) (+4) E: (-4) (-4)
(C)	31. The net charge on an atom is the algebraic sum of the charges of the protons and the charges of the electrons. What is the net charge of this atom? ( ) 
(+1)	32. In the ring around the nucleus of this atom is one________. 
(Electron)	33. Name / Charge / Symbol for charge Proton / Positive / ( ) Neutron / Neutral / (0) Electron / Negative / ( )
(+) (-)	34. This picture shows two positively charged protons and one neutron in the__________of the atom. 
(Nucleus)	35. Neutrons have a ( ) electric charge. Electrons have a ( ) electric charge.

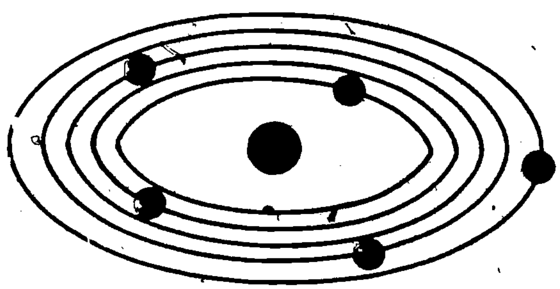
Continue on Page 19

YOUR ANSWER: (From P-16A) True, each of the 100 or so elements that have been identified has its own distinctive atom.

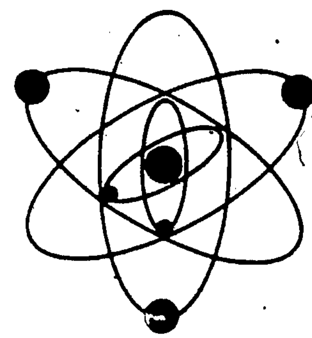
You are right.

The atomic number tells us how many protons the atom of an element has. The normal atom is electrically balanced-- so for each proton, one electron.

Since we have spoken of electrons being in orbit, it is only natural to compare the atom to our solar system. However, such comparisons are misleading. The solar system looks like this:



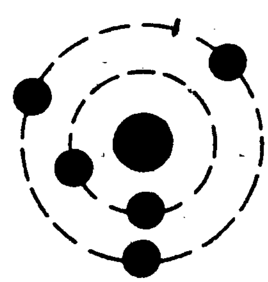
SOLAR SYSTEM



ATOM

All the orbiting planets are in approximately the same plane. In an atom, the electrons do not lie in one plane but move within spheres at different distances from the nucleus. These spheres are like the layers of an onion. In fact, we sometimes call them layers. But, most commonly, we call the path in which an electron moves a <u>shell</u>.

In the drawing of the atom above, each electron has its own orbit. But here the electrons are grouped into 2 separate <u>shells</u>. The same atom will normally be drawn like this:

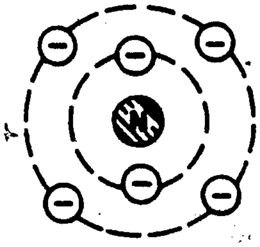


Which of the statements below is true?

The electrons in one shell can all have the same orbit. Page 20

The electrons in one shell can all have individual orbits. Page 22

15

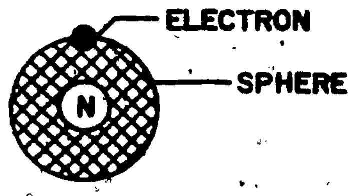
(0) (-)	36. Electrons travel around the nucleus in paths called orbits. There are 2 electrons in the ______ nearest the nucleus and 4 electrons in the ____________ farthest from the nucleus. 
(Orbit) (Orbit)	37. The electrons that ring the nucleus have ( ) charge. Protons in the nucleus have a ( ) charge. Neutrons in the nucleus have a ________ charge.
(-) (+) (Neutral or Zero)	38. Which of these pairs will have a net charge of 0? ( ). A: (-1) (-7) B: (+6) (+1) C: (+6) (-6) D: (-3) (-3)
(C)	39. Traveling around the nucleus are small particles called ____________________.
(Electrons)	40. The ______________ has a negative charge.
(Electron)	41. A positively charged particle found only in the nucleus of an atom is called a ____________________.
(Proton)	42. A molecule is made up of two or more ____________.
(Atoms)	43. Draw an atom with two electrons (-), two protons (+), and one neutron (n). (Draw at bottom of page.)

Continue on Page 21.

YOUR ANSWER: The electrons in one shell can all have the same orbit.
(From P-18)

No, let's go over it once again.

Electrons orbit around the nucleus in spheres at different distances



from the nucleus. The electrons are grouped into shells according to the size of the sphere the orbiting electrons make.

When you see or draw a picture of an atom, the electrons are grouped into shells as in Figure A below. But remember each electron can have its own orbit within the shell it is grouped, as shown in Figure B below.

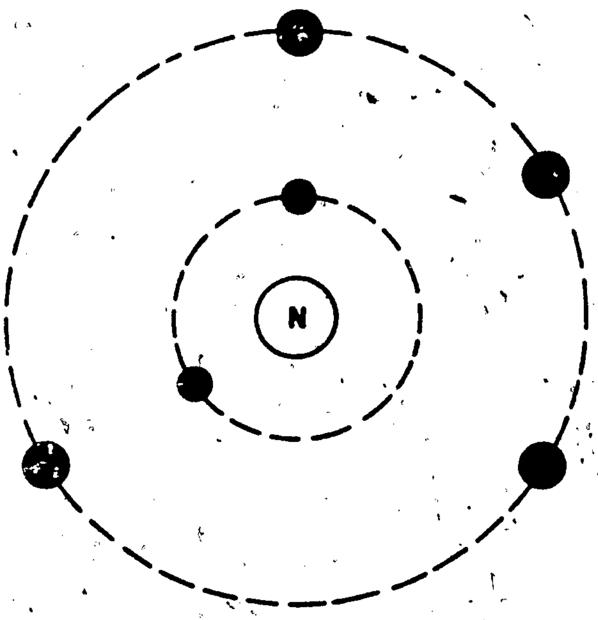


FIGURE A

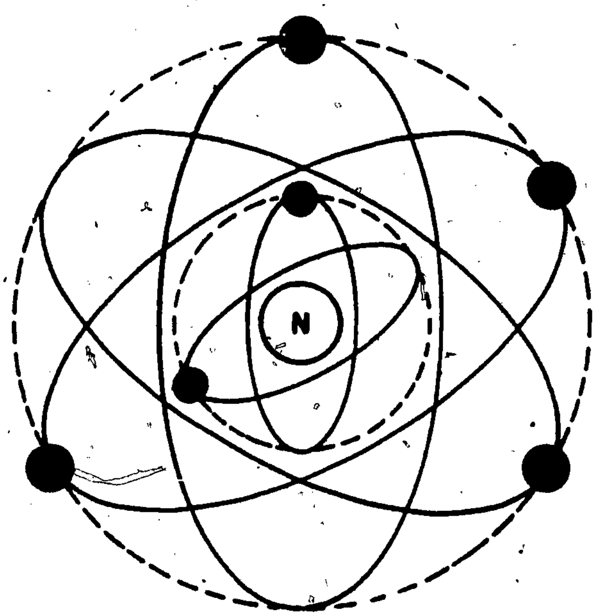
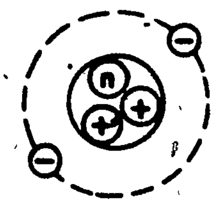


FIGURE B

Return to Page 18 and select the correct answer.



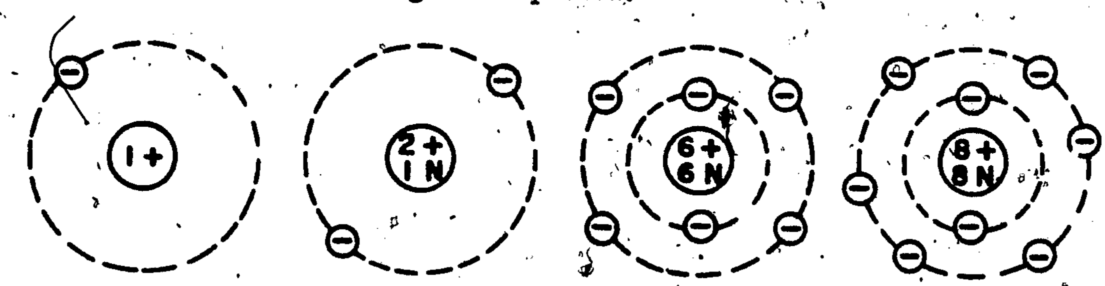
44. A neutral atom is one that has
   1. an equal number of protons and neutrons.
   2. more electrons than protons.
   3. the same number of protons as electrons.

(3. the same number of protons as electrons)

45. The smallest part of an element is a/an__________.

(atom)

46. Here are diagrams of the atoms of four different elements. The - sign indicates the negative charge of an electron. The + sign indicates the positive charge of a proton.



These are normal atoms. That means that the electrical charges in the atoms are balanced. The number of protons exactly equals the number of electrons in all atoms in their normal state. Therefore, the negative charges of the electrons exactly balance the positive charges on the protons. That is why a normal atom is described as electrically balanced. Note that the presence of neutrons has no effect, because neutrons are themselves electrically neutral.

The normal atom of the element neon has ten electrons.

What particles can we be sure of finding in its nucleus?

Ten protons.	Page 12B
Ten neutrons.	Page 14B
Five protons and five neutrons.	Page 16B

YOUR ANSWER: The electrons in one shell are all in individual orbits. (From P-18)

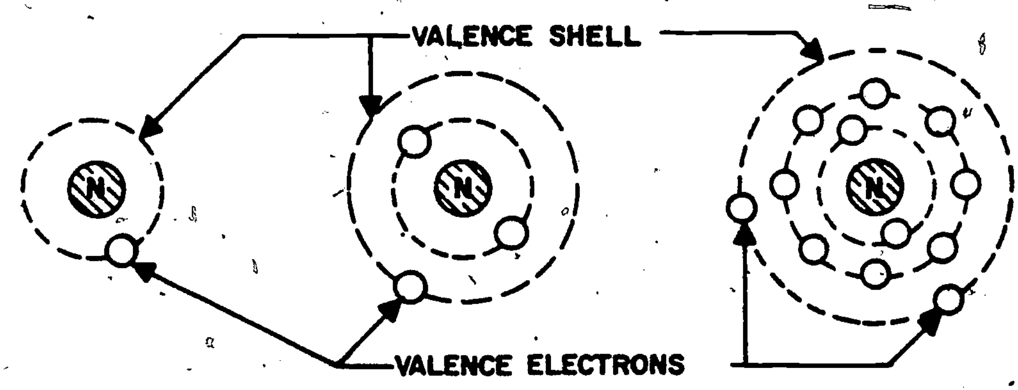
Right you are. Very good.

Each shell, according to its distance from the nucleus, can be composed of a maximum number of electrons. Beginning with the innermost shell and working outward, the shells are lettered, starting with K and running sequentially to Q in the most complex elements. Starting with the innermost shell K, the maximum numbers of electrons in each shell are 2, 8, 18, 32, 32, 18, 8, 2.

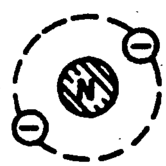
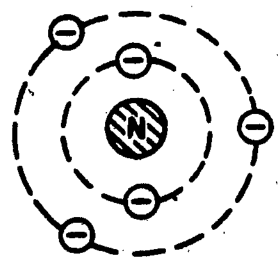
Now when the outermost shell of any atom has 8 electrons, the shell is complete. In chemistry, the elements that have 8 electrons in the outermost shell of their atoms will not combine readily with other elements and these elements are classified as chemically inert. There are only 6 of these elements found in nature: Helium, Neon, Argon, Kryton, Radon, and Xenon.

In electronics, the outermost shell is ~~the~~ shell we are interested in. It is the number of electrons in this shell that will determine if a material is a good conductor of electricity or a poor one.

The outermost shell is called the Valence Shell and the electrons in the Valence Shell are called Valence Electrons.



Now continue at the top of Page 23.

	1. A neutral atom is one that has 1. an equal number of protons and neutrons. 2. more electrons than protons. 3. the same number of protons as electrons.
(3. the same number of protons as electrons.)	2. Draw a nucleus with two electrons in orbit around it.
	3. The outermost shell is called the VALENCE shell or ring. How many electrons are in the valence shell of this atom? 
(3)	4. The____________________shell is called the valence shell.
(Outermost)	5. The electrons in the valence shell or valence ring are called VALENCE ELECTRONS. Valence electrons are located in the__________shell.
(Valence)	6. _______________electrons are located in the valence shell of an atom.
(Valence)	7. If a NEUTRAL atom has 4 protons, it must also have ______________________.

Continue on Page 25.

YOUR ANSWER: Yes.
(From P-31)

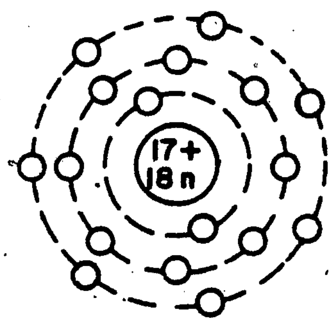
You are correct.

The single valence electron of silver and gold, as well as of copper, is easily jarred loose. It is the availability of this electron that makes copper so important in electronics. Silver is used, too, and occasionally gold, but cost prohibits their being used as widely as copper.

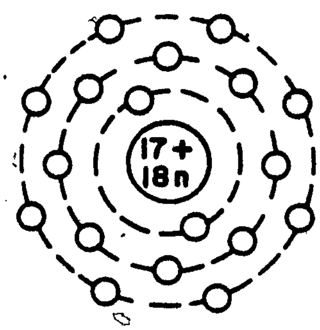
You have been told that the normal atom is electrically balanced because it contains an equal number of protons and electrons.

When an atom gains or loses an electron, it becomes electrically charged, because it is no longer in electrical balance. The atom that has been unbalanced by the gain or loss of an electron is called an ion of that atom. Ions, clearly, can be positive or negative, depending on whether they have a shortage or surplus of electrons.

Here are diagrams of chlorine atoms. One is a normal chlorine atom; the other is an ionized chlorine atom.



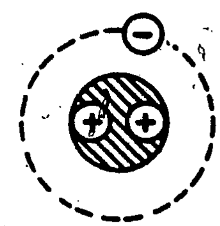
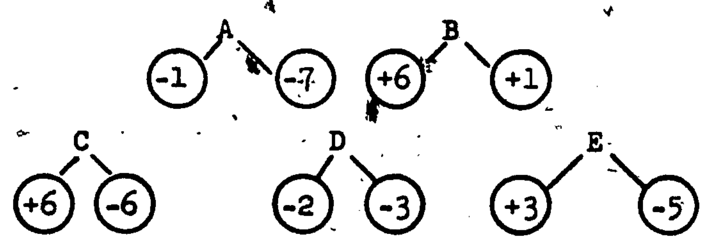
A



B

A is the ion and it is positively charged. Page 26A

B is the ion and it is negatively charged. Page 28

(4 electrons)	8. If an atom has 2 protons and 2 electrons, it is a ____________ atom.
(Neutral)	9. Sometimes the valence electrons are called free electrons. Free electrons are found in the ____________ shell.
(Valence or outermost)	10. An atom with more protons than electrons has more positive than ____________ charges.
(Negative)	11. In this picture of a charged atom, there are ( ) protons and ( ) electron(s). Therefore, the atom has a ____________ charge. 
(2) (1) (Positive)	12. ____________ electrons are in the outermost shell, ring, or orbits.
(Valence or free)	13. Which of these pairs will have a net charge of -2? 
(E)	14. The nucleus of the atom is made of neutrons and protons. The neutrons have a 0 charge; the protons have a + charge. Therefore, the net charge of a nucleus is ( ).

Continue on Page 27.

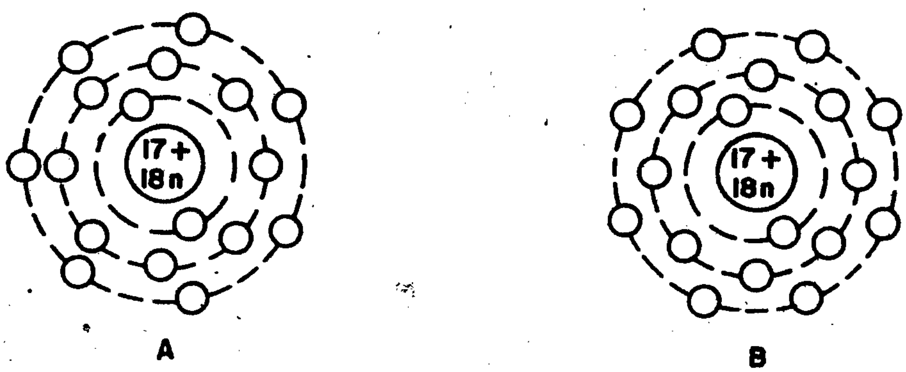
26A

YOUR ANSWER: A is the ion and it is positively charged.
(From P-24)

You are incorrect.

An ion is an atom that is electrically unbalanced. It has either a negative or a positive charge. And that means it has either a surplus or a deficiency of electrons. It has gained or lost an electron for some reason.

Your counting can't be accurate. If you look again, you will find that in illustration A there are equal numbers of electrons and protons. And that means that A is not an illustration of an ion.



A is the ion and it is positively charged. Page 26A (At top)

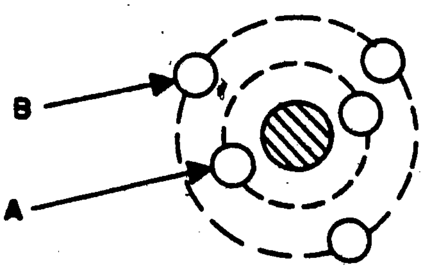
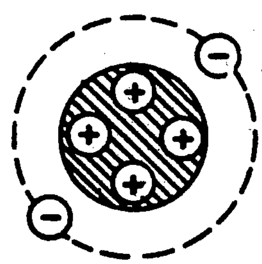
B is the ion and it is negatively charged. Page 28

26B

YOUR ANSWER: One negative charge each.
(From P-28)

This answer is correct as far as it goes. It tells us that the charge is negative, but it doesn't tell us anything about the size of the charge. As you know, the charge of an electron is the smallest negative charge known. There is a special name that indicates this size of charge.

Now, return to Page 28 and select the more complete answer.

(+)	15. Electrons travel around the nucleus in paths called________________.
(Orbits)	16. Electrons in orbits near the nucleus are called "bound" electrons. Particle A is a______________electron. Is B a bound electron? (Yes/No). 
(Bound) (No)	17. The three particles of the atom you have studied are called____________, ____________, and ____________.
(Electrons, protons, neutrons) (Any order)	18. This atom has a (+ / - / 0) charge. 
(+)	19. Only those electrons in the outermost orbit around the nucleus are called____________ or valence electrons.
(Free)	20. All electrons of an atom except those in the outermost orbit are______________electrons.
(Bound)	21. An atom that has a + charge must have more ____________than ______________.

Continue on Page 29.

YOUR ANSWER: B is the ion and it is negatively charged.
(From P-26A)

You are correct.

Figure B has one more electron than is needed to balance the protons in the nucleus. Therefore, it has a negative charge. If it had one less electron than is needed to balance the protons, it would have had a positive charge.

A proton and a neutron are about the same size and weight, but each is only one-third the size of an electron. This means that protons and neutrons, which make up the nucleus, are much denser than electrons. It's like comparing a bowling ball to a circus balloon.

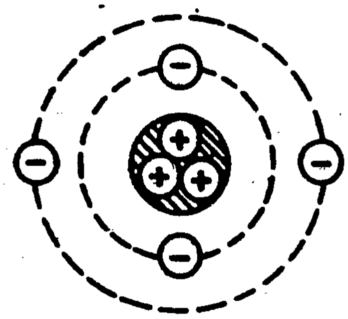
The electron is the smallest negative charge known. It has exactly the same strength of charge as a proton, but, of course, a proton and an electron have opposite charges. We say the charges of an electron and a proton are equal and opposite. These charges are referred to as <u>elemental charges</u>.

What charges do electrons have?

One negative charge. Page 26B

One negative elemental charge each. Page 32B

16

(Protons) (Electrons)	22. All the + charges of an atom are found in the __________________ of the atom.
(Nucleus)	23. This atom has a _______________ charge. 
(Negative)	24. An atom which does not have an equal number of protons and electrons is an <u>ion</u>. An unbalanced atom is an ____________________.
(Ion)	25. An atom with more electrons than protons is a negative ion and an atom with more protons than electrons is a positive _________________.
(Ion)	26. An atom with more electrons than protons has a ________________ charge and is a _______________ ion.
(Negative Negative)	27. An electron has a ___________________________ charge.
(Negative)	28. An atom with the same number of electrons and protons has a _______________________ charge.
(Neutral or Zero)	29. The valence electrons are in the ________________ shell.
(Outermost or Valence)	30. Matter is all things that have ____________________ and __________________ ________________.

Continue at top of Page 31.

To summarize this set:

1. Matter is anything which has weight and occupies space.

2. Molecule
   a. smallest part of a compound.
   b. consists of 2 or more atoms chemically combined.

3. Atom
   a. smallest part of an element.
   b. consists of electrons in orbit around a nucleus.
      (1) Electrons have a negative charge.
      (2) The nucleus consists of protons and neutrons.
         (a) Protons have a positive charge.
         (b) Neutrons have no charge.

4. Elements
   a. are materials that consist of only one type of atoms.
   b. Over 100 elements have been identified.

5. Compounds
   consist of 2 or more elements chemically combined.

6. The atomic number assigned to an element is the number of protons in an individual atom.

7. The net charge of an atom is the algebraic sum of the protons and electrons in that atom.

8. Valence electrons are the electrons in the outermost orbit.

9. An atom is normally electrically balanced because it has an equal number of protons and electrons.

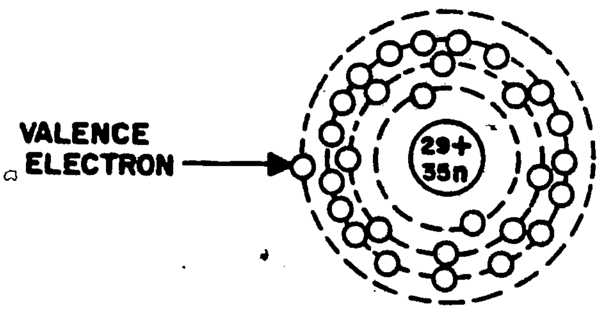
10. If an atom loses or gains an electron, it becomes a charged atom.
   a. A charged atom is called an ion.
   b. An excess of electrons results in a negative charge; an atom in this condition is called a negative ion.
   c. A deficiency of electrons results in a positive charge; an atom in this condition is called a positive ion.

11. The coulomb
   a. a unit of electrical charge.
   b. a specific number of electrons or protons (6.28×10^{18} to be exact).

The End.

Go to page 35.

(weight occupy space)	31. An ion is a charged______________.
(atom)	32. An atom with a - charge has more______________than __________________.
(electron protons)	33. An atom with more electrons than protons is a ____________________ ion.
(negative)	34. An electron has a____________________charge.
(negative)	35. This is a diagram of a copper atom. It has 29 electrons and 35 neutrons.



Note that there is only one electron in the outer shell. This shell is called the valence shell.

The valence shell determines the electrical characteristics of an atom. Electron flow through a copper wire, or any electrical conductor, can take place because the last shell of each of the conductor's atoms is not complete and the movement of electrons from one atom to another is possible.

The electrons in the valence shell are called valence electrons. The copper atom has one valence electron. The atoms of gold and silver also have one valence electron each.

Are the electrical characteristics of gold and silver similar to those of copper?

Yes. Page 24

No. Page 32A

32A

YOUR ANSWER: No.
(From P-31)

Why not? It is the availability of valence electrons that determines how atoms act electrically. Thus, different atoms with the same number of valence electrons will behave electrically in much the same way.

Now, return to Page 31 and select the correct answer.

32B

YOUR ANSWER: One negative elemental charge for each electron.
(From P-28)

You are correct.

There's one negative elemental charge on each and every electron; one positive elemental charge on each and every proton.

This elemental charge is too small for practical use. It's so small that if the electricity used in your home were measured in elemental charges, your electric bill would be covered with numbers just to tell how much electricity you used.

For practical purposes, the size of an electrical charge is measured in units called coulombs. Coulombs are named after a Frenchman who was among the first to try to measure the strength of electrical charges. There are 6,280,000,000,000,000,000 elemental charges in one coulomb. If you were to rewrite this number in powers of tens, which you will learn about later, it would be 6.28×10^{18} (tells us the decimal point was moved to the left 18 places.) From now on, when you are asked "What the practical unit of electrical charge is?" -- it is one coulomb or 6.28×10^{18} elemental charges.

Go to the top of page 33 and continue.

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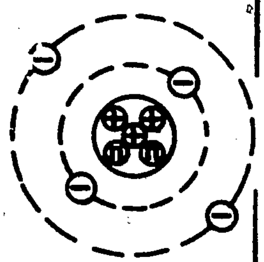
160

	1. The practical unit of electrical charge is the _________________.
(coulomb)	2. The charge on an electron is a/an _________________ elemental charge.
(negative)	3. The charge on a proton is a _________________ elemental charge.
(positive)	4. 6.28×10^{18} elemental charges are one _________________.
(coulomb)	5. The practical unit of electrical charge is the _________________.
(coulomb)	6. The atom that has 6 electrons and 5 protons is a negative _________________.
(ion)	7. The smallest part of an element is a/an _________________.
(atom)	8. The smallest part of a compound is a/an _________________.
(molecule)	9. An atom that has 2 electrons and 5 protons is a _________________ _________________.
(positive ion)	10. A compound is composed of two or more _________________ chemically combined.
(elements)	11. Draw an atom with 3 protons, 2 neutrons, and 4 electrons (The first shell can have only 2 electrons in it.)

Continue on page 34 at the top.

	12. Which of these pairs will have a net charge of -6? ( ) A: (-1) (-7) B: (+6) (+1) C: (+6) (-6) D: (-3) (-3) E: (+3) (-5)
(D)	13. Two or more atoms may combine to form a__________.
(Molecule)	14. 1. A proton has a ( ) charge. 2. A neutron has a__________charge. 3. An electron has a ( ) charge. 4. The nucleus of an atom has a__________charge.
(1. (+) 2. neutral or zero 3. (-) 4. positive)	15. The smallest physical particle into which matter can be divided is called a/an__________.
(Atom)	16. Free electrons are in the__________ shell of an atom. Other electrons in the atom are called__________ electrons.
(Outermost or valence) Bound)	17. Molecules can be broken down into__________.
(Atoms)	18. The outermost shell is called the__________shell.
(Valence)	19. The normal hydrogen atom, which has 1 proton and 1 electron, has a net charge of__________.
(Zero)	

Continue on Page 30.

REVIEW TEST FOR ELECTRICAL PHYSICS

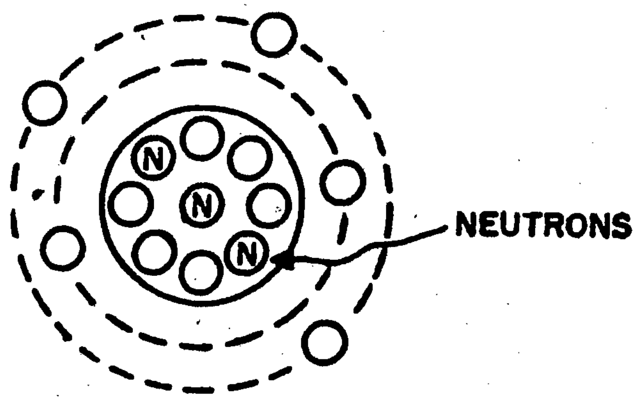
1. Matter is defined as all things that have ______________ and ______________.

2. The smallest particle of water that still retains the characteristics of water is a/an ______________ water.

3. Matter which consists of only one type of atom is the definition of a/an ______________.

4. Compounds are formed when 2 or more ______________ are chemically combined.

Use Figure A below to answer questions 5 through 11.



5. How many protons are in the atom? (   ) Label them P.

6. How many electrons are in the atom? (   ) Label them E.

7. The charge of an electron is ______________.

8. The nucleus has a ______________ charge.

9. The net charge of the atom is (   ).

10. The neutron has a (positive/negative/neutral) charge.

11. How many valence electrons are shown in Figure A above?

12. A silicon atom has 14 electrons, 14 protons, and 12 neutrons; what will its atomic number be? ( )

13. The outer shell of an atom is the ______________________ shell.

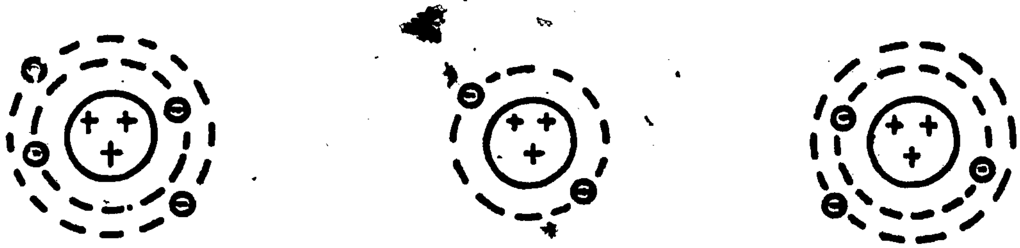
14. An atom in a state of electrical balance has a net charge of

______________________.

15. Which electrons would be the easiest to displace?

a. Negative electrons.
b. Bound electrons.
c. Valence electrons.
d. Neutrons.

16. Which of the following atoms is in a state of electrical balance? ________



A B C

17. A normal atom which has lost one electron has a ______________________ charge.

18. If an atom gains two electrons, it will have a ______________________ charge.

19. The unit of electrical charge is the ______________________.

20. An ion is a/an (balanced/unbalanced/neutral) atom.

Department of Medicine
School of Health Care Sciences

CARDIOPULMONARY LABORATORY SPECIALIST

BASIC PHYSICS - MATTER

July 1973

Sheppard Air Force Base, Texas

10-6

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Designed For ATC Course Use

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172

ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by Page)	REVIEW QUESTIONS (by No)

MATTER

OBJECTIVES

1. Write the definition of matter.

2. List the three states of matter.

3. Identify the states of matter from a given list of diagrams which show the transfer of each state of matter from one container to another.

4. Match the terms volume, mass, universal attraction, weight, density, inertia, porosity, impenetrability with a list of statements describing these terms.

5. Draw the "Magic Circle" for weight, volume, and density; and write the formula for finding:
   a. weight
   b. volume
   c. density

6. Match the terms element, compound, molecule, and atom with a list of statements describing these terms.

SUGGESTED READING TIME 57 MINUTES

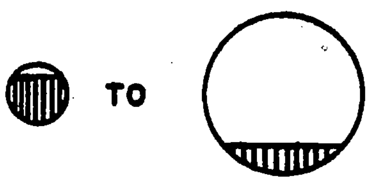
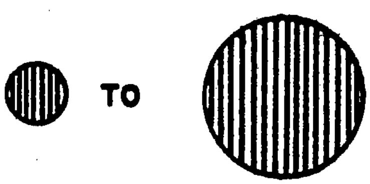
	1. The earth and the planets, or anything that can be found on or in them, take up space and have weight (a vacuum does not have weight). These things are called <u>matter</u>. Matter is anything that has weight and occupies ____________________.
SPACE	2. The pencil you are writing with has weight and occupies space. The pencil, therefore, is considered ________________.
MATTER	3. You are surrounded by matter. The air you breathe, the food you eat, your own body are all matter. These things and anything that has weight and occupies space are called __________________.
MATTER	4. The definition of matter is anything that ________ ____________ and ____________ __________.
HAS WEIGHT OCCUPIES SPACE	5. What is the definition of matter? ____________________________________ ____________________________________ CONTINUE ON PAGE 3

(From page 6A)
2A

You will be embarrassed when you return to page 6A and look at the diagram you said represents a solid. Go back now and think about your choice. You will find that it does not have the properties of a solid. Choose the correct one and continue the program.

(From pages 4A or 6B)
2B

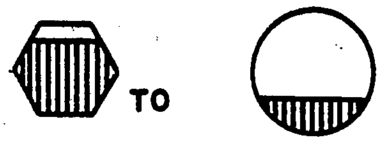
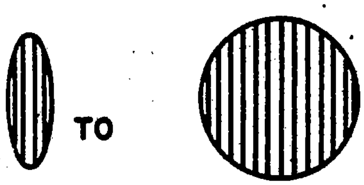
Good. You know how liquids react and look when transferred from one container to another. Gases will react in a certain way, too. They will assume the shape <u>and</u> the volume of a new container, as shown by helium being blown into a balloon. A set of diagrams showing the transfer of gas from one container to another would look like:

If your answer is:	Turn to page:
	4B
	6A

ANYTHING THAT HAS WEIGHT AND OCCUPIES SPACE.	6. Matter exists as a solid. It also exists as a gas and a liquid. The three states in which matter exists are ____________, ______________ and ____________.
SOLID LIQUID GAS	7. Water, blood, and gasoline are liquids. Steel, wood, and ice are solids. Oxygen, CO_2, and water vapor are gases. Gases, solids, and liquids are the three ____________ of ____________.
STATES MATTER	8. What are the three states of matter? 1. ________________ 2. ________________ 3. ________________
SOLID LIQUID GAS	9. Each state of matter behaves differently when moved from one container to another. When the <u>gas</u> from a can of "Spare Tire" is released into a tire, it occupies the volume and assumes the shape of the tire. If milk is poured from a <u>pint</u> bottle into a <u>quart</u> pan, will the liquid assume the shape and the volume of the pan? If your answer is: — Turn to page: Yes — 4A No — 6B

(From page 3, frame 9)
4A

Incorrect. It does not assume the volume of the pan. If you pour the milk (1 pint) into the pan (1 quart), will it fill the pan? Of course not, but it will assume the shape. This is the way liquids react in the transfer process. They assume the shape but NOT the VOLUME. The transfer of liquid shown as a diagram would look like:

If your answer is:	Turn to page:
	2B
	8A

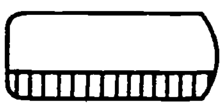
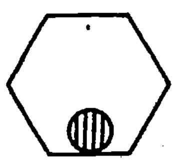
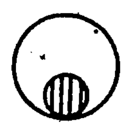
(From page 2B)
4B

Gas will take up the entire space and assume the shape of the new container when transferred. Return to page 2B and look at the diagrams; see which set of diagrams represents a gas and then turn to the correct answer page.

	10. You are not reading what you should be! If you had followed instructions, you wouldn't be reading this frame. Return to frame 9 and continue the program.
ANSWER TO 20A W= DV $D=\frac{W}{V}$ $V=\frac{W}{D}$	(From page 20A) 11. An ELEMENT is a substance that <u>cannot</u> be reduced to simpler substances by <u>chemical</u> means. Gold, oxygen, and platinum cannot be reduced to simpler substances by ______________ means because they are ______________.
CHEMICAL ELEMENTS	12. A substance that cannot be broken down into a simpler substance by chemical means is called a/an ______________.
ELEMENT	13. Elements are the basic substances that are combined to form the many things that we know as <u>compounds</u>. Water and sugar are examples of compounds because they are a combination of two or more elements. An element cannot be reduced to a __________ ______________ by chemical means, and a/an ______________ is made up of two or more elements. CONTINUE ON PAGE 7

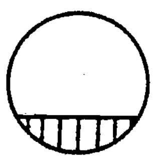
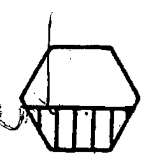
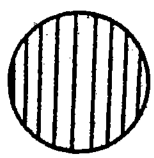
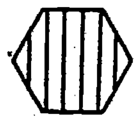
(From page 2B)
6A

Right. You have shown that you know a gas will take the size and shape of a new container if transferred. So far, you know what liquids and gases do when they are transferred from one container to another. Solids react entirely differently. They assume NEITHER the shape nor the volume of the new container. Move a block of wood from a small box to the back of a truck. It does not change in shape or volume. Shown as a diagram, transfer of solids would look like:

If your answer is:	Turn to page:
 to 	2A
 to 	10B

(From page 3, frame 9)
6B

Very good. As you have shown, liquids assume the shape of a new container but not the volume (unless the two volumes are the same). This can be shown in a diagram, which might look like:

If your answer is:	Turn to page:
 to 	2B
 to 	13B

SIMPLER SUBSTANCE COMPOUND	14. There are many common things that are elements or compounds. Hydrogen, iron, aluminum, carbon, and tin are all examples of ______________ because it has been found that they cannot be broken down or changed into something simpler (by chemical means).
ELEMENTS	15. Some common examples of compounds are earth, wood, paper, salt, and air. In order to be classed as a compound, the substance must have at least ______________ elements.
TWO (2)	16. Plastic, cotton, and air can all be reduced to a material or substance that is simpler or different, since they are made up of several different elements. They are known as ______________.
COMPOUNDS	17. Matter is made up of very small particles called <u>atoms</u> and <u>molecules</u>. These two small particles are different, since it takes 2 or more <u>atoms</u> to make a <u>molecule</u>. Another way to say it is-- an atom combined with another atom or atoms makes a/an ______________. CONTINUE ON PAGE 9

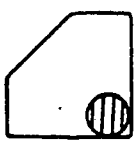
(From page 4A)
8A

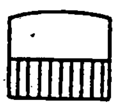
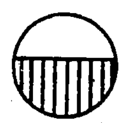
Wrong. The diagram shows that the liquid is assuming the shape <u>and</u> the volume. Liquids will assume the shape <u>and</u> the volume ONLY when the two containers have the same volume . This, of course, is not characteristic of liquids. Go to page 4A and choose the diagrams showing the transfer of liquid from one container to another.

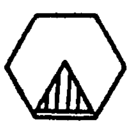
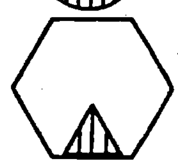
(From page 10B)
8B

ANSWERS TO PAGE 10B - - a. L, b. S, c. G

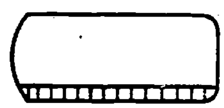
Identify the state of matter in the diagrams below that show the transfer of matter from one container to another. The shaded area represents matter. Fill in the blank between each set of diagrams, using a G for gas, L for liquid, and S for solid.

a.  ____ 

b.  ____ 

c.  ____ 

d.  ____ 

e.  ____ 

f.  ____ 

Turn to page 10A

	(From frame 17, page 7)
MOLECULE	18. An atom is the smallest particle of an element that can combine with other atoms to form molecules. A molecule is the smallest part of a substance that will have all the characteristics of that substance. The smallest part of water that still has all the properties of water is a/an ____________.
MOLECULE	19. A molecule will have all the properties of a substance. The particles that make up the molecules and do not necessarily have any of the properties of the substance are called ____________.
ATOMS	20. Remember that a/an ________ does not have to have any of the properties of the substance of which it is a part. The smallest particle of a substance that does have all the properties of it is a/an ____________. CONTINUE ON PAGE 11A

183

(From page 8B)
10A

ANSWERS TO PAGE 8B - - a. S, b. L, c. S, d. G, e. L, f. G.

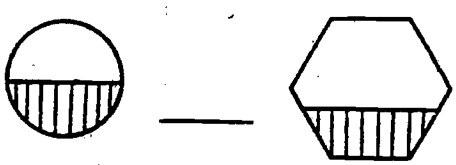
There are several general properties which <u>all matter has in common</u>. These are: volume, mass, universal attraction, weight, density, inertia, porosity, and impenetrability. Would steel have the same general properties as wood?

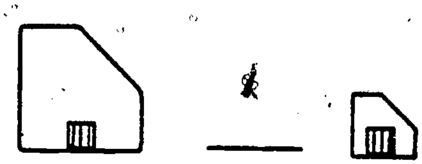
If your answer is:	Turn to page:
Yes	14B
No	12A

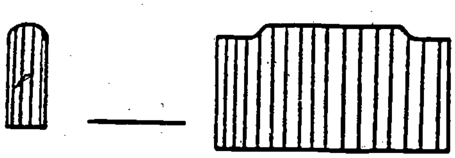
(From page 6A)
10B

RIGHT. As a quick review-- liquids assume the shape but not the volume; gas will take both the new shape and volume; a solid will not change either its shape or its volume. All these transfers from container to container can be shown by diagrams.

Identify the states of matter in the diagrams below. Use G for gas, L for liquid, and S for solid.

a. 

b. 

c. 

Turn to page 8B

(From page 9, frame 20)
11A

ANSWERS TO FRAME 20 - - atom, molecule

Identify each statement below as a description of either an element, compound, molecule, or atom. Write the name in the provided blank.

a. Something that is made up of several different elements.

____

b. A small particle that when combined with other particles of similar size makes a molecule. ______________________

c. This cannot be reduced to a simpler substance by chemical means. ______________________

d. The smallest part of a substance that retains all the properties of that substance. ______________________

TURN TO PAGE 14C

(From page 15A)
11B

Very good. Apparently you know how to use the magic circle. Any one of the three properties is just as easy to find. Turn to page 17A to check your understanding of the magic circle.

(From page 13A)
11C

Your answer, water, is incorrect. Remember that density is the weight per unit volume of matter. The density of mercury is 850 pounds per cubic foot, whereas fresh water has a density of 62.5 pounds per cubic foot. In other words, a unit volume of mercury (in this case, a cubic foot) weighs more than a unit volume of water; consequently, mercury is denser than water. Now return to page 13A and select the correct answer.

(From page 10A)
12A

Your answer, no, is incorrect. We said that there were several general properties which all matter has in common. Even though steel and water are different states of matter, they are still matter; and, therefore, have the same general properties. Return to page 10A and select the correct answer.

(From page 14B)
12B

You're right, very good. All matter occupies space; therefore, it has volume. The next general property we will cover is mass. The measure of the quantity of matter in a body is called its mass. The mass of a given body is constant-- it does not vary. As an example of mass, consider a sponge. It contains a definite measurable amount of mass. Whether we squeeze, stretch, or soak the sponge in water, the mass will not change, even though the size and shape may be altered. The amount of sponge will remain unchanged. In other words, the mass of the sponge will remain constant.

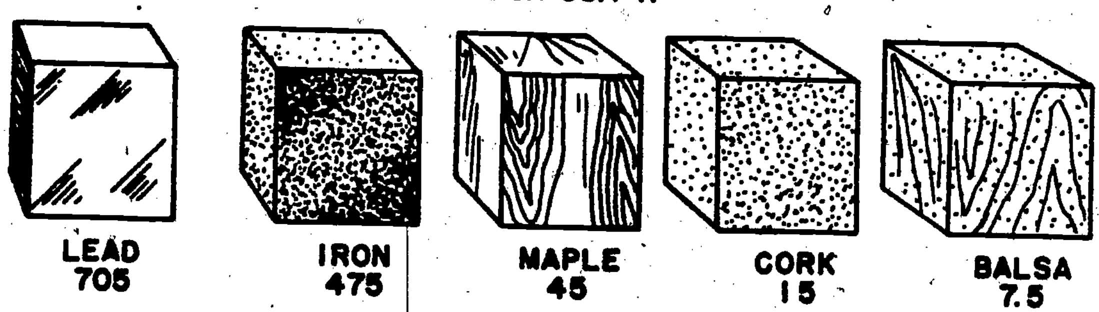
If you squeeze a rubber ball, you are also decreasing its mass.

If your answer is:	Turn to page:
True	18D
False	14A

(From page 16A)
13A

Weight is the attractive force of the earth for a body.

The next general property of matter we will cover is density. Density is the <u>weight of a unit volume of matter</u>. Iron is denser than wood. This means that one cubic foot of iron weighs more than one cubic foot of wood. The more matter (mass) there is in a given volume of a substance, the denser that material is. Shown below are some examples of densities.



Which would be denser, water or mercury?

If your answer is:	Turn to page:
water	11C
mercury	20B

(From page 6B)
13B

Wrong. The diagram shows that the liquid is assuming the shape and the volume. Liquids will assume the shape <u>and</u> the volume ONLY when the two containers have the same volume. This, of course, is not characteristic of liquids. Go back to page 6B and choose the correct answer.

(From page 12B)
14A

You selected false, and you're right. Always remember that the mass of a given body is constant. The next general property of matter we will cover is universal attraction. All matter attracts all other matter. This fact was first stated by Sir Isaac Newton, and it is known as Newton's law of universal gravitation. As an example, the earth is bound to the sun by the mutual attraction of the matter contained in the sun and the earth. Would universal attraction have anything to do with why we are bound to the earth?

If your answer is:	Turn to page:
Yes	16A
No	19B

(From page 10A)
14B

You are absolutely right. We said that the general properties of matter were common to all matter.
Let's now discuss each one of the general properties of matter, starting with volume.
If matter occupies space, as we found it does, it must have length, width, and height. In other words, volume is the measure of the amount of space which matter occupies.
Does gas have volume?

If your answer is:	Turn to page:
Yes	12B
No	15B

(From page 11A)
14C

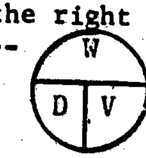
ANSWERS TO PAGE 11A: a. Compound b. Atom c. Element d. Molecule

This completes the program on matter. Review the objectives before taking the self-test.

18

(From page 16B)
15A

No. You can only put the other <u>two</u> values to the right of the = sign. Thus W=VD. The formula was derived like this---



W = DV

As you notice in the circle, the V and the D are side by side. They are also side by side when they are substituted in the formula. If you want to find the volume or the density, then your formula will change. What is the formula for finding volume?

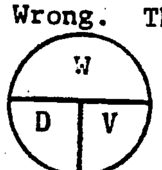
If your answer is:	Turn to page:
W = DV	17B
V = WD	19A
$V = \frac{W}{D}$	11B

(From page 14B)
15B

Wrong, think again. Doesn't the air, which is a gas, occupy a certain amount of space in a balloon? The CO_2 in a life raft occupies a certain amount of space, doesn't it? The volume of gas is determined by the size of the container in which it is contained and this quantity of volume is measured in cubic units, such as cubic inches, cubic feet, etc. Now return to page 14B and select the correct answer.

(From page 18A or 18C)
15C

Wrong. The formula for finding volume is <u>not</u> V = WD. The magic circle



has the W OVER the D. It would become $V = \frac{W}{D}$.

Turn to page 17A and continue the program.

234

(From page 14A)
16A

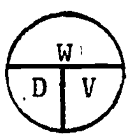
You're right. We are attracted to the earth, as is the earth attracted to us, by universal attraction (gravitation). Of course, the farther away from the earth's surface a body is, the less gravitational attraction there will be on that body.
Now, let's move on to the next general property of matter --- weight. The attraction of the earth for a body acts as a 'pull' on that body. We may say that the earth exerts an attractive force on the body. The measure of the attractive force of the earth for a body is called the weight of the body. As an example, if you weigh 145 pounds, the mass of your body and the mass of the earth mutually attract each other with a force of 145 pounds. Therefore, weight is the ____.

Turn to page 13A

(From page 19C)
16B

Answers from page 19C. -- 1 - G, 2 - E, 3 - F, 4 - A. 5 - B, 6 - C, 7 - D, 8 - H.

Now let me introduce you to the "Magic Circle."



W= Weight
V= Volume
D= Density

There is nothing magic about it, but it does make memory work a little easier. With it, we can find any ONE of three characteristics of matter (volume, density, or weight). You must know two in order to find the third. To do this, take the one you wish to find from the circle and place the letter to the left of the = sign. Then place the other two, just as they appear in the circle, to the right of the = sign. For instance, if you wish to find the weight of an object, take the W out of the circle, put an = sign after it, and place the remaining two known values after the = sign like this:

If your answer is:	Turn to page:
$W = \frac{W}{VD}$	15A
$W = DV$	18A
$W = \frac{V}{D}$	18C

(From page 11B, 15C, 18A, 18C, or 19A)
17A

Right! You should be ready for a test in writing formulas and the magic circle. If you don't feel you can derive a formula from the magic circle, return to page 16C and go through the frames on the magic circle again; otherwise, draw the magic circle and write the formula for finding density.

Magic Circle Formula

Turn to page 18B for answer

(From page 15A)
17B

W = DV is the formula for finding weight, not volume. The unknown must go to the left of the = sign; so, for finding volume, the V goes to the left (V=). Return to page 15A and select the correct formula as you get it from the magic circle.

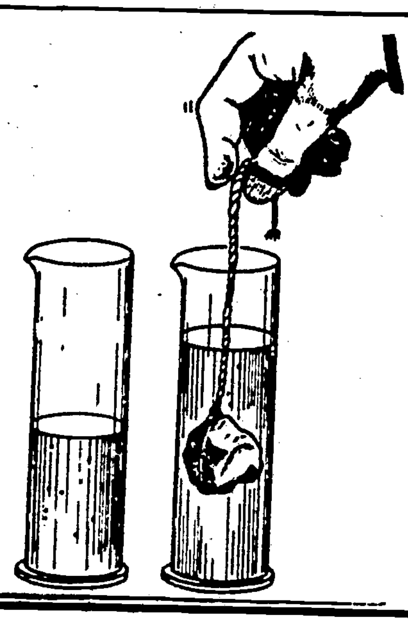
(From page 22A)
17C

Yes, water will seep through a cement block foundation unless the blocks are waterproofed because of the porous nature of cement.

The last general property of matter we will cover is impenetrability. No two objects can occupy the same space at the same time because all matter is impenetrable. A nail driven into a board does not penetrate the wood, but pushes the fibers aside. The drawing shown below illustrates the impenetrability of matter. Explain why. ______________

____

____



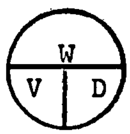
CONTINUE ON PAGE 22B

(From page 16B)
18A

Very good. As you have indicated by your formula, the W is taken from the magic circle and placed to the left of the = sign. The V and the D are side by side. This, of course, means volume times density = weight. If you were going to find the volume of an object, the formula would be:

If your answer is:	Turn to page:
$V = WD$	15C
$V = \frac{W}{D}$	17A

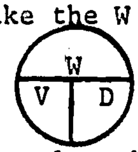
(From page 17A)
18B

ANSWERS TO PAGE 17A: 

and $D = \frac{W}{V}$

Turn to page 20A

(From page 16B)
18C

No. $W = \frac{V}{D}$ is not correct. If you take the W from the magic circle, to find weight you will have this --- 

The V and the D are side by side. It is also that way in the formula. W=DV means weight equals volume times density.

If you want to find the volume of an object, you substitute from the magic circle and have this formula:

If your answer is:	Turn to page:
$V = WD$	15C
$V = \frac{W}{D}$	17A

(From page 12B)
18D

Wrong. Remember, we said that the mass of a given body is constant; it does not vary. By squeezing the rubber ball, all we have done is change its volume. Now return to page 12B and select the correct answer.

(From page 15A)
19A

Draw a magic circle ... Now look at the W and the D. Are they side by side as you indicated in your formula? As you have noticed by now, the W is OVER the D with a line between them. The problem asked for the formula for finding volume. As you take the letters from the magic circle, they will fall right into their proper places and look like this:

$$V = \frac{W}{D}$$

Turn to page 17A and continue the program.

(From page 14A)
19B

Your answer, no, is incorrect. Remember, universal attraction means that all matter attracts all other matter. Therefore, we are bound to the earth's surface by a certain force because of the attraction between our bodies and the earth's surface.
Now return to page 14A and select the correct answer.

(From page 22B)
19C

Match the terms with the statements.

1. Weight________ J
2. Volume________
3. Mass ________
4. Universal attraction ______
5. Density________
6. Inertia________
7. Porosity_______
8. Impenetrability____

A. All matter attracts all other matter
B. The weight of a unit volume of matter
C. Matter lacks the ability to either start or stop itself.
D. All matter is granular (space between particles).
E. The measure of the amount of space which matter occupies
F. The measure of the quantity of matter in a body. It is constant.
G. The measure of the attractive force of the earth for a body
H. No two objects can occupy the same place at the same time.

CONTINUE ON PAGE 16B

(From page 18B)

20A

Draw the magic circle for weight, density, and volume, and write the formulas for finding weight, density, and volume.

Magic Circle here: Formulas here:

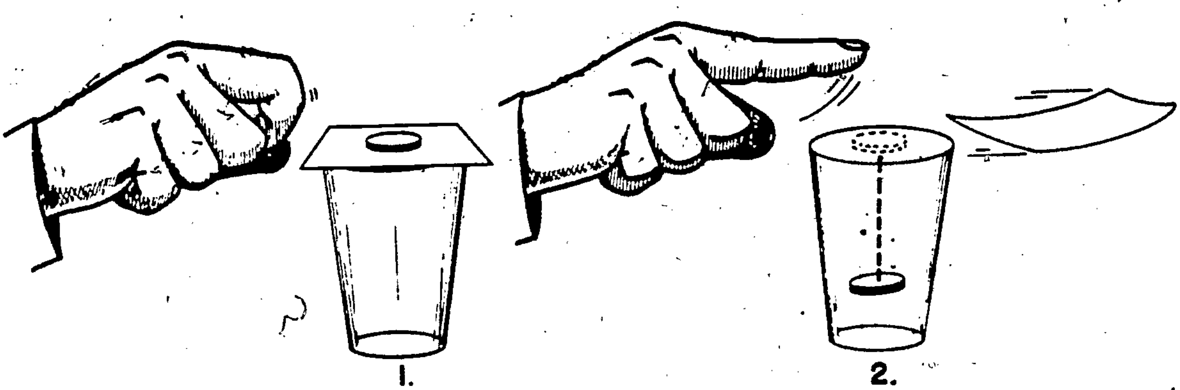
Turn to page 5, frame 11

(From page 13A)

20B

Very good. Mercury is denser than water. Remember, we said that density is the weight of a unit volume of matter. The density of water (fresh) is 62.5 pounds per cubic foot, whereas the density of mercury is approximately 850 pounds per cubic foot.

The next general property of matter we will cover is inertia. According to Newton's law of inertia, a body continues in its state of rest, or uniform motion, unless an unbalanced force acts on it. In other words, matter lacks the ability to either start or stop itself. Some examples of inertia are-- the inability to stop a speeding car when the brakes fail and the inability of an aircraft to make a carrier landing without arresting gear. In the sketch shown below, the inertia of the coin (inability to start itself) allows us to flick the card from under it, and the coin drops directly into the glass.



Would inertia ever be a factor on your body if you were a passenger riding in an automobile? Yes/No ___________

Give an example.____

____

____

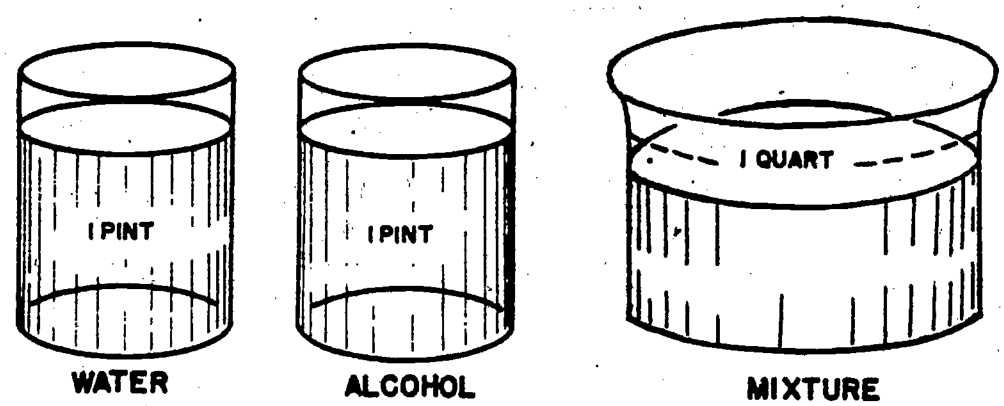
____

Turn to page 21A

(From page 20B)
21A

Yes, it would. An example might be as follows: if you were a passenger riding in a car traveling at 60 miles per hour and the car stopped suddenly, what would be the action of your body if you were not wearing seat belts? According to the law of inertia, a body in motion continues in motion unless acted upon by an outside force. Therefore, your body would be thrown forward and through the windshield. If the car accelerated suddenly, the action of your body would be being thrown against the back of the seat. These are both examples of inertia.

Porosity is the next general property of matter we will cover. <u>All matter is granular</u>, that is, it has space or pores between the particles. The amount of space between the particles depends upon the structure of the material. In the sketch shown below, notice that when a pint of water and a pint of alcohol are mixed, they do not equal a quart of the mixture.



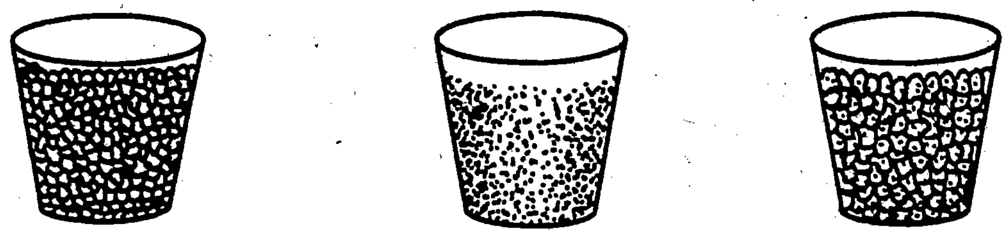
This would suggest that the alcohol partially fills the spaces between the particles of water.

CONTINUE ON PAGE 22A

195

(From page 21A)
22A

To illustrate the point more clearly, look at the illustration below.



If we had two similar containers, one filled with gravel and one filled with sand, and if both of these containers were emptied into a larger one, the container with the sand and gravel mixture would not be completely full, because the sand would fill the spaces between the gravel. Could water seep through the cement foundation of a house? Yes/No

Why? ______________________________

____

____

____

Continue on page 17C

(From page 17C)
22B

Impenetrability of matter is shown in the illustration because the water level rises. The object being lowered into the water takes some of the water's space, which indicates that no two objects can occupy the same place at the same time.

Continue on page 19C

SELF-TEST

MATTER

1. Write the definition of matter.

____

____

2. List the three states of matter.

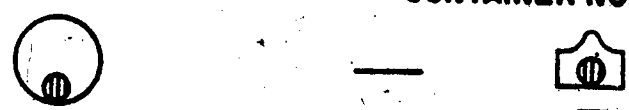
   1. ____________

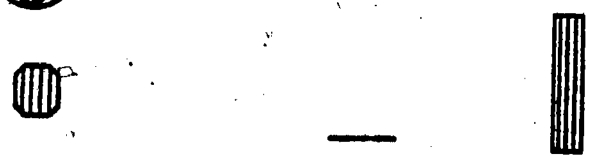
   2. ____________

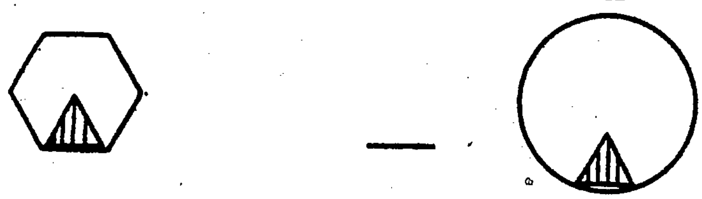
   3. ____________

3. Identify the state of matter by writing a G for gas, S for solid, and L for liquid in the spaces provided between each set of diagrams, showing the transfer of states of matter from container number 1 to container number 2. The lined area represents the space occupied by matter.

CONTAINER NO. 1 **CONTAINER NO. 2**

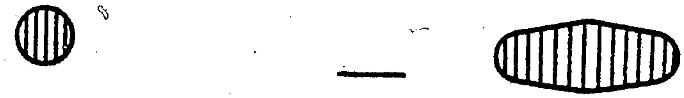
a. 

b. 

c. 

d. 

e. 

f. 

4. Match the terms volume, mass, universal attraction, weight, density, inertia, porosity, and impenetrability with the list of statements describing these terms.

1. Weight	_____	A. All matter attracts all other matter.
2. Volume	_____	B. The weight of a unit volume of matter.
3. Mass	_____	C. Matter lacks the ability to either start or stop itself.
4. Universal attraction	_____	D. All matter is granular (space between particles).
5. Density	_____	E. The measure of the amount of space which matter occupies.
6. Inertia	_____	F. The measure of the quantity of matter in a body. It is constant.
7. Porosity	_____	G. The measure of the attractive force of the earth for a body.
8. Impenetrability	_____	H. No two objects can occupy the same place at the same time.

5. Draw the "Magic Circle" for weight, volume, and density, and write the correct formula for finding each of them.

Weight ----

Draw the magic circle here

Volume ----

Density ---

6. Identify each of the following phrases or statements as an element, compound, molecule, or atom. Place the correct name in the space provided below the statement.

a. Matter that contains several different elements.

____

b. The smallest particle of an element that can combine with other particles to form molecules.

____

c. Water, trees, dirt, and snow are all examples of

______________________________.

d. Gold, hydrogen, and mercury cannot be reduced to a simpler substance by chemical means. They are known as

______________________.

e. A substance that is broken down to the smallest particle possible and still retains all the properties of that substance is a/an

______________________.

f. Each particle that combines with other particles to form a molecule is called a/an

______________________.

g. Matter that cannot be reduced to a simpler substance by chemical means is known as a/an

______________________.

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199

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BASIC PHYSICS ATOMIC STRUCTURE
and
STATIC ELECTRICITY

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245

PURPOSE OF STUDY GUIDES, WORKBOOKS, PROGRAMMED TEXTS AND HANDOUTS

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The STUDY GUIDE (SG) presents the information you need to complete the unit of instruction, or makes assignments for you to read in other publications which contain the required information.

The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

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20

ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by page and/or frame)	REVIEW QUESTIONS (by No)

OBJECTIVES

1. Write the definition of matter.
2. Define a molecule.
3. State the composition of a molecule.
4. Define an atom.
5. List the three parts of an atom and state which parts form the nucleus.
6. Write the name of the particle that has a positive (+) electrical charge and forms part of the nucleus of an atom.
7. Write the name of the particle that has no electrical charge (N) and forms part of the nucleus of an atom.
8. Write the name of the particle found in an atom that has a negative (-) electrical charge.
9. Define a neutral atom.
10. Define a positively charged atom.
11. Given sketches of atoms, select the atom(s) having a positive charge.
12. Briefly define a negatively charged atom.
13. Given sketches of atoms, select the atom(s) having a negative charge.
14. State briefly how the atomic number of an atom is determined.
15. Given sketches of atoms, determine the atomic number of each.
16. State briefly how the atomic weight (mass) of an atom is determined.
17. Given sketches of atoms, determine the atomic weight (mass) of each.
18. Define static electricity.
19. Explain briefly in writing how static electricity is produced.
20. List at least one (1) example of how static electricity is produced.
21. Write the law of charges that apply to static electricity.

20

22. List at least two (2) hazards of static electiricty that apply to aviation.

23. List at least three (3) devices used in aviation to reduce the hazards of static electricity.

SUGGESTED READING TIME 106 MINUTES

INTRODUCTION

Are you aware that sound, heat, light, electricity, and radio waves are really different from water, air, wood, glass, metals, and stone? Sound, heat, light, etc., are forms of energy, whereas water, air, wood, etc., are composed of matter. When reduced to its simplest terms, our whole physical universe is made up of just two things, energy and matter. During this lesson on Atomic Structure and Static Electricity, we shall explore a little of both these subjects.

Start program on next page

208

	1. Anything that occupies space and has weight is referred to as matter. The pencil you are writing with and the paper you are writing on are classified as ________.
matter	2. Matter, besides being in solid form such as your pencil, may also be in either liquid or gas form. Therefore, the air you breathe and the water you drink are also classified as ________.
matter	3. Matter, therefore, may be found in three forms, which are ________, ________, and ________.
solids, liquids, gases	4. The chair you are sitting on is an example of matter in the solid form. The ocean is an example of matter in the ________ form.
liquid	5. Therefore, anything around us is an example of matter in one form or another, because it all occupies space and has weight. Consequently, we say that matter is anything that occupies ________ and has ________.
space weight	6. The definition of matter is:

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Anything that occupies space and has weight.	7. If we could take some matter, any matter, and break it down to the smallest particle we possibly could, and when we had this very small particle it was still the same substance that we started with, we would then have a molecule. Therefore, the very smallest bit of glass that can still be identified as glass is a glass ________________.
molecule	8. The smallest particle of any matter that still contains all the properties of that matter is a molecule. The smallest bit of water that can be identified as water, is a water ________________.
molecule	9. Define a molecule:
The smallest particle of any matter that still contains all the properties of that matter.	10. Molecules are composed of smaller particles linked together. These smaller particles are known as atoms. For example, we already know that the smallest bit of water that contains all the properties of water is a molecule. But if we were to break down this molecule of water (H_2O), we would no longer have water, but instead we would have two atoms of hydrogen (H_2) and one atom of oxygen (O). Therefore, molecules are two or more ____________ linked together.

CONTINUE ON NEXT PAGE

20

atoms	11. If two or more atoms linked together form a molecule, then we could say that a molecule is composed of two or more ____________ linked together.
atoms	12. Molecules, therefore, are composed of two or more atoms ______________ together.
linked	13. Molecules are composed of:
Two or more atoms linked together.	14. All matter can be classified as either an element or a compound. As you have learned previously, an element is matter that cannot be broken down to any simpler substance. Some examples of elements are: gold, iron, hydrogen, oxygen. Compounds such as salt, sugar, paper, water are substances formed by a combination of elements. (NO RESPONSE REQUIRED)
	15. We said that water, which is a compound, is composed of hydrogen and oxygen. Hydrogen and oxygen **are** the elements which have combined to make the compound of water (H_2O). Sugar, which is a compound, is composed of the elements of carbon, hydrogen, and oxygen. In this case, carbon, hydrogen, and oxygen are the ______________ which combine to form the ______________ of sugar.

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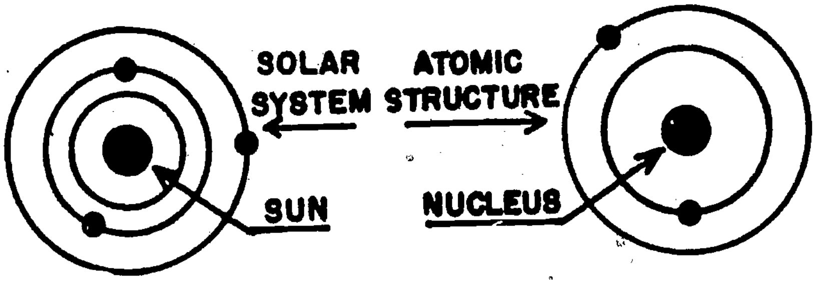
elements compound	16. If we were to take any of these elements, of which there are presently over 100 known, and tried to **break them down chemically**, it would meet with failure. As an example, no matter what is done to the element of carbon, you get nothing but carbon from it. The reason that carbon cannot be chemically reduced to a simpler substance is **that** carbon is an ________________.
element	17. The smallest particle of any of these elements is known as an atom. An atom is the smallest particle of an element that can combine with other atoms to form molecules. One molecule of water (H_2O), then, would be composed of three ____________, two hydrogen and one oxygen.
atoms	18. An atom is defined as:
The smallest particle of an element that can combine with other atoms to form molecules.	19. All atoms are composed of a number of parts. The core or **centermost** part is known as the nucleus. The nucleus of an atom may be compared to the sun in our solar system around which planets revolve. The nucleus also accounts for almost all the weight (mass) of an atom. In the sketch below, notice the resemblance of an atom to our solar system.  The core or **innermost** part of an atom is the ________________.

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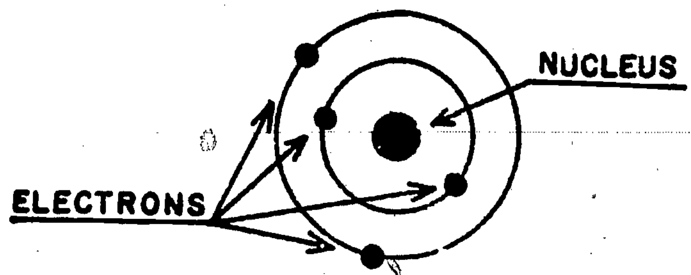
nucleus	20. The nucleus of an atom contains two of the three main parts of the atom. These two parts are the proton and the neutron. The two particles found in the nucleus of an atom are the ______ and the ______.
proton neutron	21. The third part of the atom is the electron. The electron revolves or orbits around the nucleus, as shown in the sketch below.  The part of the atom which orbits around the nucleus is the ______.
electron	22. The parts of the atom that form the nucleus are the ______ and ______ and the part which revolves around the nucleus is the ______.
proton neutron electron	23. List the three parts of an atom. 1. 2. 3. The nucleus is composed of the ______ and ______.

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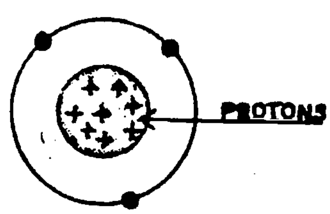
1. Proton 2. Neutron 3. Electron proton neutron	24. The proton, which is one of the particles found in the nucleus, makes up part of the weight or mass of an atom. The proton, which makes up part of the weight or mass of an atom, is found in the ________________.
nucleus	25. The number of protons found in the nucleus usually depends on the type of material in question. As an example, gold has 79 protons in the nucleus, whereas carbon **has only** 6. As you can see by these figures, the weight of an element is partly determined by the protons, gold being heavier than carbon. One of the particles found in the nucleus of an atom that makes up part of the weight or mass is the ________________.
proton	26. The proton has a positive electrical charge; the symbol used for the proton is (+). Below is an example of how the symbol for the proton is used when sketching an atom.  The proton is the particle found within the nucleus of an atom that has a ________________ electrical charge and the symbol is __________.

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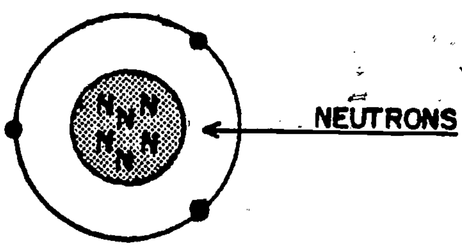
positive +	27. The particle found within the nucleus of an atom, that has a positive (+) electrical charge is the ________________.
proton	28. The neutron is the other particle found in the nucleus of an atom. The neutron, along with the proton, **forms** almost all the weight or mass of an atom. Almost all the weight of an atom is found in the ________________, which is made up of protons and ________________.
nucleus neutrons	29. The neutron is electrically neutral. It has neither a positive nor a negative electrical charge and the symbol for the neutron is N. Shown below is an example of how the symbol for the neutrons would be used when sketching an atom.  The neutron is the particle found within the nucleus of an atom that is electrically ________________ and the symbol is __________.

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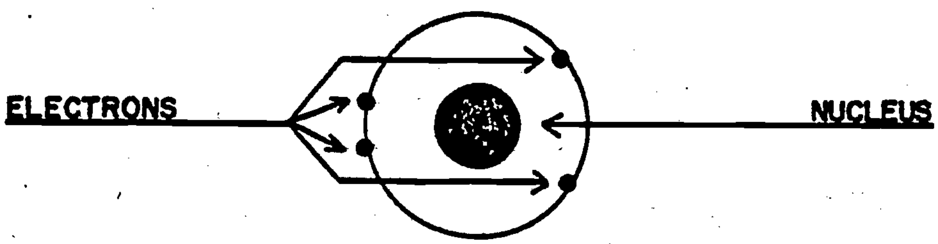
neutral N	30. The name of the particle that has no electrical charge (N) and is found in the nucleus of an atom is the ________________.
neutron	31. The third part of an atom is the electron. Electrons are the particles that are in orbit around the nucleus. The following sketch shows how the electrons might look in relation to the rest of the atom:  The part of the atom that orbits or revolves around the nucleus is the ________________.
electron	32. Earlier we said that almost all the weight of an atom was found in the nucleus. The weight of an electron, in relation to the rest of the atom, is insignificant. In reality, an electron weighs about 1/1845 as much as a proton. The weight of an ________________ is insignificant in relation to the overall weight of an atom.

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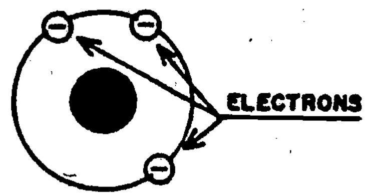
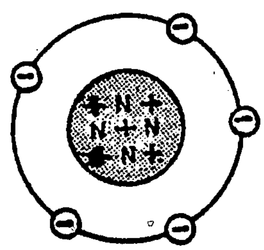
electron	33. Electrons have a negative electrical charge; the symbol for the electron is (-). Shown below is an example of how the symbol for the electron would be used when sketching an atom.  The electron is the part of an atom that orbits or revolves around the nucleus. It has a ________ electrical charge; the symbol being ______.
negative (-)	34. The name of the part of an atom that has a negative electrical charge is the ________.
electron	35. Up to this point, we have been talking about the individual parts of an atom. Now let's combine all these parts and see how an atom really looks. In the sketch of an atom shown below, note the location of the various parts.  Remember that the proton (+) and the neutron (N) form the nucleus of an atom and the electrons (-) are in orbit or revolving around the nucleus. In the space provided, draw a picture of an atom having five (5) protons, four (4) neutrons, and five (5) electrons.

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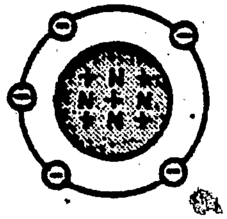
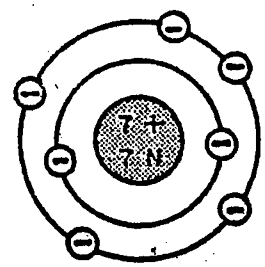


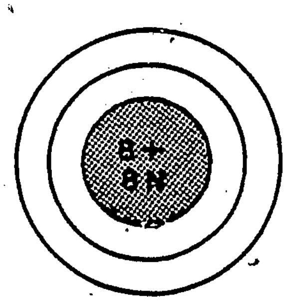
36. The orbits that the electrons make around the nucleus are referred to as <u>shells</u>. There may be any number of these shells, up to seven (7), each shell having a number of electrons orbiting in it. Below is an example. The atom shown is one of nitrogen. Notice this atom has two (2) shells, the outer one having five (5) electrons and the inner one having two (2) electrons.



The paths in which the electrons orbit are referred to as ________________.

shells

37. As we already know, an atom may have a number of shells with a number of electrons orbiting in each shell, but under <u>normal conditions</u>, the number of electrons found in an atom will be the same as the number of protons. In other words, normally there is one electron for each proton. In the sketch shown below, assuming conditions are normal, there should be how many electrons in orbit? (Circle correct answer.)



a. 8   b. 16

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a. 8	38. Even though, under normal conditions, there should be one electron for each proton, this does not have any influence on the number of neutrons in the nucleus. In some atoms, there may be the same number of neutrons as there are protons, while in other atoms, there may be more neutrons than protons. Some examples of this are: Nitrogen 7 protons (+) and 7 neutrons (N) and gold 79 protons (+) and 118 neutrons (N). Even though there may be more or less neutrons than there are protons in an atom, under normal conditions there should be one ________________ for each ________________.
electron proton	39. Since the proton (+) is a positively charged particle and the electron (-) is a negatively charged particle, the atom under normal conditions should be electrically neutral. Atoms, then, under normal conditions, are said to be electrically ________________.
neutral	40. The reason that under normal conditions atoms are said to be electrically neutral is that there are the same number of protons as electrons and the positive electrical charges of the protons balance out the negative electrical charges of the electrons. Therefore, a neutral atom is one that has the same number of ____________ as ________________.

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protons electrons	41. A neutral atom is one that ______________ ______________.
has the same number of protons as electrons.	42. Now that we know what a neutral atom is, let's talk about a positively charged atom. A positively charged atom is one having a deficiency (fewer) of electrons. If an atom has fewer electrons than protons, it would be ______________ charged.
positively	43. Atoms having a positive charge are the result of an atom losing one or more of the orbiting electrons. In some atoms, the electrons that are in the shell **farthest** from the nucleus are very loosely bound to the nucleus and, therefore, are comparatively free to move from atom to atom. The electrons that move from atom to atom are called free electrons. Electrons that move comparatively **easily from atom** to atom are ______________ ______________.
free electrons	44. **Because** these free electrons are able to move from atom to atom, we find then that it is possible to have an atom that is deficient in electrons. In other words, if we had a neutral atom, and it lost one or more of its electrons, then the atom would be deficient in electrons, or it would have fewer electrons than protons. An atom having a deficiency of electrons is one that has ______________ electrons than protons.

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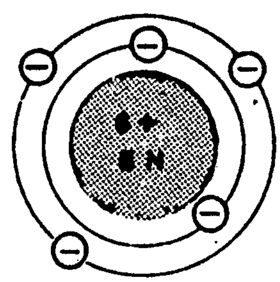
fewer	45. Now we already know that protons have a positive electrical charge and electrons have a negative electrical charge. If we had a neutral atom (one having the same number of protons as electrons) and it lost one or more of its orbiting electrons, then the result would be an atom having a deficiency of electrons, or fewer electrons than protons, which in turn would result in a positively charged atom. Therefore, a positively charged atom is one having a deficiency of ________________.
electrons	46. Write the definition of a positively charged atom.
An atom having a deficiency of electrons.	47. Keep in mind, now, that a positively charged atom is one having a deficiency of electrons. Shown below is a sketch of what a positively charged atom might look like.  Notice there are six (6) protons in the nucleus, but only five (5) electrons in orbit. This, then, is a positively charged atom, because it has a deficiency of electrons. In the space provided below, draw and label a positively charged atom.

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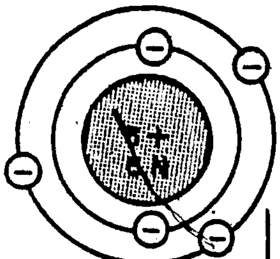
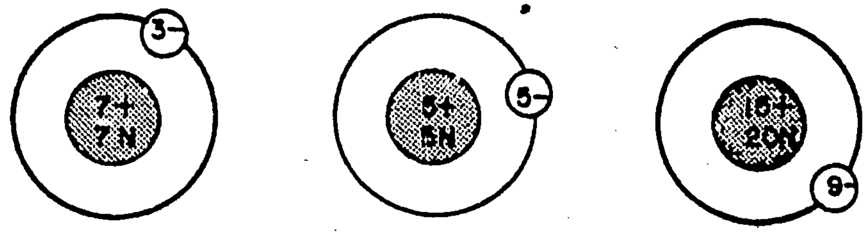
 OR EQUIVALENT	48. From the sketches shown below, select the atom(s) having a positive electrical charge.  A B C
A & C	49. Up to this point, we have been talking about neutral atoms and positively charged atoms; now let's find out what a negatively charged atom is. A negatively charged atom is one having an excess of electrons (more electrons than protons). If an atom had more electrons than protons, it would be ____________ charged.
negatively	50. Earlier we talked about free electrons moving from atom to atom. Well, if one or more free electrons moved to an atom that was neutral, in other words, one having the same number of protons as electrons, the result would be an atom having an excess of electrons, or more electrons than protons. If a free electron moved to an already neutral atom, the result would be an atom with an ____________ of electrons.

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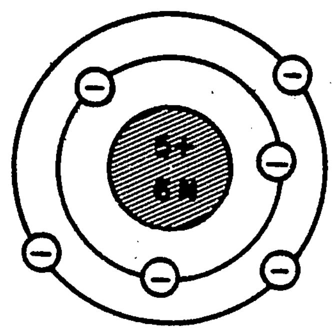
excess	51. Therefore, if an atom has an excess of electrons (electrons being negatively charged), the result would be an atom having more negatively charged electrons than positively charged protons, and in turn the entire atom would have a negative charge. If an atom has more electrons than protons, it is said to be ______________ charged.
negatively	52. Define a negatively charged atom.
An atom having an excess of electrons.	53. Remember, now, that a negatively charged atom is one having an excess of electrons. Shown below is a sketch of what a negatively charged atom might look like.  Notice there are five (5) protons in the nucleus, but there are six (6) electrons in orbit. This, then, is a negatively charged atom, because there is an excess of electrons. In the space provided, draw and label a negatively charged atom.

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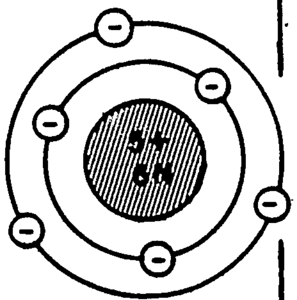
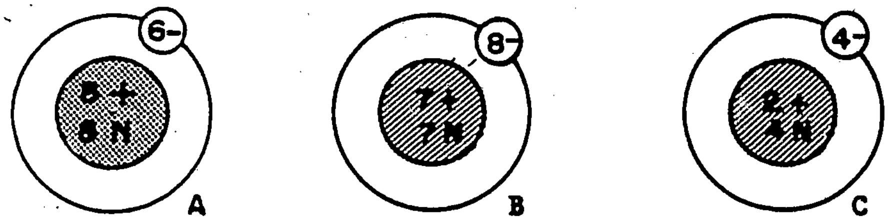
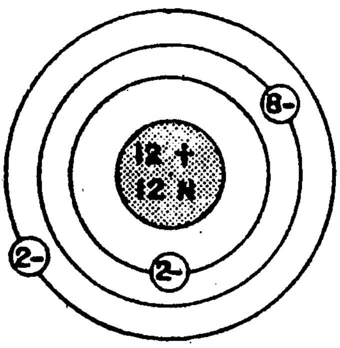
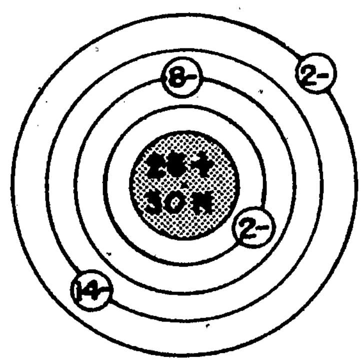
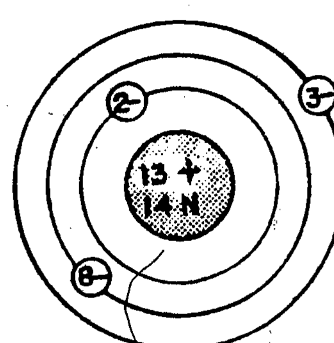
	54. From the sketches shown below, select the atom(s) having a negative electrical charge. 
B & C	55. All elements are listed under what is called the "Periodic Table of Elements". This is an orderly arrangement of all the elements in ascending <u>atomic number</u>. This is what we are going to talk about now. The atomic number of an atom is determined by the number of protons found in the nucleus. Knowing the number of protons in the nucleus of an atom will give us the atomic ________________.
number	56. Each element has an atomic number, which we said can be determined by the number of protons in the nucleus. In the carbon atom, for example, there are six (6) protons. Therefore, the atomic number of carbon is six (6). To determine the atomic number of an element, we can count the number of ________________ in the nucleus.

CONTINUE ON NEXT PAGE

22

protons	57. State briefly how the atomic number of an atom is determined.
By counting number of protons in the nucleus.	58. Knowing the number of protons in the nucleus, then, will give us the atomic number of an atom. The atomic number of the atom shown below would be: (Circle correct answer.) a. 8 b. 12 c. 24 d. 2 
b. 12	59. Determine the atomic number of each of the atoms shown below. A  Atomic Number ________ B  Atomic Number ________

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A. 26 B. 13	60. Along with the fact that the elements are listed by their atomic number, they are also listed in the "Periodic Table of the Elements" by their <u>atomic weight or mass</u>. To determine the atomic weight (mass) of an element, all that is necessary is to count the total number of particles (protons and neutrons) found in the nucleus. Counting the total number of particles (protons and neutrons) found in the nucleus of an atom will determine the atomic ________________.
weight (mass)	61. For example: The copper atom has 29 protons and 35 neutrons contained within the nucleus. To determine the atomic weight of copper, we simply add the number of protons to the number of neutrons to obtain the total number of particles in the nucleus. The atomic weight (mass) of copper, then, would be 64. To determine the atomic weight (mass) of an element, we must count the total number of ________________ found in the nucleus.
particles (protons, neutrons)	62. The atomic weight of an atom is determined by:

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Counting total number of particles in the nucleus.

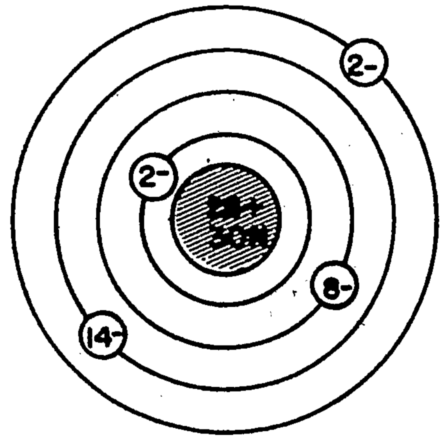
63. If the atomic weight (mass) of an atom is determined by finding the total number of particles found in the nucleus, the atomic weight of the atom shown below would be:

a. 26

b. 30

c. 14

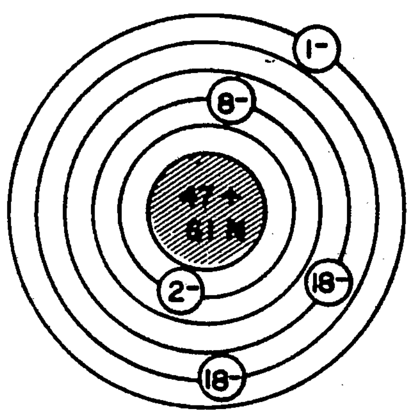
d. 56



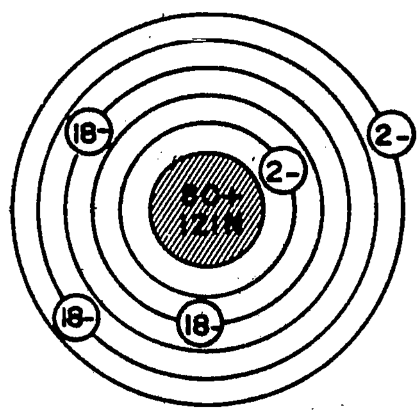
d. 56

64. From the sketches of atoms shown below, determine the atomic weight (mass) of each.

A



B



Atomic Weight ________

Atomic Weight ________

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A. 108 B. 201	65. Now that we have covered the portion of the program that applies to **atomic structure**, let's find out what **atomic structure** has to do with electricity. No response required.
	66. In the remaining portion of this program, we will be learning about the most basic type of electricity, which is **static electricity** (electricity at rest). The next portion of this program is about ______ ______________.
static electricity	67. The occurrence of static electricity or electrification can be observed in a number of ways. You sometimes experience an annoying shock when you touch the door handle of an automobile after sliding over plastic seat covers. You may feel a shock after walking across a wool carpet and touching a metal door knob or other metal object. The slight crackling sound that is heard when dry hair is brushed and a tendency of sheets of paper to resist separation are other examples of the occurrence of electricity. Static electricity or electrification is the process of producing an electric charge on an object. The object is said to be charged with electricity. Because this charge is confined to the object, it is ~~said~~ to be an electrostatic charge. Thus, static electricity is electricity at rest. No response required.

CONTINUE ON NEXT PAGE

22

	68. The word "static" means not moving or at rest. Therefore, **static electricity** means electricity at ________.
rest	69. Electricity that does not move is known as ________ ________.
static electricity	70. Static electricity is ________ ________.
electricity at rest.	71. Static electricity is produced by <u>friction</u>. The friction of one object passing across another object will produce ________ ________.
static electricity	72. Rubbing a glass rod across a piece of silk will cause friction between the glass and the silk. This will produce ________ ________.
static electricity	73. To produce static electricity, you have to have ________ between two or more objects.
friction	74. How is static electricity produced? ________ ________
By friction between two c·· more objects.	75. We have already learned that friction between glass and silk would produce static electricity. Also, the air passing over the skin of an aircraft will produce ________ ________.

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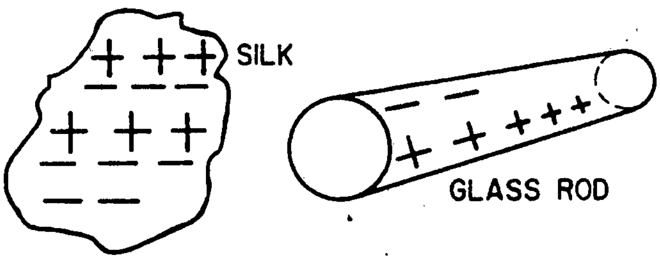
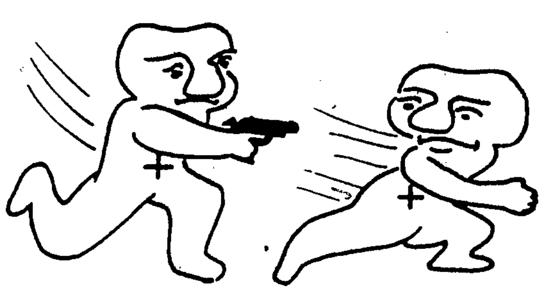
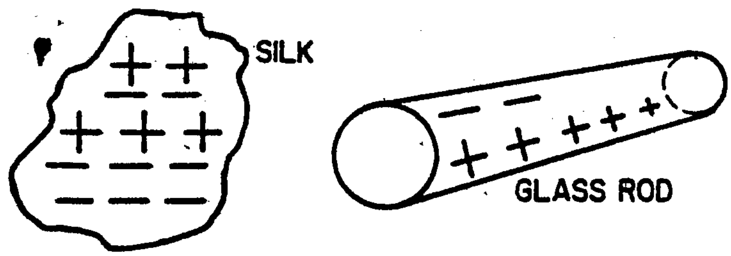
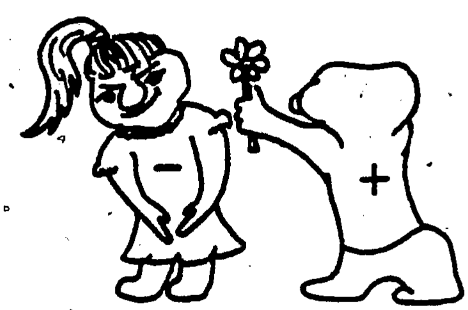
static electricity	76. List one example of how static electricity is produced. ________________ ________________
Rubbing glass across silk. Air passing over an aircraft or equivalent.	77. Static electricity, even though it is at rest, will have some kind of a charge. This charge will either be positive or negative, depending on the amount of electrons. The charge will depend on the amount of ________________.
electrons	78. If our object is positively charged, it will have a deficiency of electrons. Which of the two objects below is positively charged?  ________________
glass rod	79. If two objects are positively charged, they will repel or push each other away. This is the first law of charges. Like charges will ________________.
repel	80. The first law of charges is: ________________ ________________
	

CONTINUE ON NEXT PAGE

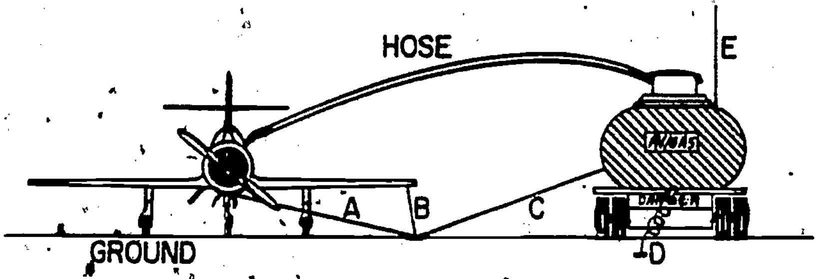
<table>
<tr><td>Like charges repel</td><td>81. The second type of charge is the negative charge. An object is said to have a negative charge if there is an excess of electrons. If an object has an excess of electrons, it is ________ charged.</td></tr>
<tr><td>negatively</td><td>82. Which of the two objects below has a negative charge?


________</td></tr>
<tr><td>The silk</td><td>83. The second law of charges is: <u>Unlike charges attract</u>. If you had two objects, one negatively charged and the other positively charged, what would happen? ________
</td></tr>
<tr><td>They would attract each other.</td><td>84. The second law of charges is: ________
________</td></tr>
</table>

CONTINUE ON NEXT PAGE

Unlike charges attract.	85. Usually, these two laws are written as one. This is: Like charges repel, unlike charges attract. Write the law of charges that apply to static electricity. ______________________ ______________________
Like charges repel, unlike charges attract.	86. We already know that if two objects are charged, one positive and the other negative, these objects will attract each other. When these two objects are brought together, the charges will try to equalize out. When this happens, there will be a small spark between the two objects. This spark is the hazard of __________ __________________.
static electricity	87. Static electricity, although of no practical value in aviation, is always present as a hazard. Static electricity around aircraft is always a _________.
hazard	88. The small spark that is the hazard of static electricity could, and sometimes does, cause fires. The greatest hazard of static electricity around aircraft is ____________.
fire	89. Fire, of course, is the greatest hazard of static electricity. Static electricity will also cause radio interference and it could also shock you. The three hazards of static electricity are: __________, ____________, and ______________

CONTINUE ON NEXT PAGE

fire, shock, and radio interference.	90. Now that we know what the hazards of static electricity are, and we also know that static electricity is of no practical value to us, we must now learn how to guard against static electricity. No response required.
	91. There are several devices used to reduce the hazards of static electricity. The first is the <u>grounding wire</u>. The first device we are going to learn about is the _____________ _____________.
grounding wire	92. A grounding wire is a conductor used to connect an object to the earth to eliminate static charges. The chain hanging off the back of a gasoline truck is an example of a _____________ _____________.
grounding wire	93. A grounding wire is used to connect airplanes and fuel trucks to the earth during refueling. In the drawing in this frame, there are four (4) grounding wires being used. Which of the labeled lines represent grounding wires?  _________ _________ _________ _________

CONTINUE ON NEXT PAGE

A, B, C, & D	94. List the device used to connect an object to the earth. _______________.
grounding wire	95. The next device used to connect an aircraft to the ground is the static conductor tire. The device that grounds the aircraft during landings is the _______ _______ _______.
static conductor tire	96. The static conductor tire is a tire with powdered carbon mixed in with the rubber. The carbon is what grounds the airplane. A tire with carbon in it is called a _______________
static conductor tire	97. List the two devices used to reduce the hazards of static electricity that we have covered so far. _______________ and _______________.
Grounding wire Static conductor tire	98. The next device is the bonding wire. A bonding wire is a conductor that is used to connect parts of a plane that are normally insulated from each other. To connect a part to an aircraft so no buildup of charges would occur, a _______ _______ would be used.
bonding wire	99. Usually, radios are installed in aircraft on rubber mounts. The rubber mount insulates the radio from the aircraft. This is one case where a _______ _______ would be used.

CONTINUE ON NEXT PAGE

23

bonding wire	100. List the devices used to connect parts of a plane that are insulated from each other. ____________ ____________.
bonding wire	101. The last device is the <u>static discharger</u>. The static discharger is a rubber-covered cotton wick impregnated with graphite. A cotton wick that is impregnated with graphite and covered with rubber is a ____________ ____________.
static discharger	102. The static discharger is attached to the trailing edge of wings, rudders, and elevators. There are as many as necessary installed on an aircraft. The device installed on the trailing edge of an aircraft wing is a ____________ ____________.
static discharger	103. The static discharger has a sharp point on the end and this gives the excess electrons a path to flow off the aircraft. To permit a rapid discharge of electrons, the ____________ ____________ has a sharp point on the end.
static discharger	104. The main purpose of a static discharger is to eliminate the static charge that is built up during flight. To eliminate the charge on an aircraft during flight, a ____________ ____________ is used.

CONTINUE ON NEXT PAGE

static discharger	105. List the device used to eliminate static charges on an aircraft during flight. ______________ ____________________.
static discharger	Now, let's review all we have covered on **atomic structure and static electricity.**
	106. Anything that occupies space and has weight is referred to as ________________.
matter	107. Matter may be found in three (3) forms and these are ______________, ________________, and ________
solids, liquids, gases	108. Matter, then, is anything that ________________ space and has ________________.
occupies weight	109. The smallest particle of any matter that still contains all the properties of that matter is a ___________________.
molecule	110. The smallest bit of water that can be identified as water is a water ___________________.
molecule	111. Therefore, a molecule is the __________________ particle of any matter that still contains all the ____________________ of that matter.
smallest properties	112. Molecules are composed of smaller particles linked together. These smaller particles are known as _______________.

CONTINUE ON NEXT PAGE

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atoms	113. Two or more atoms linked together will compose a ______.
molecule	114. Molecules, therefore, are composed of two or more atoms ______ together.
linked	115. The smallest particle of any element is known as an ______.
atom	116. Therefore, an atom is the smallest particle of an element that can combine with other atoms to form ______.
molecules	117. An atom is composed of three (3) parts, which are the ______, ______, and ______.
proton neutron electron	118. The two particles found in the nucleus of an atom are the ______ and the ______.
proton neutron	119. The name of the particle found in the nucleus of an atom that has a positive electrical charge is the ______.
proton	120. The proton has a positive electrical charge and is found in the ______ of an atom.
nucleus	121. The name of the particle found in the nucleus of an atom that is electrically neutral is the ______.

CONTINUE ON NEXT PAGE

neutron	122. The neutron has no electrical charge and it is found in the ______________ of an atom.
nucleus	123. The name of the particle that has a negative electrical charge and is in orbit around the nucleus of an atom is the ______________.
electron	124. The electron has a negative electrical charge and is found in __________ around the nucleus of an atom.
orbit	125. An atom having the same number of protons as electrons is said to be a ______________ atom.
neutral	126. A neutral atom is one having the same number of ______________ as ______________.
protons electrons	127. An atom having a deficiency of electrons is said to be a ______________ charged atom.
positively	128. A positively charged atom is one having __________ electrons than protons.
fewer or less	129. An atom having an excess of electrons is said to be a ______________ charged atom.
negatively	130. A negatively charged atom is one having __________ electrons than protons.
more	131. If we counted the number of protons in the nucleus of an atom, this would give us the atomic ________.

CONTINUE ON NEXT PAGE

23

number	132. Therefore, the atomic number of an atom can be determined by counting the number of ________ in the nucleus.
protons	133. By counting the total number of particles found in the nucleus of an atom, this would give us the atomic ________.
weight	134. Therefore, the atomic weight of an atom is determined by counting ________ ________ found in the nucleus.
all or total number of particles	135. Static electricity is electricity at ________.
rest	136. Static electricity is produced by ________.
friction	137. List one example of how static electricity is produced. ________ ________.
Rubbing a glass rod with silk or equivalent.	138. Write the law of charges that apply to static electricity. ________ ________
Like charges repel, unlike charges attract.	139. List the hazards of static electricity around air-craft. ________ ________

CONTINUE ON NEXT PAGE

Fire, shock, and radio interference.	140. List the devices used to reduce the hazards of static electricity around aircraft. ____________ ______________________ ______________________
Grounding wire, bonding wire, static discharger, static conductor tire (any order)	141. This is the end of your lesson on Atomic Structure and Static Electricity. If there is anything you did not understand, refer ~~back~~ to the page or pages covering that subject. Finally, return to the objectives on pages ii and iii, and if you think you can do what they require of you, then you are ready for the Self-Test.

CONTINUE ON NEXT PAGE

23

ATOMIC STRUCTURE
AND
STATIC ELECTRICITY

SELF-TEST

1. Write the definition of matter. ______

______

2. A molecule is defined as: ______

______

3. State the composition of a molecule. ______

______

4. Write the definition of an atom. ______

______

5. The three parts of an atom are:

   1.

   2.

   3.

   The nucleus is composed of which parts? ______

______

6. The name of the particle that forms part of the nucleus of an atom and has a positive electrical charge (+) is the

______

7. Write the name of the particle that forms part of the nucleus of an atom and has no electrical charge (N).

______

8. The name of the particle found in an atom that has a negative electrical charge (-) is

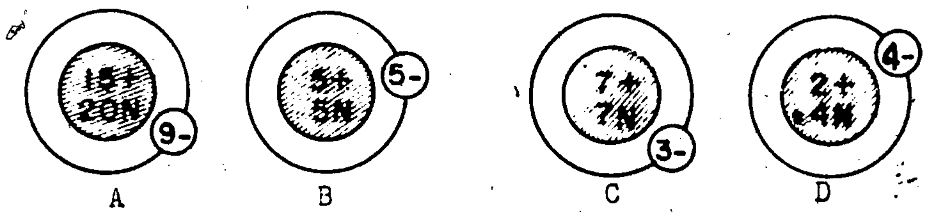
______

9. Briefly define a neutral atom.

CONTINUE ON NEXT PAGE

10. A positively charged atom is one defined as:

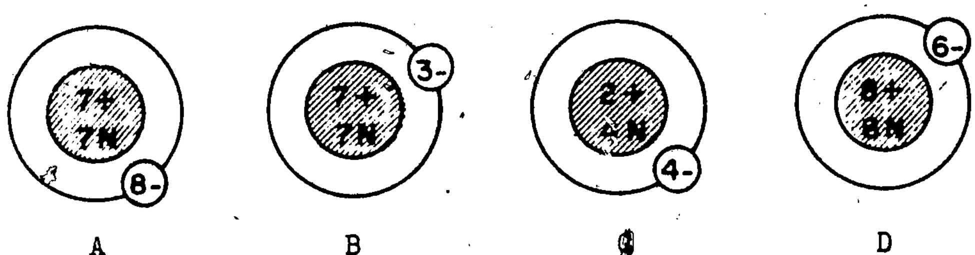
11. From the sketches of atoms shown below, select the atom(s) which have a positive electrical charge.



Write your selection(s) here. ______________________

12. The definition of a negatively charged atom is:

13. From the sketches of atoms shown below, select the atom(s) which have a negative electrical charge.

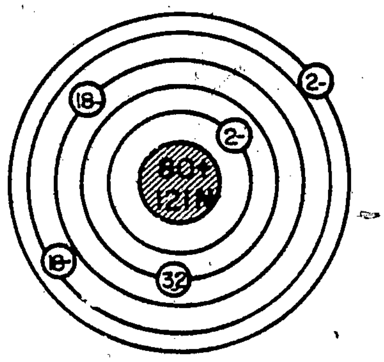


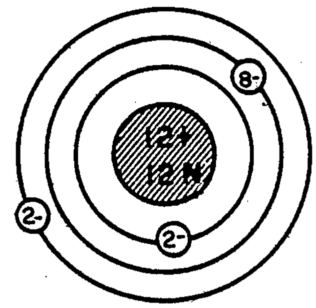
Write your selection(s) here. ______________________

14. State briefly how the atomic number of an atom is determined.

CONTINUE ON NEXT PAGE

15. From the sketches of atoms shown below, determine the atomic number of each.

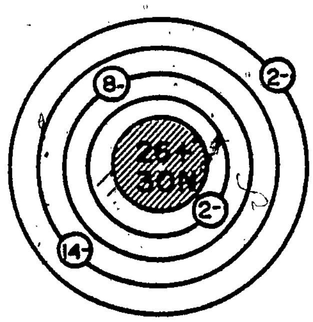


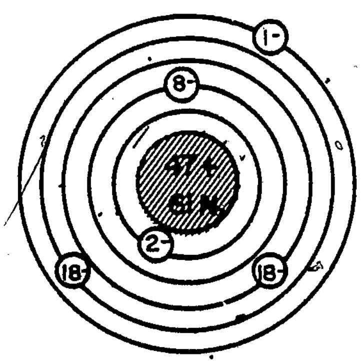


Atomic Number ________ Atomic Number ________

16. State briefly how the atomic weight (mass) of an atom is determined.

17. From the sketches of atoms shown below, determine the atomic weight (mass) of each.





Atomic Weight ________ Atomic Weight ________

CONTINUE ON NEXT PAGE

18. Define static electricity. ______________________________

____

19. Explain briefly, in writing, how static electricity is produced.

____

____

20. List at least one example of how static electricity is produced.

____

____

21. Write the law of charges that apply to static electricity.

____

____

22. List at least two hazards of static electricity that apply to aviation.

______________________________ ______________________________

______________________________ ______________________________

23. List at least three devices used in aviation to reduce the hazards of static electricity.

____

____

____

____

PREPARE THE MAN

PROGRAMMED TEXT 3ALR91630-I-4a (6)

Department of Medicine
School of Health Care Sciences

Technical Training

CARDIOPULMONARY LABORATORY SPECIALIST

BASIC PHYSICS

WORK, POWER, AND ENERGY

(ELECTRICAL)

July 1973

10-6

SHEPPARD AIR FORCE BASE

Original Material Prepared
by
Naval Air Technical Training Command
(2TPT-5120-05)

Designed For ATC Course Use

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PREPARE THE MAN

2TPT-5120-05

Technical Training

BASIC PHYSICS

WORK, POWER, AND ENERGY

(ELECTRICAL)

May 1967

SHEPPARD AIR FORCE BASE

Original Material Prepared
by
Naval Air Technical Training Command

Designed For ATC Course Use

244

ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by page and/or frame)	REVIEW QUESTIONS (by No)

WORK, POWER AND ENERGY

(Electrical)

OBJECTIVES:

1. State the basic formula for electrical power.
2. State the unit of measurement for electrical power.
3. State the relationship of horsepower to watts.
4. Given selected values of voltage, current and/or resistance, solve for electrical power in watts and horsepower.
5. Define efficiency.
6. Given power in and power out, solve for the efficiency of a motor.

FORMULAE FOR WORK, POWER, AND ENERGY

1. Electrical power = volts x amperes
2. Electrical horsepower - 746 watts
3. $P = E \times I$
4. $P = I^2R$
5. $P = \frac{E^2}{R}$
6. Efficiency = $\frac{\text{output}}{\text{input}} \times 100$

SUGGESTED READING TIME 60 MINUTES

1A

Whenever an electric current flows through a resistance, heat is generated. Heat is a form of energy and, since energy cannot be created, the heat must be produced by a conversion of energy from the electric energy to the form of heat energy.

The soldering iron with which you have been working converts electrical energy to heat energy. In this case, we use the heat energy to do work. The lights in this room convert electrical energy to light energy. A motor converts electrical energy to mechanical energy. And a generator converts mechanical energy to electrical energy.

In our study of mechanical work, power, and energy, we learned that power is the time rate of doing work or consuming energy.

The formula for solving the amount of power used is:

Power = $\frac{\text{work}}{\text{time}}$. page 3A

Power = work x time. page 5B

1B

YOUR ANSWER: The watt, then, is the time rate for doing electrical work.

Yes, this is true. But this answer is not the most correct answer.

Return to page 3A and select the answer that tells a more complete story than this one does.

2A

YOUR ANSWER: Watt.

Quite right.

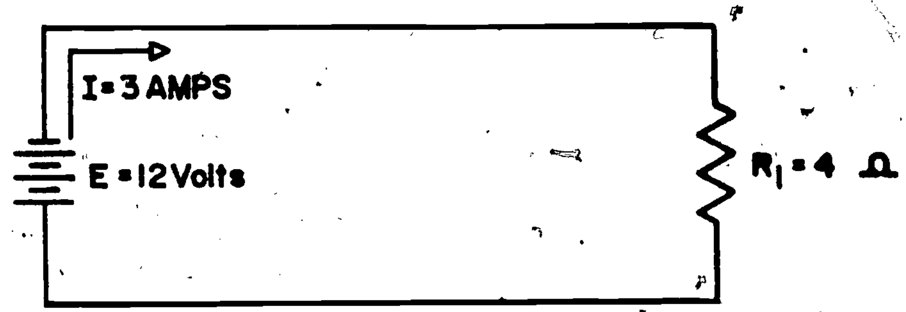
When we say that 746 watts equal one horsepower, we mean that the power consumed by an electrical device may be expressed in equivalent horsepower.

For example: Consider the power consumed by a large motor that draws 125 amperes from a 600-volt circuit.

$$P = E \times I = 600 \times 125 = 75,000 \text{ watts.}$$

This may be expressed in equivalent horsepower as

$$\frac{75,000 \text{ watts}}{746 \text{ (watts in 1 hp)}} = 100.2 \text{ hp}$$



How much power is consumed in the circuit above?

36 watts. page 4A

12 watts. page 6B

3A

YOUR ANSWER: Power = $\frac{\text{work}}{\text{time}}$.

Right.

The unit of electrical power is the WATT, named after James Watt. One watt of power equals the work done in one second by one volt of potential difference in moving one coulomb of charge. Since one coulomb per second is an ampere, power in watts equals the product of amperes times volts. Thus:

Power in watts = volts x amperes

or

$$P = E \times I$$

Where P is power in watts, E is voltage and I is the intensity of current flow.

The watt then is:

the time rate for doing electrical work.	page 1B
the time rate for consuming electrical energy.	page 6A
both the above.	page 5A

3B

YOUR ANSWER: 100 watts.

Our answer to your answer. How come?

You have already solved a similar problem, using the formula P = E x I, or you couldn't have gotten to the preceding page. Once more, P = E x I, NOT P = IR.

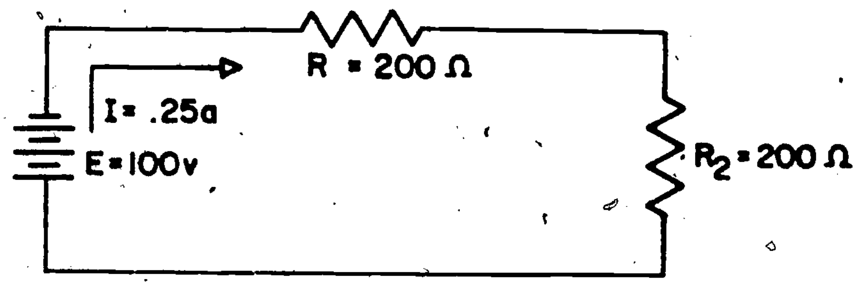
With the formula P = E x I firmly in your mind, return to page 4A and solve for the correct answer.

4A

YOUR ANSWER: 36 watts.

Very good. $P = E \times I$ and don't you forget it.

Let's try another one.



How much power is consumed in the circuit?

25 watts. page 7A

100 watts. page 3B

4B

YOUR ANSWER: $P = \frac{E^2}{R}$.

Right you are.

$P = E \times I$. $P = I^2R$ and $P = \frac{E^2}{R}$.

Now, solve this problem.

A certain circuit consumes 600 watts of power from a 200-volt source.

What is the current flow in the circuit?

3 amperes. page 8B

120,000 amperes. page 10A

5A

YOUR ANSWER: Both the above.

Very good.

Electrical power is the time rate at which charge is forced to move by voltage. This is why the power in watts is equal to the product of volts and amperes. Thus, the basic power formula is P = E x I.

For example, when a 6-volt battery produces 2 amps. in a circuit, the battery is producing 12 watts of power.

The voltage states the amount of work per unit of charge, and the current includes the time rate at which the charge is moved.

There is a further example of the relationship between electrical power and mechanical power in the fact that

746 watts = 1 horsepower = 550 ft.-lbs. per second.

The unit for the amount of power consumed in a circuit is the

watt. page 2A

volt. page 8A

5B

YOUR ANSWER: Power = work x time.

Come, come now.

Power is the time rate for doing work or consuming energy.

When we talk about the rate of something, we are going to divide that "something" by time. For example: If you drove 200 miles in 5 hours, you would have to divide 200 by 5 to find out how many miles-per-hour you were travelling. There are many other such "rates", such as miles-per-gallon, gallons-per-minute, or in our case, salary-per-month. These are all "rates", some quantity per unit of time.

Return now to page 1A and select the correct answer.

6A

YOUR ANSWER: The watt, then, is the time rate for consuming electrical energy.

You are correct, as far as you have gone. But you seem to have forgotten one very important point. Before energy can be consumed, work must be done.

Now, go back to page 3A and select the more correct answer.

6B

YOUR ANSWER: 12 watts.

No.

The formula for power is P = E x I, NOT P = I x R.

Once more, electrical power is the time rate at which charge is forced to move by voltage. This is why the power in watts is equal to the product of volts and amperes. The basic power formula is P = E x I.

Let's return to page 2A and solve for the correct answer.

6C

YOUR ANSWER: 100 watts.

Wrong.

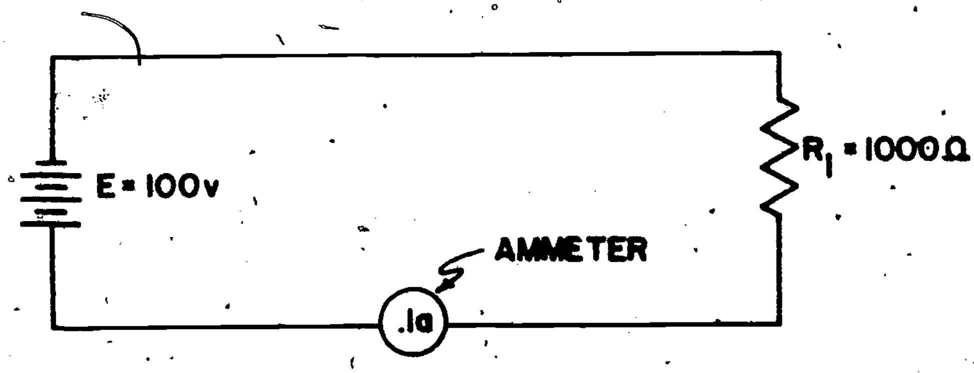
With the formula written right on the problem page, you still won't use it. Come on now, let's get down to the business at hand. P = E x I, not P = IR. Get this formula straight in your mind; you will be using it for a long time to come.

Now, let's go back to page 7A and solve the problem correctly.

7A

YOUR ANSWER: 25 watts.

Right. P is still equal to E x I.



What is the power consumption in the circuit?

10 watts.	page 9A
100 watts.	page 6C

7B

YOUR ANSWER: P = E x I.

Well, at least you remembered the basic power formula.

But you were asked, which formula you would use to solve for power, if voltage and resistance of the circuit were known.

We just gave you the formula on the preceding page: $P = \frac{E^2}{R}$.

Here is an explanation as to how we arrive at this formula. P = E x I in our basic power formula. $I = \frac{E}{R}$ in Ohm's law. We can substitute $\frac{E}{R}$ for "I" in the basic power law, thus, $P = E \times \frac{E}{R}$ or $P = \frac{E^2}{R}$.

Now, go back to page 9A and select the correct answer.

8A

YOUR ANSWER: Volt.

You are not correct.

Earlier in your studies of basic electricity, you were told that the "volt" is a unit of electromotive force. Now suppose you pushed against the wall, surely you are applying a pressure, but unless you moved the wall, you could not do work; thus, no work, no time rate for doing work. The same is true of an electrical plug in the wall. We know that there is approximately 110 volts available there, 110 volts of electromotive force ready and able to do electrical work, but unless we use this voltage to make current flow, no electrical work can be done; thus, no power can be consumed.

Return to page 5A and select the correct answer.

8B

YOUR ANSWER: 3 amperes.

Very good. Just a little transposition of our basic power law $P = E \times I$. $I = \frac{P}{E}$ and $E = \frac{P}{I}$.

$P = E \times I$ $\qquad P = I^2R$ $\qquad P = \frac{E^2}{R}$

A certain soldering iron offers 200 ohms of resistance to 3 amperes of current flow. The power used, then, is $P = I^2R = 3 \times 3 \times 200 = 9 \times 200 = 1800$ watts.

How much power is consumed by a circuit that has .5 ampere of current flowing through a resistance of 500 ohms?

125 watts.	page 11A
250 watts.	page 13A

9A

YOUR ANSWER: 10 watts.

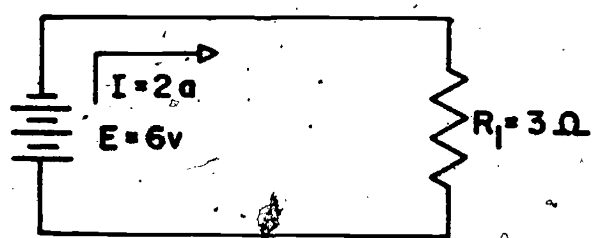
Good. You are remembering that $P = E \times I$ in our basic power law.

When current flows in a resistance, heat is produced. The heat energy is evidence that power is used in producing current in a resistance. The power is generated by the source of applied voltage and consumed in the resistance in the form of heat.

It is convenient, then, to have a power formula to express power in watts in terms of resistance.

For current: $P = I^2R$

For voltage: $P = \frac{E^2}{R}$



$P = E \times I = 6 \times 2 = 12$ watts

$P = I^2R = 4 \times 3 = 12$ watts

$P = \frac{E^2}{R} = \frac{36}{3} = 12$ watts

If you knew the voltage and resistance in a circuit, which formula would you use to solve for power:

$P = \frac{E^2}{R}$. page 4B

$P = E \times I$. page 7B

9B

YOUR ANSWER: 750 watts.

Again, we answer your answer with, not quite.

The formula again is $P = I^2R$, not $P = IR$; you forgot to square I in your solution.

Go back to page 11A and try again.

10A

YOUR ANSWER: 120,000 amperes.

Holy Mackerel there. What size conductor do you suppose we would have to have, to carry this amount of current?

This is just a little transposition of our basic power formula. We were given a power consumption of 600 watts from a 200-volt source and asked to solve for current (I). O. K.; let's see how it's done.

1. Correct formula: $P = E \times I$.
2. $600 = 200 \times I$.
3. Divide both sides by 200 thus,

$\frac{600}{200} = \frac{200}{200} \times I$. The 200's on the right side cancel each other, and we have $I = \frac{600}{200} = ?$

Return to page 4B and try again.

10B

YOUR ANSWER: $E = I \times R$.

Oh! come on, now. All through this lesson, we have been dealing directly with the basic power formula. And when we ask you to identify the power formula, you give us $E = IR$, which is Ohm's law.

Let's get serious about this business and pay attention to what you are reading.

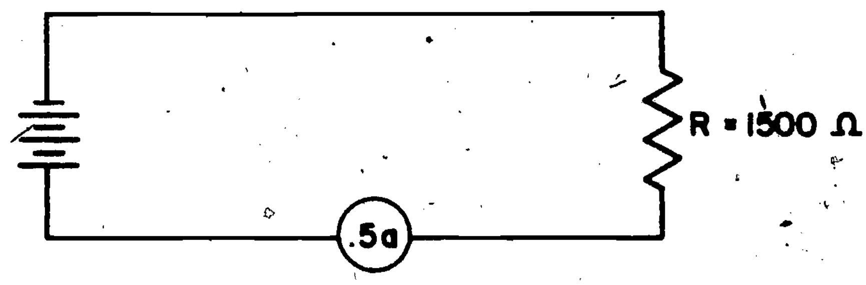
Return to page 16A and select the correct answer.

11A

YOUR ANSWER: 125 watts.

Right.

Remember, $P = E \times I$; $P = I^2R$; $P = \frac{E^2}{R}$.



How much power is consumed in the above circuit?

375 watts. page 14A

750 watts. page 9B

11B

YOUR ANSWER: Both the above.

Very good.

We said earlier that 746 watts was equal to one horsepower. Now, let's solve a problem using equivalent horsepower.

In a certain circuit, we have a voltage source of 373 volts supplying 4 amperes of current. How much power is consumed by the circuit in (a) watts and (b) horsepower.

(a) 1492 watts.
(b) 2 horsepower. page 17A

(a) 93.25 watts.
(b) .11 horsepower. page 12B

12A

YOUR ANSWER: (A) P = 50,000 watts. (B) P = 1,000,000 watts.

Wrong. But let's see why you are wrong.

First, you did not use the correct formula. With voltage and resistance known, we use the formula $P = \frac{E^2}{R}$. Not $P = \frac{E}{R}$, which you used in both problems.

Problem (A)

$$P = \frac{E^2}{R}$$

$$P = 50 \times \frac{50}{1000}$$

$$P = \frac{2500}{1000}$$

$$P = ?$$

Problem (B)

$$P = \frac{E^2}{R}$$

$$P = 100 \times \frac{100}{10,000}$$

$$P = \frac{10,000}{10,000}$$

$$P = ?$$

Complete these problems; then continue on page 16A.

12B

YOUR ANSWER: (a) 93.25 watts. (b) .11 horsepower.

You are not correct.

First of all, $P = E \times I$, not $P = \frac{E}{I}$.

You have solved for horsepower correctly, however; let's try again.

1. $P = E \times I$
2. $P = 373 \times 4 = ?$ watts
3. $HP = ? \frac{\text{watts}}{746\ (\text{watts/hp})} =$ ______________ hp.

After solving this problem correctly, continue on page 17A.

13A

YOUR ANSWER: 250 watts.

Not quite.

Again, the values given here, current flow at .5 ampere through a resistance of 500 ohms.

Let's see how we solve this problem.

1. Use the correct formula: $P = I^2R$.
2. $P = .5 \times .5 \times 500$
3. $P = .25 \times 500$
4. $P = ?$

We arrive at the formula $P = I^2R$ by using Ohm's law once again. $P = E \times I$ in our basic power law. $E = IR$ in Ohm's law. Substituting IR for E in our power formula, we get $P = IR \times I$ or $P = I^2R$.

Return to page 8B and solve for the correct answer.

13B

YOUR ANSWER: Ohms.

True. But you seem to be forgetting that heat is generated when current flows through a resistance. Heat being energy, it must have been created, in this case by the conversion of electrical energy to heat energy. How much heat the resistor can consume before it will char or crack depends a lot on its physical size, especially with the carbon resistor; the larger it is, the more heat it can absorb and give up. So not only do we have to know the ohmic value, but we must also know how much current and voltage it will handle, since $P = E \times I$.

With this in mind, continue on page 18A.

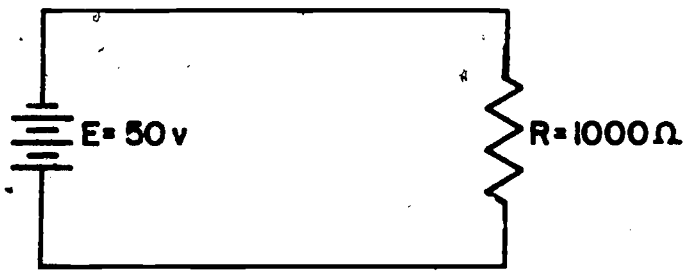
14A

YOUR ANSWER: 375 watts.

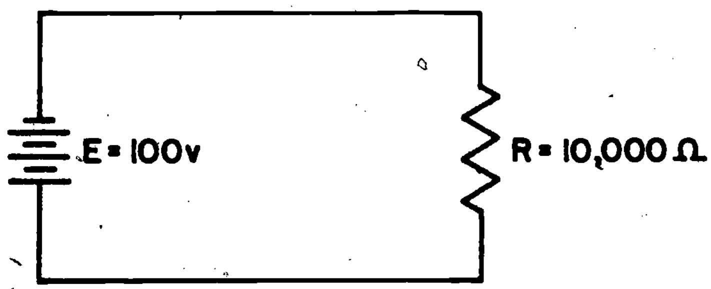
Very good. $P = E \times I$. $P = I^2R$. $P = \frac{E^2}{R}$.

Solve for P in the following circuits:

(A)



(B)



(A) P = 2.5 watts.
(B) P = 1 watt. page 16A

(A) P = 50,000 watts.
(B) P = 1,000,000 watts. page 12A

15A

YOUR ANSWER: Watts.

You are partially correct. But you seem to forget the unit of measurement for all opposition to current flow.

Resistors are devices which offer a specified amount of opposition to current flow.

Don't forget that resistors are rated not only in watts, but also in their ohmic value.

Continue on page 18A.

15B

YOUR ANSWER: 128.7 per cent.

You have erred in two ways.

First, you were told that no machine is ever 100 per cent efficient.

Second, you didn't pay any attention to the formula for efficiency.

Once more, the formula for efficiency:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100.$$

Now, let's solve the problem. We have a 1-hp motor which requires 960 watts input power:

1. $\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100.$
2. Put in known values. $\text{Efficiency} = \frac{746 \text{ (watts/hp)}}{960 \text{ (input)}}.$

Efficiency = ____________________ per cent.

After solving this problem correctly, continue on page 20A.

16A

YOUR ANSWER: (A) P = 2.5 watts.
(B) P = 1 watt.

Right you are.

Electrical lamps and soldering irons are examples of electrical devices that are rated in watts. The wattage rating of a device indicates the rate at which the device converts electrical energy (power) into another form of energy, such as light and heat.

For example, a 100-watt lamp will produce a brighter light than a 75-watt lamp, because it converts more electrical energy into light energy.

Electric soldering irons are of various wattage ratings, with the high wattage irons changing more electrical energy to heat energy than those of low wattage ratings.

Rather than indicate a device's ability to do work, its wattage rating may indicate the device's operating limit. These power limits generally are given as the maximum or minimum safe voltages and currents to which a device may be subjected. However, in cases where a device is not limited to any specific operating voltage, its limits are given directly in watts.

The basic power formula is:

$P = E \times I.$ page 18A

$E = I \times R.$ page 10B

17A

YOUR ANSWER: (a) 1492 watts.
(b) 2 horsepower.

You are correct.

Remember **always** to use the formula provided, and you can't go wrong.

Let's review our study of electrical power.

1. The unit for power consumed in a circuit is the______.

watt	2. The basic power formula is $P =$ ________ x ________.
$P = E \times I$	3. $P = E \times I$ is the basic formula for________________.
power	4. With current and resistance known in a circuit, power consumption can be found by using the formula $P =$ ______.
$P = I^2R$	5. With voltage and resistance known in a circuit, power consumption can be found by using the formula $P =$ __________.
$P = E^2 \div R$	6. One horsepower is equal to______________watts.
746	7. 746 watts is equal to one________________.
horsepower	8. Power is the__________rate for consuming energy.
time	9. Power is the product of voltage and ____________, and its unit is the________________.
current watt	10. The power formula can be written in several separate forms. Underline the form in which it cannot be written. a. $P = EI$. b. $P = \frac{E^2}{R}$. c. $P = IR$. d. $P = I^2R$.
$P = IR$	

Continue on page 19A

18A

YOUR ANSWER: P = E x I.

That is correct. P = E x I and don't you forget it.

A resistor is an example of a device whose limit is given directly in watts. It may be used in circuits with widely different voltages, depending on the desired current. However, the resistor has a maximum current limitation for each voltage applied to it. The product of the resistor's voltage and current must not exceed a certain wattage.

Thus, resistors are rated in watts, in addition to their ohmic resistance value. Resistors of the same resistance value are available in different wattage values. Carbon resistors, for example, are commonly made in wattage ratings of 1/3, 1/2, 1, and 2 watts. The larger the physical size of a carbon resistor, the higher its wattage rating, since a larger amount of material will absorb and give up heat more easily.

Resistors are rated in

watts. page 15A

ohms. page 13B

both the above. page 11B

18B

Here are the correct answers.

a. 67.8 per cent.

b. 3300 watts.

c. 4.42 horsepower.

If your answers do not agree, turn to page 23A for correct solution.

If your answers do agree, turn to page 25A and continue.

19A

We have one more item to learn before we come to the end of this lesson. That item is efficiency.

All machines lose some power by heat and friction. If they didn't, they would be 100 per cent efficient and the output would be equal to the input. For instance, suppose a one-horsepower motor only required 746 watts to operate at its rated horsepower. We know that one horsepower is equal to 746 watts, so the output would equal the input and the motor would be 100 per cent efficient. But NO machine is ever 100 per cent efficient.

To find out just how efficient an electrical device is, we use this formula:

$$\text{Efficiency} = \frac{\text{output (watts)}}{\text{input (watts)}} \times 100.$$

Let us suppose we have a 10-horsepower motor connected to a 400-volt source at 20 amps. The output then is 10 x 746 (watts in one hp) or 7460 watts. The input is P = E x I = 400 x 20 = 8,000 watts. Now, let's see how efficient this motor is.

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100 = \frac{7460}{8000} = .9325 \times 100 = 93.25 \text{ per cent, or}$$

rounded off 93.3 per cent.

Now you try one.

What is the efficiency of a 1-horsepower motor that requires an input of 960 watts?

77.7 per cent. page 20A

128.7 per cent. page 15B

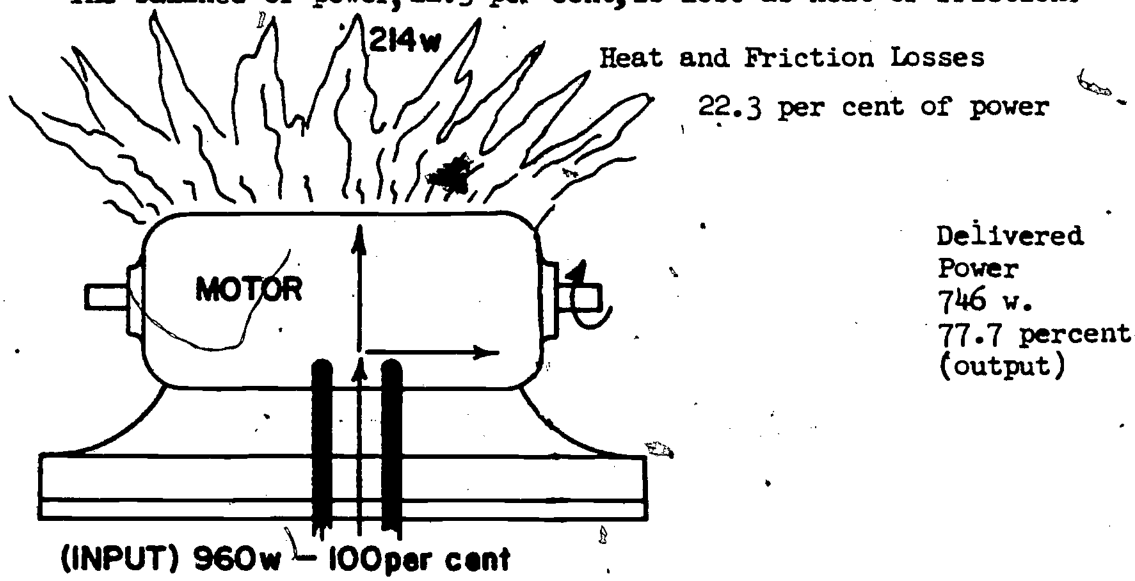
20A

YOUR ANSWER: 77.7 per cent.

Correct. We had an input of 960 watts and an output of one horsepower. We were told that one horsepower is equal to 746 watts; our problem looks like this:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100 = \frac{746}{960} = 0.777 \times 100 \text{ or } 77.7 \text{ per cent.}$$

The balance of power, 22.3 per cent, is lost as heat or friction.



In the figure above are pictured the power and the power losses. If you follow the arrows through this picture, you will find the input power is electrical power. It splits up in the motor, going in two directions. The losses in the form of heat are radiated upward and the output in the form of mechanical power is delivered to the shaft.

Now consider this problem. We have a 5-horsepower motor that draws 20 amperes from a 200-volt circuit; what is the efficiency of this motor?

93.25 per cent. page 22A

107.23 per cent. page 24A

21A

YOUR ANSWER: 373 watts.

Wrong. But do not despair; we will go over the problem with you.

The problem again was to solve for the input power of a 4-hp. motor operating at 80 per cent efficiency.

1. Use the correct formula: Efficiency = $\frac{\text{output}}{\text{input}}$ x 100.
2. Plug in known values. $80 = \frac{4 \times 746 \text{ (watts/hp} \times 100}{\text{input}}$.
3. Multiply both sides by "input": Thus,

   $80 \times \text{input} = \frac{4 \times 746 \times 100}{\text{input}} \times \text{input}.$
4. "input" on right side cancel out and we have

   $80 \times \text{input} = 4 \times 746 \times 100.$
5. Divide both sides by 80.

   $\frac{80 \times \text{input}}{80} = \frac{4 \times 746 \times 100}{80}$, thus,

   $\text{input} = \frac{4 \times 746 \times 100}{80} =$ ________________ watts.

Complete the problem, then continue on page 26A.

22A

YOUR ANSWER: 93.25 per cent.

You are correct.

Now let's see how we could solve for the input power, if the efficiency and output were known.

First, we will use the correct formula:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100.$$

Now suppose that we had a 5-horsepower motor operating at 74.6 per cent efficiency.

1. Put into formula known values:

$$74.6 = \frac{5 \times 746 \times 100}{\text{input}}$$

2. Multiply both sides of the equation by "input":

$$\text{Input} \times 74.6 = \frac{5 \times 746 \times 100}{\text{Input}} \times \text{input}$$

3. Then, we have

$$\text{Input} \times 74.6 = 3730 \times 100 = 373{,}000$$

$$\text{Input} = \frac{373{,}000}{74.6} = 5{,}000 \text{ watts}$$

Now you solve one.

A 4-horsepower motor operates at 80 per cent efficiency; what is the input power?

3730 watts. page 26A

373 watts. page 21A

23A

This is how the problem should have been solved to obtain the correct answer:

1. $\text{Efficiency} = \frac{\text{output (watts)}}{\text{input (watts)}} \times 100.$
2. output = 3(hp) x 746 (watts/hp) = 2238 watts.
3. input power = E x I = 220 x 15 = 3300 watts.
4. $\text{efficiency} = \frac{2238}{3300} \times 100 = .678 \times 100 = 67.8$ per cent.
5. To solve for equivalent horsepower, simply divide the input power (in watts) by 746 (watts per hp).

   Thus:

   $$\frac{3300}{746} = 4.[illegible]2 \text{ hp.}$$

Now, continue on page 25A.

24A

YOUR ANSWER: 107.23 per cent.

We can't very well go along with your answer, since we already have told you that $\boxed{\text{No}}$ machine is ever 100 per cent efficient.

Our problem is to solve for the efficiency of a 5-hp. motor drawing 20 amperes from a 200-volt circuit. O. K., let's solve it.

1. $P = E \times I$.
2. $P = 200 \times 20 = 4{,}000$ watts.
3. $\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100$.
4. $\text{Efficiency} = \frac{5 \times 746 \text{ (watts. hp)}}{4{,}000 \text{ watts}} \times 100$.
5. Efficiency = ______________ per cent.

After you solve this problem correctly, continue on page 22A.

25A	1. In our study of electrical power, we found that the unit of measurement for electrical power is the__________.
watt	2. The time rate for consuming energy is__________.
power	3. The basic power formula is P = _______ x _______.
$P = E \times I$	4. If current and power in a circuit were known, you could solve for voltage by using the formula E = __________.
$E = \frac{P}{I}$	5. In a circuit where voltage and power are known, you could solve for current by using the formula I = __________.
$I = \frac{P}{E}$	6. We have two formulas with which to express power in watts in terms of resistance; they are: for current, P = __________. for voltage, P = __________.
current. $P = I^2R$ voltage. $P = \frac{E^2}{R}$	7. Write the three formulas for power. P = ________ P = ________ P = ________
$P = E \times I$ $P = I^2R$ $P = \frac{E^2}{R}$	8. The ratio of power output to power input is called ______.
efficiency	9. Efficiency is the ratio of power______ to ______.
output input	10. The formula used to solve for efficiency is, efficiency = ________ ÷ ________ x 100, and is expressed in percentages.

Continue on page 27A

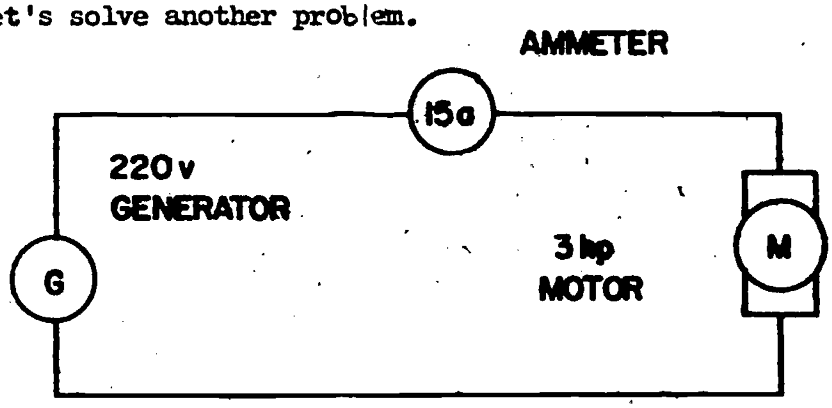
26A

YOUR ANSWER: 3730 watts.

Very good.

Just don't forget to use the correct formula. The correct formula will depend on the known factors. By knowing the basic formula, plugging in the known values a little transposing, and you are in business.

Let's solve another problem.



(a) What is the efficiency of the 3-hp. motor in the above drawing? ______________________ per cent.

(b) What is the input power in watts? ____________ watts.

(c) What is the input power in equivalent horsepower? ______ hp

Turn to page 18B for correct answer.

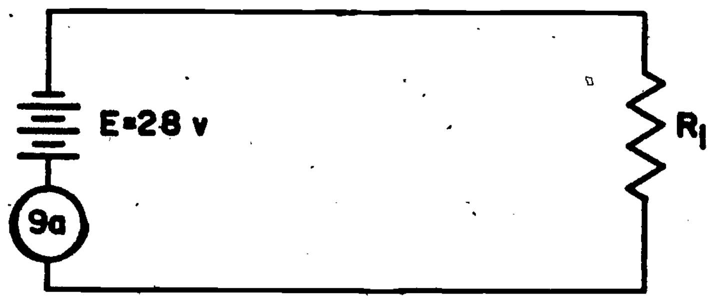
<u>27A</u> output input	11. Write the formula for efficiency. — ________________________________
efficiency = $\frac{\text{output}}{\text{input}} \times 100$	12. Write the definition of efficiency. ________________________________ ________________________________
Efficiency is the ratio of power output to power input.	13. Write the definition of electrical power. ________________________________ ________________________________
Power is the time rate for consuming energy.	14. This completes our study of electrical work, power, and energy. In other words, this is the ________________________________.
END.	

REVIEW TEST FOR WORK, POWER, AND ENERGY

(Electrical)

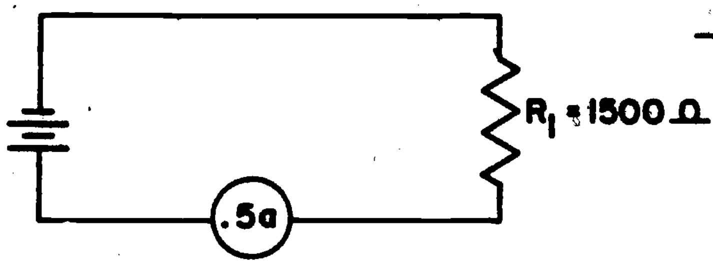
1. The basic formula for electrical power is: P = ________ x ________.
2. The unit of measurement for electrical power is the ____________.
3. One electrical horsepower is equal to ____________ watts.
4. In the figure below, how much power is consumed by the circuit?

________ watts.



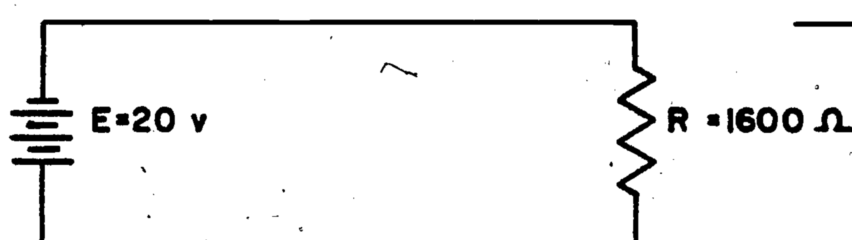
5. In the figure below, how much power is consumed by the circuit?

________ watts.



6. In the figure below, how much power is consumed by the circuit?

________ watts.



7. A certain generator supplies 373 volts to a load which is operating at 4 amperes. What is the power consumed by the load in (a) watts, and (b) in equivalent horsepower?

(a) ________________ watts

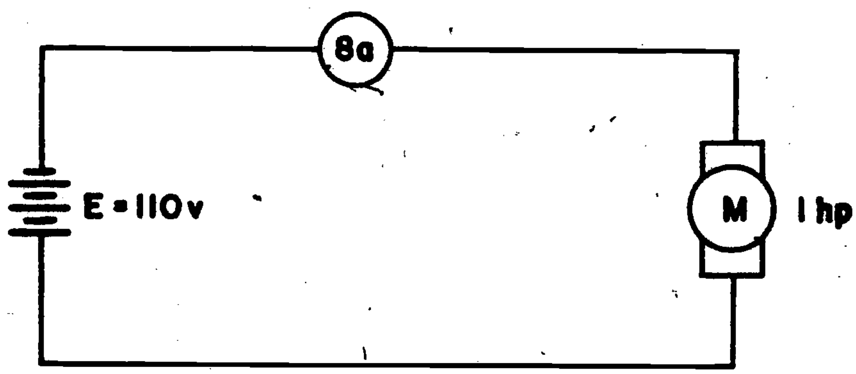
(b) ________________ horsepower

8. The ratio of power output to power input is called ________________.

9. Write the formula for per cent of efficiency. ____________________.

10. What is the efficiency of the motor in the following circuit?

________________ per cent.



PREPARE THE MAN

STUDY GUIDE/WORKBOOK 3ALR91630-I-4

Department of Medicine
School of Health Care Sciences

Cardiopulmonary Laboratory Specialist

ENERGY, OHM'S LAW, AND BASIC CIRCUITS

May 1973

10-6

SHEPPARD AIR FORCE BASE

321

PURPOSE OF STUDY GUIDES AND WORKBOOKS

Study Guides and Workbooks are training publications authorized by Air Training Command (ATC) for student use in ATC courses.

The STUDY GUIDE (SG) presents the information you need to complete the unit of instruction, or makes assignments for you to read in other publications which contain the required information.

The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the student study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

THE STUDY GUIDE AND WORKBOOK (SG/WB) contains both SG and WB material under one cover. The two training publications may be combined when the WB is not designed for you to write in, or when both SG and WB are issued for you to keep.

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Prepared by the Instructor Staff, Radiology Course

Medical Service School, Sheppard AFB, Texas

Date of Preparation May 1970

Department of Medicine
Clinical Medicine Training Branch
Sheppard Air Force Base

SG/WB 3ALR91630-I-4d
May 1973

ENERGY, OHM'S LAW, AND BASIC CIRCUITS

OBJECTIVES:

1. Identify statements pertaining to energy as either true or false.
2. List the three basic requirements for a simple circuit.
3. Given illustrations of electrical symbols, label the components depicted.
4. Select the correct definition of Ohm's Law.
5. Identify Ohm's Law expressed as a mathematical formula.
6. Calculate current and voltage of a simple circuit.
7. Select true statements regarding a DC series circuit.
8. Select the correct formula for determining current and resistance.
9. Compute total resistance and current for a DC series circuit.
10. Select true statements regarding a parallel circuit.
11. Compute current, voltage and resistance for a parallel circuit.
12. Select the definition of a series-parallel circuit.
13. Draw a series-parallel circuit and label voltage, resistance, and current.
14. Select the correct unit of measure for electric power consumed.
15. Compute the current through each branch of a circuit, and total current, and the power consumed in watts.

INTRODUCTION:

This Student Study Guide/Workbook was prepared as part of a programmed lecture. As a Cardiopulmonary Laboratory Technician you will not be required to repair electrical circuits; however, a basic concept of electrical circuits and Ohm's Law will be an essential building block for later instruction pertaining to lab equipment and electrical protection.

INSTRUCTIONS:

Do not respond in the SSG/WB until directed by the instructor. After each exercise you will be given the correct answers. Use the questions and the summary as a review of the lesson.

INFORMATION:

EXERCISE 1:

Label the following statements pertaining to energy as True or False.

____ a. Potential energy is energy in motion.

____ b. Energy can be neither created nor destroyed.

____ c. A match represents potential energy.

____ d. Electrons flowing within a conductor represent kinetic energy.

____ e. Energy cannot be converted to different forms.

____ f. A burning match represents thermal energy.

____ g. Electrons will only flow from negative to positive.

____ h. Current flow is limited by the use of resistive devices.

____ i. An increase in circuit resistance will result in an increase in current flow.

____ j. Current will flow when two differently charged bodies are connected by a conductor.

EXERCISE 2:

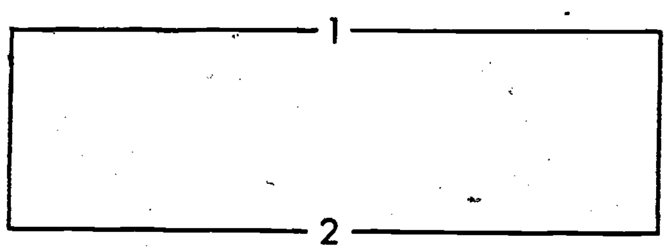
1. List the three basic requirements for a basic or simple circuit.

   a. ______________________________

   b. ______________________________

   c. ______________________________

2. In the illustration below, (1) represents a lamp and (2) represents a three-cell battery. Draw the symbols for these two electrical components below.

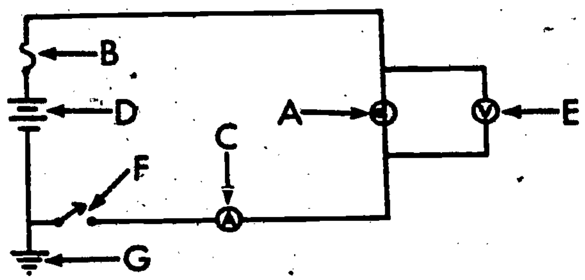


(1) LAMP

(2) THREE-CELL BATTERY

EXERCISE 3:

Study the illustration below. Write the name of each component represented by the symbols next to the corresponding letter:



A. ______________ E. ______________

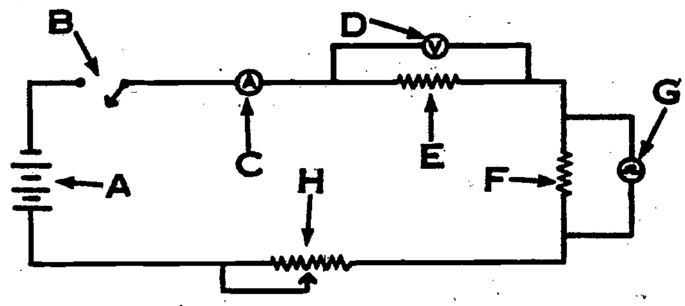
B. ______________ F. ______________

C. ______________ G. ______________

D. ______________

EXERCISE 4:

1. Study the illustration below. Write the name of each symbol beside the corresponding number:



A. ______________ E. ______________

B. ______________ F. ______________

C. ______________ G. ______________

D. ______________ H. ______________

2. Energy at rest is considered to be

a. kinetic energy.

b. potential energy.

3. Energy in motion is considered to be

a. kinetic energy.

b. potential energy.

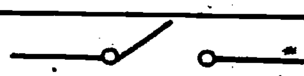
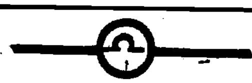
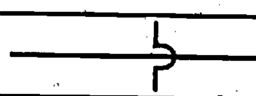
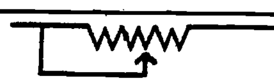
4. List the three basic requirements for a simple circuit.

a. ______________________________

b. ______________________________

c. ______________________________

5. Complete the following chart:

SYMBOL	TITLE
	LAMP
	
	FUSE
	
	VOLTMETER
	
	GROUND
	
	CONNECTING WIRES
	
	FIXED RESISTOR
	

6. Draw a simple circuit diagram containing any six (6) of the components listed below:

a. 2 cell battery
b. fuse
c. lamp
d. switch
e. ground
f. Ohmmeter
g. connecting wires
h. crossed-over wires
i. fixed resistor
j. rheostat
*k. Ammeter
**l. Voltmeter

*An AMMETER must be connected in series with the load. (This will be explained later in the course.)

**A VOLTMETER should be connected across the load or between load and ground. (This will also be explained later in the course.)

242

EXERCISE 5:

1. Which of the following is not a form of Ohm's Law?

   a. $I = ER$

   b. $E = IR$

   c. $R = \frac{E}{I}$

   d. $I = \frac{E}{R}$

2. If E and I of a circuit are known, ________ can be determined. (Select one.)

   a. voltage

   b. current

   c. resistance

   d. potential difference

3. If a circuit contains 25 ohms of resistance with 50 volts applied, the current will be

   a. 20 amps.

   b. .5 amps.

   c. 2 amps.

   d. 1250 amps.

Study the illustration and complete the following statement:

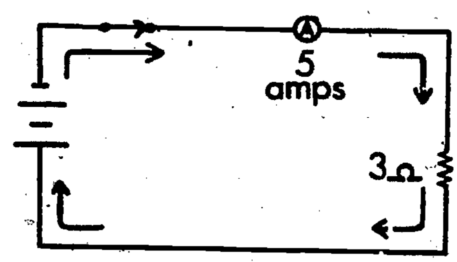
4. The voltage in this circuit is

   a. 1 2/3 volts.

   b. 15 volts.

   c. .6 volts.

   d. 8 volts.



5. The formula used to solve the preceeding problem is.

   a. $I = \frac{E}{R}$

   b. $R = \frac{E}{I}$

   c. $E = IR$

   d. none of the above.

EXERCISE 6;

1. The most basic electrical circuit is the

   a. parallel circuit.

   b. series circuit.

   c. series-parallel circuit.

2. The relationship that exists between current, voltage, and resistance is stated in

   a. Kirchoff's Law.

   b. Lenz Law.

   c. Ohm's Law.

3. List the three basic requirements for a series circuit.

   a. ______________________

   b. ______________________

   c. ______________________

4. Select the statement below that is true. Circle the correct letter.

   a. Voltage is the same at all points in a series circuit.

   b. Current is the same at all points in a series circuit.

   c. Resistance is the same at all points in a series circuit.

28

5. Which formula correctly expresses the fact that current is the same at all points in a series circuit?

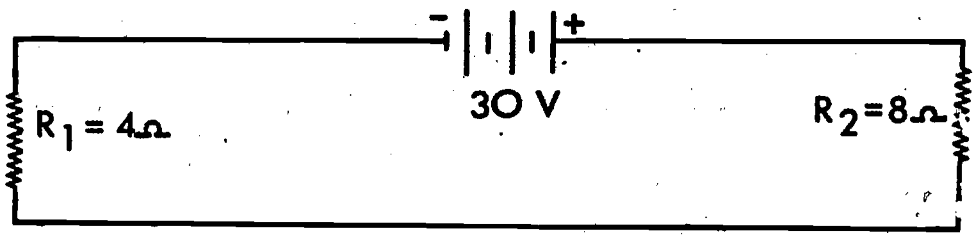
   a. $I_t = I_1 \times I_2 \times I_3$

   b. $I_t = I_1 \div I_2 \div I_3$

   c. $I_t = I_1 - I_2 - I_3$

   d. $I_t = I_1 = I_2 = I_3$

6. Determine the total resistance of this series circuit:



The total resistance is

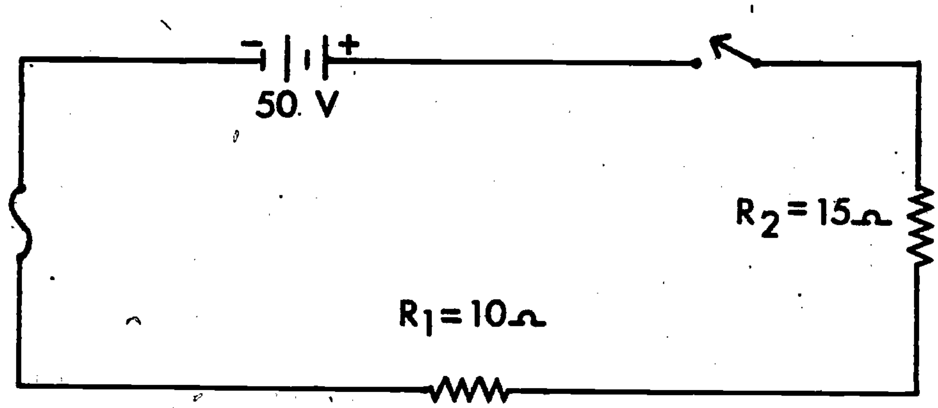
a. 5 ohms.

b. 8 ohms.

c. 12 ohms.

d. 20 ohms.

Study the illustration below then answer questions 7, 8, 9 and 10.



7. What is the total resistance of this series circuit?

____

8. What is the total current of this series circuit?

____

9. If the voltage remains constant and the total resistance is doubled, what is the new current?

____

10. If the voltage remains constant and the total resistance is cut in half, what is the new current?

____

11. If the voltage remains constant in a series circuit and the resistance is reduced to one-half its original value, the current will

   a. remain the same.

   b. increase to double its original value.

   c. decrease to one-half its original value.

12. If the voltage is reduced to one-half its original value in a series circuit and the resistance remains constant, the current will

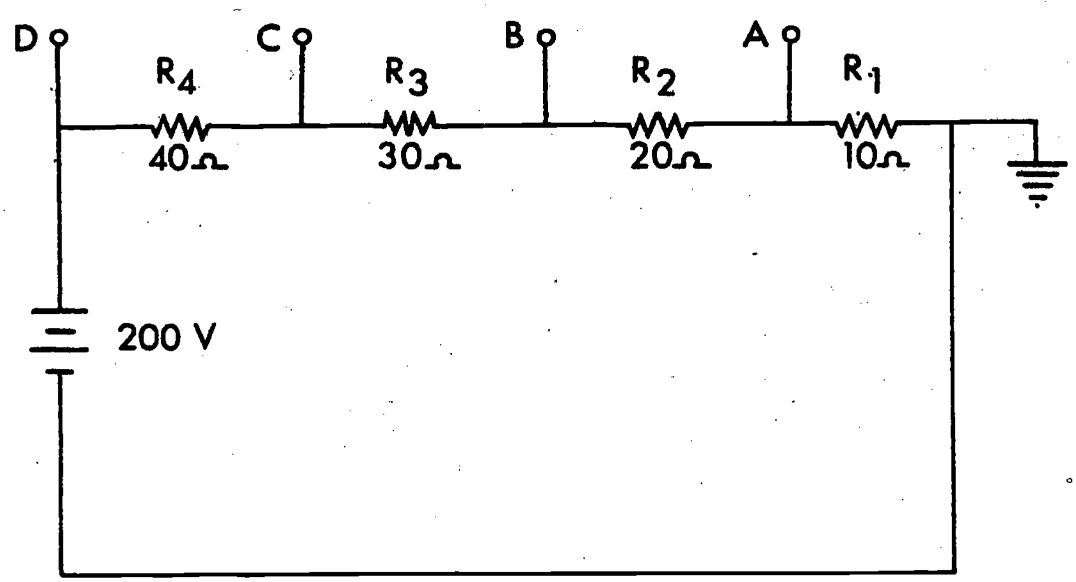
   a. remain the same.

   b. increase to double its original value.

   c. decrease to one-half its original value.

<u>EXERCISE 7:</u>

1. Study the illustration below and compute the voltage drops.

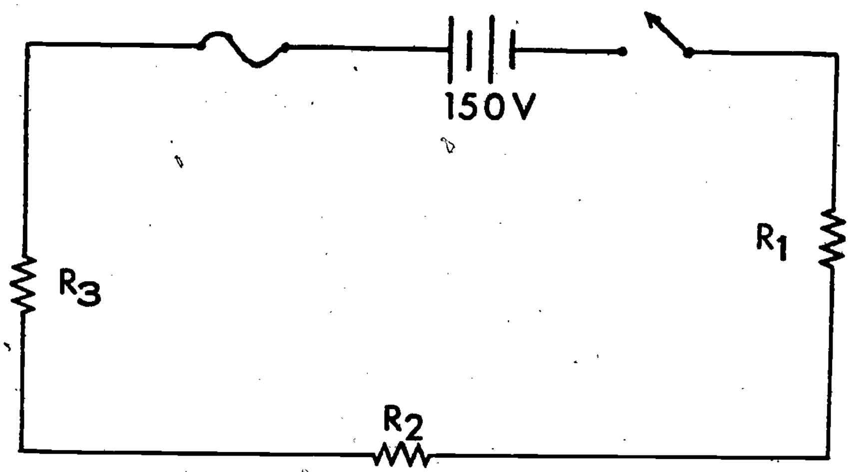


a. $E_{R_1} =$ c. $E_{R_3} =$

b. $E_{R_2} =$ d. $E_{R_4} =$

284

2. Study the illustration below and determine the following: total resistance, total current, and voltage drops across all three resistors.



$R_1 = 30\Omega$ $R_2 = 60\,\Omega$ $R_3 = 10\Omega$

<u>Total Resistance</u>: $R_t = R_1 + R_2 + R_3$

$R_t =$

<u>Total Current</u>: $I_t = \frac{E_t}{R_t}$

$I_t =$

<u>Voltage Drops</u>: $E = IR$

$E_{R_1} =$

$E_{R_2} =$

$E_{R_3} =$

EXERCISE 8:

1. How many possible paths for current flow are there in a series DC circuit?

   a. One
   b. Two
   c. Three
   d. Four

2. The three basic components for any circuit are

   a. power source, load and switch.
   b. power source, conductor and wire.
   c. power source, load and wire.
   d. power source, fuse and load.

3. In a DC series circuit, the total current is equal to

   a. all the currents at various points added together.
   b. the current at any point in the circuit.
   c. the total resistance divided by the total voltage.
   d. none of the above.

4. To find the total resistance in a DC series circuit, you would

   a. add all the resistances.
   b. take the difference between the largest and smallest resistor.
   c. divide the total current by the total voltage.
   d. multiply the total current by the total voltage.

5. If the voltage in a series DC circuit is doubled and the resistance is held constant, the current will

   a. double.
   b. be one-half.
   c. be the same.
   d. decrease.

6. If the voltage in a series DC circuit remains constant and resistance increases, the current must

   a. decrease.
   b. increase.
   c. double.
   d. reduce one-half.

7. What form of Ohm's Law is used to find the voltage drop across a resistor?

a. $I = \frac{E}{R}$

b. $R = \frac{E}{I}$

c. $E = IR$

d. $E = \frac{I}{R}$

8. The larger the value of a resistor in a DC series circuit, the ________ the voltage drop across that resistor.

a. smaller

b. larger

c. less

d. none of the above

9. If a series DC circuit contains four resistors of 5, 10, 20, and 100 ohms value, what is the total resistance of the circuit?

a. 95 ohms

b. 35 ohms

c. 135 ohms

d. 150 ohms

10. An important thing to remember about voltage dividers is to start at ____________ and add the ________________ to the tap off point used.

a. ground - resistive values

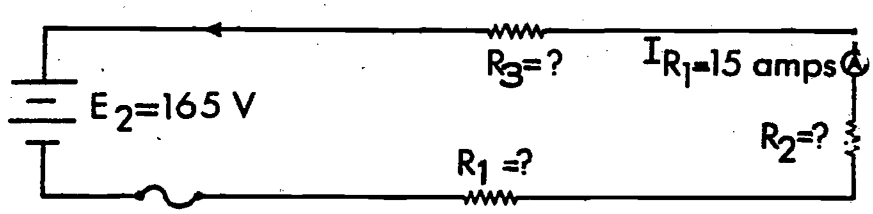
b. ground - voltage drops

c. ground - applied voltage

d. ground - reference point

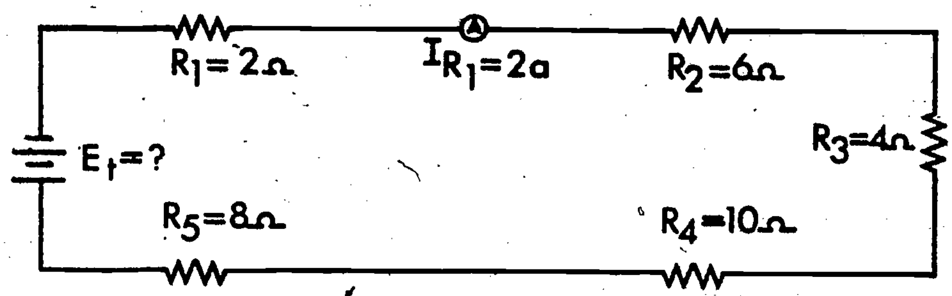
EXERCISE 9:

1. Study the illustration below and calculate the total resistance of this circuit.



R_t = ____________

2. Study the illustration below and calculate the total resistance, applied voltage, and voltage drop across each resistor.



a. $R_t = R_1 + R_2 + R_3 + R_4 + R_5$

$R_t =$

b. $E_t = I_t R_t$

$E_t =$

c. $E_{R_1} = I_1 R_1$ $E_{R_2} = I_2 R_2$ $E_{R_3} = I_3 R_3$ $E_{R_4} = I_4 R_4$ $E_{R_5} = I_5 R_5$

$E_{R_1} =$ $E_{R_2} =$ $E_{R_3} =$ $E_{R_4} =$ $E_{R_5} =$

3. If 10 amperes of current are flowing toward a point in a series DC circuit, how much current is flowing away from that point?

a. 1 amp
b. 10 amps
c. 5 amps
d. 20 amps

4. The voltage drop across a resistor can be determined by multiplying the current by

a. the applied voltage.
b. the ohmic value of the resistor.
c. total resistance of the circuit.
d. total voltage of the circuit.

5. The sum of the voltage drops in a series circuit is equal to

a. the total resistance.
b. the total current.
c. the applied voltage.
d. none of the above.

6. A series DC circuit contains three resistors. The applied voltage, the current, and the values of two resistors are known. How can the value of the unknown resistance be determined?

   a. By dividing the current into the voltage.

   b. By dividing the current into the voltage, and subtracting the total of the known two resistors from it.

   c. By multiplying the current by the voltage.

   d. By multiplying the current by the voltage, and subtracting the total of the two known resistors from it.

7. The equation for finding total resistance in a series DC circuit is

   a. $R_t = R_1 - R_2 - R_3 -.$

   b. $R_t = R_1 \times R_2 \times R_3 \times.$

   c. $R_t = R_1 + R_2 - R_3 +.$

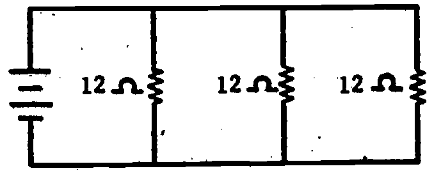
   d. $R_t = R_1 + R_2 + R_3 +.$

8. The correct form of Ohm's Law for finding current is

   a. $I = \frac{R}{E}$ b. $I = ER$ c. $I = \frac{E}{R}$ d. $I = E^2R$

PARALLEL CIRCUIT - RESISTANCE

LIKE RESISTANCE METHOD

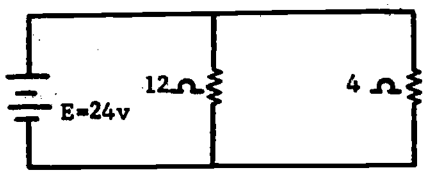


$R_t = \frac{R}{N}$

$R_t = \frac{12}{3}$

$R_t = 4$ ohms

OHM'S LAW METHOD



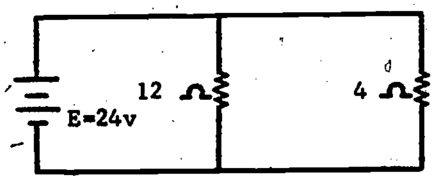
$I_1 = \frac{E}{R_1}$ $\quad I_2 = \frac{E}{R_2}$ $\quad I_t = I_1 + I_2$

$I_1 = \frac{24}{12}$ $\quad I_2 = \frac{24}{4}$ $\quad I_t = 2+6 = 8$

$I_1 = 2$ amps $\quad I_2 = 6$ amps $\quad R_t = \frac{E}{I_t} = \frac{24}{8}$

$R_t = 3$ ohms

PRODUCT/SUM METHOD

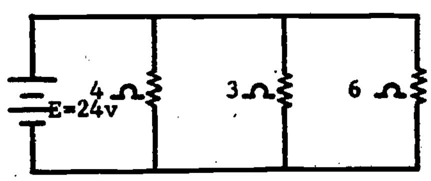


$R_t = \frac{R_1 \times R_2}{R_1 + R_2}$ $\quad R = \frac{12 \times 4}{12 + 4}$

$R_t = \frac{48}{16}$

$R_t = 3$ ohms

RECIPROCAL METHOD



$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ $\quad \frac{1}{R_t} = \frac{9}{12} = \frac{3}{4}$

$\frac{1}{R_t} = \frac{1}{4} + \frac{1}{3} + \frac{1}{6}$ $\quad R_t = \frac{4}{3}$ or $1\frac{1}{3}$

$\frac{1}{R_t} = \frac{3+4+2}{12}$

EXERCISE 10:

1. The voltage across any resistor in a parallel circuit is equal to

   a. the total current.

   b. the applied voltage.

   c. the total resistance.

   d. none of the above.

337

2. The current through the various branches of a parallel circuit are equal when

   a. the voltage drops are the same.

   b. the resistors are the same size.

   c. only two resistors are used.

   d. more than two resistors are used.

3. A formula that <u>cannot</u> be used for finding total resistance in a parallel circuit is

   a. $R_t = \frac{E_t}{I_t}$

   c. $R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$

   b. $R_t = \frac{R_1 \times R_2}{R_1 + R_2}$

   d. $R_t = \frac{N}{R}$

4. When two 50 ohm resistors are connected in parallel, the equivalent resistance is

   a. 100 ohms.

   b. 50 ohms.

   c. 25 ohms.

   d. 5 ohms.

5. When a 10 ohm, 20 ohm, and 30 ohm resistors are connected in parallel, the equivalent resistance is

   a. more than 30 ohms.

   b. less than 10 ohms.

   c. less than 30 but more than 10 ohms.

   d. 20 ohms.

<u>EXERCISE 11</u>:

1. The definition of a series-parallel circuit is a circuit containing a group of

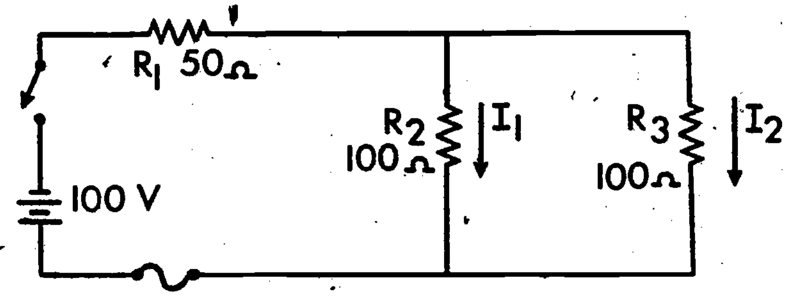
   a. resistors connected in series with other resistors.

   b. series resistors connected in series with other resistors.

   c. parallel resistors connected in series with other resistors.

   d. resistors connected in parallel with other resistors.

2. Study the illustration below and complete the following:



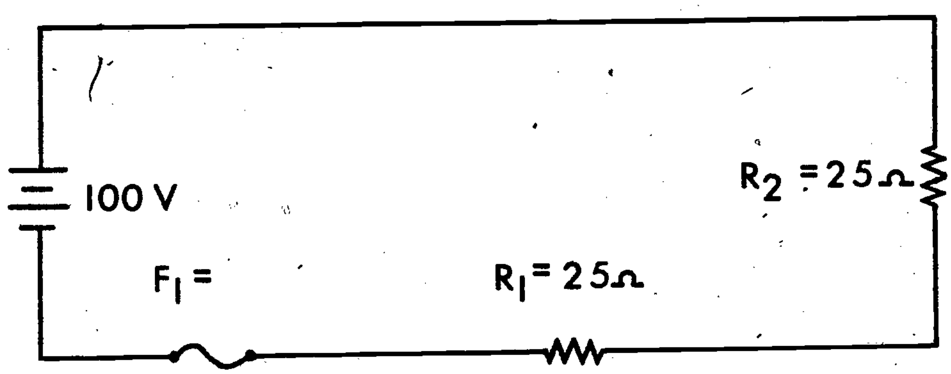
a. Draw an equivalent series circuit.

b. Determine the total resistance of this circuit.

c. Determine the total current of this circuit.

EXERCISE 12:

Study the diagram below. Determine the total resistance, total current, the power consumed in watts, the ampere rating of F_1, and the minimum wattage ratings of Resistor 1 and Resistor 2. After you have determined these values, answer the question that follows:



R_t =

W =

I_t =

F_1 =

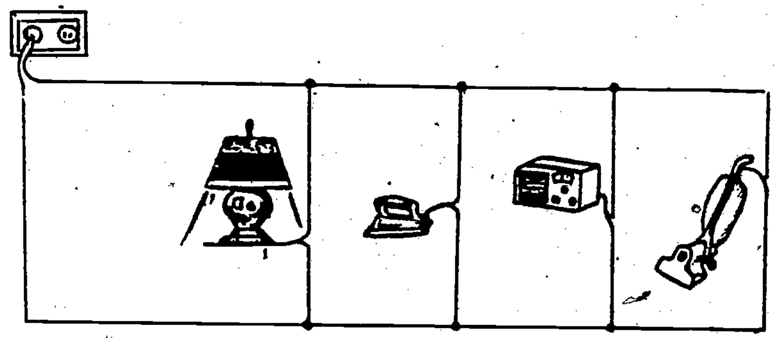
Wattage rating of R_1 __________, R_2 __________.

What would happen if a 1 ampere fuse was installed in this circuit?

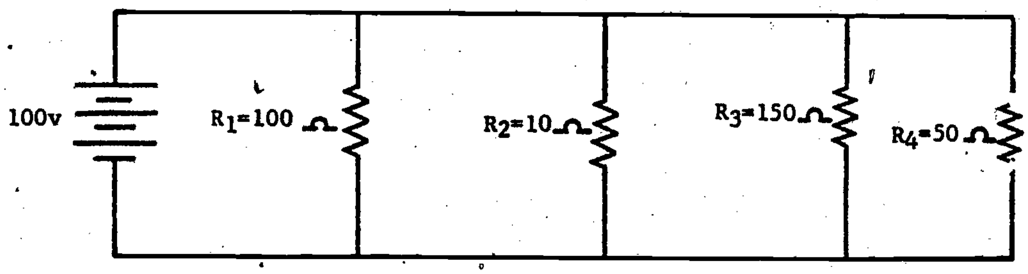
____

EXERCISE 13:

Study the illustration below. Part B represents a schematic diagram of the pictorial drawing in Part A.



A.



B.

Compute the following values:

I_1 = ________

I_2 = ________

I_3 = ________

I_4 = ________

I_t = ________

W = ________

What would happen if all these devices were plugged into an extension cord rated at 10 amps?

EXERCISE 14:

You have a generator rated at 3,500 watts at 110 volts. From this generator you need to operate a 30 MA, 90 KVP x-ray machine which requires 30 amps at 110 volts.

Can this x-ray machine be safely used with this generator?

REVIEW TEST

1. Identify each statement below as either true or false.

   ____ a. Potential energy is energy in motion.

   ____ b. Energy can neither be created nor destroyed.

   ____ c. A match represents potential energy.

   ____ d. Electrons flowing within a conductor represent kinetic energy.

   ____ e. Energy cannot be converted to different forms.

   ____ f. A burning match represents thermal energy.

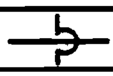
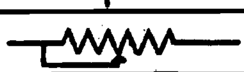
2. List the basic requirements for a simple circuit.

   a. ______________________________

   b. ______________________________

   c. ______________________________

3. Write in the name of the electrical component depicted:

SYMBOL	COMPONENT
	
	
	
	
	
	
	
	
	
	
	
	

4B-73-6440

4. **Ohm's Law is defined as:** (select one)

   a. Resistance varies directly with the current and inversely with the voltage.

   b. Voltage varies directly with the resistance and directly with the current.

   c. Current varies directly with the voltage and inversely with the resistance.

   d. None of the above.

5. Which of the following is not a form of Ohm's Law?

   a. $R = \frac{E}{I}$

   b. $I = ER$

   c. $E = IR$

   d. $I = \frac{E}{R}$

6. Complete the following statements:

   a. If a circuit contains 30 ohms of resistance with 60 volts applied, the current will be

      (1) 30 amps.

      (2) .5 amps.

      (3) 2 amps.

      (4) 1800 amps.

   b. If the circuit has 4 amps of current and 25 ohms of resistance, the applied voltage is

      (1) 100 volts.

      (2) 21 volts.

      (3) 50 volts.

      (4) 6.25 volts.

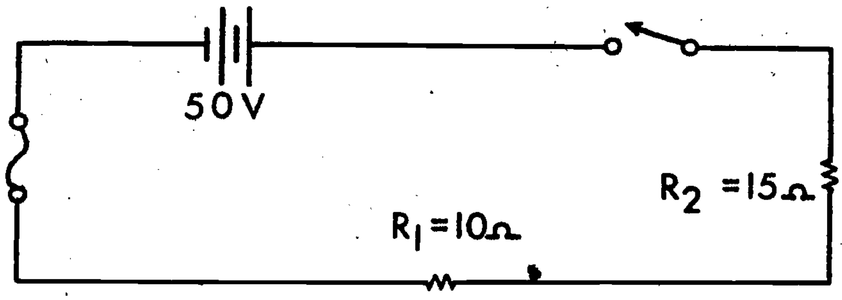
7. Check (✓) the true statements.

   ____ a. Current is the same at all points in a series circuit.

   ____ b. Total resistance in a series circuit is equal to the sum of the separate resistances.

   ____ c. Voltage drops in a series circuit must add up to and equal the applied voltage.

8. Study the illustration below and compute the total resistance and the total current of this circuit.



a. R_t = ____________

b. I_t = ____________

9. Select the correct equation for computing the following values in a series circuit.

a. Total resistance ____________

b. Total current ____________

(1) $R_t = R_1 - R_2 - R_3 -$

(2) $I_t = I_1 + I_2 + R_3 +$

(3) $I_t = I_1 = I_2 = I_3 =$

(4) $R_t = R_1 + R_2 + R_3 +$

10. Complete the following by selecting the correct statement:

a. A parallel circuit is a circuit in which

(1) Two or more devices are connected across different voltage sources.

(2) A group of parallel resistors are connected in series with other resistors.

(3) Two or more devices are connected across the same voltage source.

b. In a parallel circuit, the voltage across any branch is equal to

(1) the applied voltage.

(2) the total resistance.

(3) the total current.

(4) none of the above.

c. The currents through the various branches of a parallel circuit are the same when

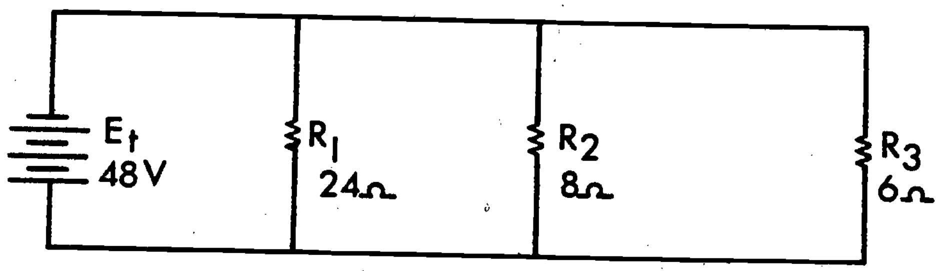
(1) more than two resistors are used.

(2) only two resistors are used.

(3) the voltage drops are different.

(4) the resistors are the same.

11. Study the diagram below, then solve for the unknown voltages, currents, and resistances.



E_1 =	______	I_1 =	______	R_1 =	24
E_2 =	______	I_2 =	______	R_2 =	8
E_3 =	______	I_3 =	______	R_3 =	6
E_t =	48V	I_t =	______	R_t =	______

12. The definition of a series-parallel circuit is a group of

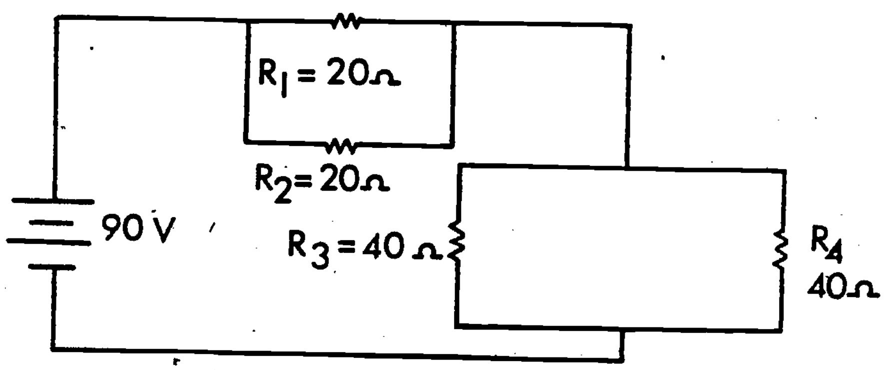
a. resistors connected in series with other resistors.

b. parallel resistors connected in series with other resistors.

c. series resistors connected in series with other resistors.

d. resistors connected in parallel with other resistors.

13. Study the diagram below and draw an equivalent series circuit. Compute the values of E_t, R_t, and I_t.



EQUIVALENT CIRCUIT:

E_t = ______

R_t = ______

I_t = ______

14. The unit of measure for electrical power is the

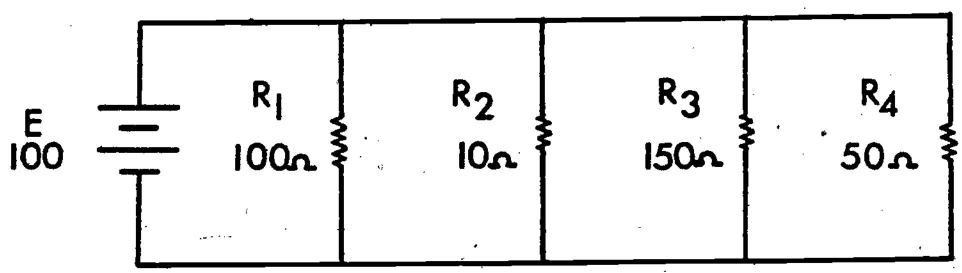
    a. volt.

    b. watt.

    c. ampere.

    d. ohm.

15. Study the diagram below and compute the following values: I_1, I_2, I_3, I_4, I_t, and W.



I_1 = ______ I_4 = ______

I_2 = ______ I_t = ______

I_3 = ______ W = ______

SUMMARY

ENERGY, OHM'S LAW, AND BASIC CIRCUITS

Energy exists in two states, potential or kinetic. Potential energy is energy at rest while kinetic energy is energy in motion. Energy can neither be created nor destroyed; however, its form can be changed to acccomplish a specific job. For example, electrons at rest are potential energy; when placed in motion they become kinetic energy, and as they move through a conductor or resistive device, their energy may be converted to heat, light or magnetic force.

An electrical circuit is any closed loop in which electrons may flow and finally return to their starting position without passing the same point twice.

Schematic symbols and abbreviations are used instead of pictorial circuits. This makes it possible to convey much more information in less space.

Ohm's Law states that the current flowing in a circuit is directly proportional to the applied voltage and inversely proportional to the resistance. Ohm's Law may be stated mathematically in the following forms:

$$I = \frac{E}{R}$$

$$E = IR$$

$$R = \frac{E}{I}$$

Almost any direct-current circuit can be solved by applying one or more of these basic formulas.

Before applying Ohm's Law, you must always convert given values to volts, amperes and ohms.

It must be remembered that current varies inversely with resistance; that is, if the resistance is increased without changing the voltage, the current will decrease a proportionate amount. Doubling resistance reduces current one-half. Also, it must be remembered that current varies directly as the applied voltage; that is, if the voltage is increased and the resistance not changed, the current will increase a proportionate amount. Doubling the applied voltage doubles the current. Finally, the voltage drop across a resistance is proportionate to the product of the current and the resistance. That is, if either the resistance or the current is increased and the other remains constant, the voltage drop will increase proportionately. Doubling resistance, with the current remaining constant, or doubling the current, with the resistance remaining constant, doubles the voltage drop. Doubling both current and resistance makes the voltage drop four times as much.

In a series circuit the same current passes through each device to complete its path from the negative to the positive terminal. In a parallel circuit all current does not flow through each device. The current divides to follow two or more paths. A series-parallel circuit is a combination of series and parallel circuits.

The voltage drop between two points is the potential difference required to force the current between the two points. Voltage drops across resistances are called IR drops, since they are computed from Ohm's Law formula, E = IR. In a simple series circuit, the sum of the voltage drops in the external circuit is equal to the applied voltage.

301

When the internal resistance of the source is included in the calculations, the sum of the voltage drops around the entire circuit is equal to the EMF of the source. In a series circuit the effective or total resistance is equal to the sum of the individual resistances, or to the voltage divided by the current.

In a parallel circuit the same voltage is applied to each parallel branch, the total current is equal to the sum of the currents in the individual branches, and the effective or total resistance of the parallel branches is equal to the voltage applied to the branches divided by the total current through the branches.

Parallel resistances may be combined to obtain the effective resistance by the LIKE METHOD, OHM'S LAW, the PRODUCT/SUM METHOD, or the RECIPROCAL METHOD.

Any circuit may be reduced to an equivalent series circuit.

The sum of the currents arriving at any point in a circuit is equal to the sum of the currents leaving that point.

The unit of measurement for electric power consumed, or the rate at which work is produced, is the WATT. The alphabetical symbol for power is the letter P and is expressed in watts. Power or Wattage equals the voltage multiplied by the current. (W = E x I).

PREPARE THE MAN

STUDY GUIDE/WORKBOOK 3ALR91630-I-46

302

Department of Medicine
School of Health Care Sciences

Cardiopulmonary Laboratory Specialist

MAGNETISM AND ELECTROMAGNETISM

May 1973

10-6

SHEPPARD AIR FORCE BASE

Designed For ATC Course Use

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Department of Medicine
Clinical Medicine Training Branch
Sheppard Air Force Base

SG/WB 3ALR91630-I-4b
May 1973

303

1

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MAGNETISM AND ELECTROMAGNETISM

Part I - Exercises

Exercise 1:

1. List the three types of magnets.

   a. ______________________

   b. ______________________

   c. ______________________

2. Magnetism is defined as

   a. a force which makes it possible for a magnet to force electrons through a conductor.

   b. a force which attracts iron, steel, or other magnetic substances.

   c. a force which makes it possible for a magnet to resist the flow of electrons through a conductor.

   d. none of the above.

3. Any magnet made of hard steel would be a ______________ magnet; a magnet made of soft iron would be a ______________ magnet.

4. Magnets that lose their magnetism rapidly are called ______________.

5. Any magnet that holds its magnetism for a long time is called a ______________ magnet, and it is said to have high ______________.

Exercise 2:

1. Which of the following statements is true concerning magnetic forces?

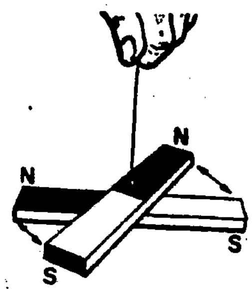
   ________ a. Like magnetic poles attract each other and unlike poles repel each other.

   ________ b. Like magnetic poles repel each other and unlike poles attract each other.

   ________ c. Both like and unlike magnetic poles repel each other.

30

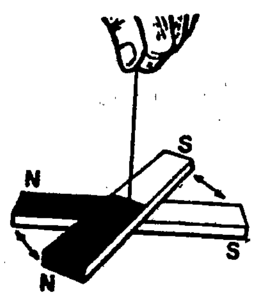
2. The force existing between the poles, as indicated by the arrows, would be that of



______ a. attraction.

______ b. repulsion.

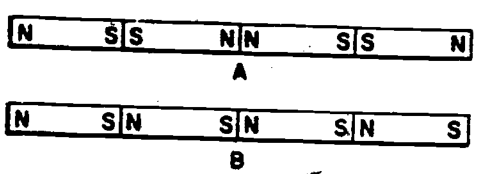
3. The force exerted between the two magnets as indicated by the arrows, would be that of



______ a. repulsion.

______ b. attraction.

4. Which of the arrangements below would have the greatest combined magnetic strength?



305

Exercise 3:

1. The space surrounding a magnet and the area occupied by the magnet is considered the

_____ a. residual magnetism.

_____ b. inducing magnet.

_____ c. magnetic field.

_____ d. reluctancy field.

2. The number of lines of force per unit area in a magnetic field is referred to as the _________________ of that magnetic field.

a. magnetic induction

b. residual magnetism

c. flux density

d. retentivity

3. The flux density in a magnetic field will _____________ when the magnetic field is increased.

a. increase

b. decrease

4. The magnetic force is greater at the poles of a magnet than in the middle; therefore, the flux will be more _____________ at the poles of the magnet.

5. As the distance from the surface of the magnet increases, the magnetic force becomes

_____ a. stronger.

_____ b. weaker.

351

Exercise 4:

1. The direction of the magnetic lines of force in the external magnetic field is from the

_____ a. South pole to the North pole.

_____ b. North pole to the South pole.

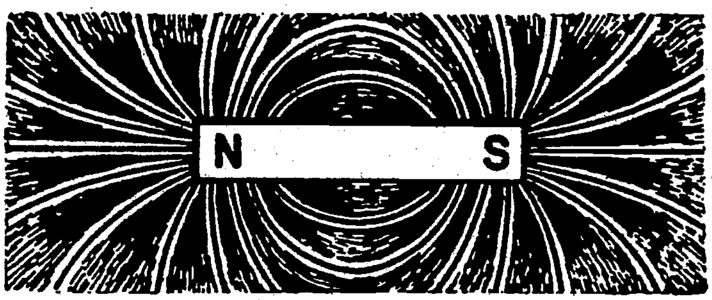
2. The direction of the magnetic lines of force on the inside of a magnet is from the

_____ a. South pole to the North pole.

_____ b. North pole to the South pole.

3. Because of their mutual repelling characteristics, lines of force in a magnetic field never _______________ one another.

4. Study the illustration below and answer the questions that follow.



a. The force which causes the flux lines to stretch out and away from each other in the magnetic field is the ____

____

b. The force which causes the flux lines to come close together at the South pole is the ____.

307

Exercise 5:

1. Substances which are strongly attracted by a magnet are called ________________ stubstances.

2. Which of the following materials would make the best permanent magnet?

   ______ a. Iron

   ______ b. Steel

   ______ c. Silver

   ______ d. Nickel

3. Identify the magnetic and nonmagnetic substances below by placing the letter "M" beside the magnetic substances or the letters "NM" beside the nonmagnetic substances.

   ______ a. Wood

   ______ b. Iron

   ______ c. Glass

   ______ d. Steel

   ______ e. Stone

   ______ f. Copper

   ______ g. Cobalt

   ______ h. Manganese

   ______ i. Gold

   ______ j. Silver

   ______ k. Nickel

4. In an unmagnetized iron bar, the magnetic molecules are arranged so that their individual magnetic strength ______________.

   a. adds

   b. substracts

   c. cancels

   d. does not exist

353

30

Exercise 6:

1. A material in which the molecules change direction quite easily will have (1) __________ permeability and (2) __________ retentivity.

(1) ____________________

(2) ____________________

2. Retentivity and residual magnetism are obviously related to each other, since __________ is the ability of a magnet to hold magnetism, while __________ is the actual magnetism which the magnet retains.

3. Because of its high retentivity, you would expect steel to have a ________________.

4. Match each term in column A with the correct definition from column B.

A - Terms	B - Definitions
_____ a. Permeability	1. The magnetism which a magnet can hold.
_____ b. Magnetic induction	2. The process by which artificial magnets are made.
_____ c. Retentivity	3. The ease with which a material can be magnetized.
_____ d. Residual magnetism	4. The ability of a material to hold magnetism.
_____ e. Reluctance	5. The opposition of a substance to become magnetized.

5. Air has a relatively low permeability. The permeability of air indicates

_____ a. the ease with which it can be magnetized.

_____ b. the ease with which it will conduct magnetic lines of force.

_____ c. both a and b.

6. Magnetic lines of force can travel through

_____ a. magnetic substances only.

_____ b. air and magnetic substances only.

_____ c. every known substance.

Exercise 7:

1. Current flow produces a ______________ around a conductor.

   ______ a. North and South pole

   ______ b. magnetic field

   ______ c. residual magnetism

2. When the current through a wire increases, the magnetic field around the wire becomes

   ______ a. larger.

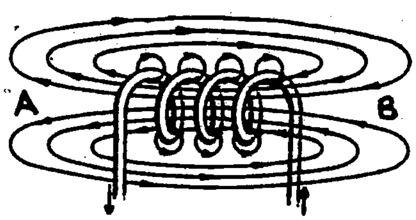
   ______ b. smaller.

3. What determines the direction of the lines of force around a current-carrying conductor?

____

4. To create a North and a South pole using a conductor, form the conductor into a ______________________.

5. The lines of force around a coil form a magnetic field which is similar to the magnetic field of a bar magnet. Study the illustration below and determine whether A or B is the North pole of the illustrated coil.



Exercise 8:

1. List the three main factors that determine the strength of the magnetic field of a coil.

a. ______________________

b. ______________________

c. ______________________

2. When an iron core is inserted into a coil, the magnetic strength of the coil is

_____ a. unchanged.

_____ b. increased slightly.

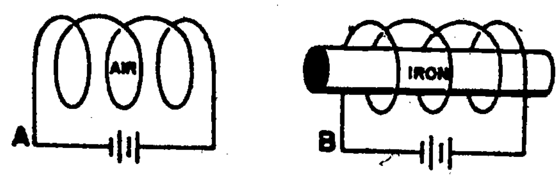
_____ c. decreased slightly.

_____ d. greatly increased.

3. Ampere-turns per inch is the unit of measurement for ______________________.

4. Magnetomotive force is equal to the current (in amperes) in the coil multiplied by the ______________________.

5. If the magnetomotive force in each of the coils below is the same, the magnetic strength of coil __________ will be much greater.



_____ a. A

_____ b. B

Exercise 9:

1. A current carrying coil whose length is greater than its diameter is known as

_____ a. an electromagnet.

_____ b. a choke coil.

_____ c. a relay.

_____ d. solenoid coil.

2. The core of an electromagnet should be constructed of a material that has

_____ a. high reluctance.

_____ b. high retentivity.

_____ c. high permeability.

3. Which of the following devices utilizes the "centering effect" of an iron core within a current carrying coil?

_____ a. Magnetic circuit breaker

_____ b. Electromagnetic lock

_____ c. Solenoid switch

_____ d. All of the above

PART II - SUMMARY

MAGNETISM

Magnetic force is an invisible force that exists in the space surrounding a magnet and is capable of attracting iron, steel, or other magnetic substances.

TYPES OF MAGNETS

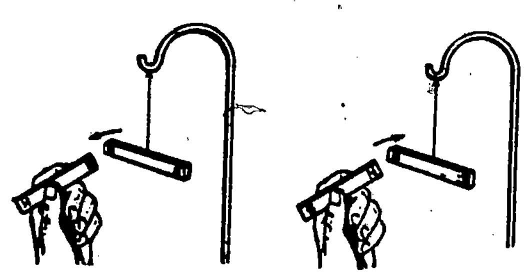
There are three types of magnets - natural, artificial, and electromagnetic.

Natural Magnets. Magnets in the natural state.
Magnetite (Lodestone)
Very limited practical use because their magnetic force is irregular and weak.

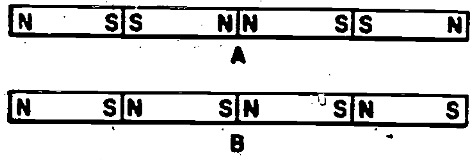
Artificial Magnets. Metals artifically magnetized.
Cheap - easy to produce. Used extensively in electrical equipment.
Temporary and Permanent Magnets.
Temporary Magnets - a magnet that loses magnetism as soon as it is separated from the magnetic field.
Permanent Magnets - a magnet that retains magnetism after being separated from the inducing magnetism.

Electromagnets. Electromagnets depend upon electric current for their magnetic energy, they are temporary magnets.

Magnetic Poles and Their Characteristics. Most magnets are able to attract materials at certain points on their surfaces. These points are the POLES where the magnetic force is concentrated. The poles are usually referred to as the NORTH and SOUTH pole and are represented by the letters "N" and "S" respectively.



One characteristic of magnets can be remembered by this simple law: LIKE MAGNETIC POLES REPEL EACH OTHER; UNLIKE POLES ATTRACT EACH OTHER.



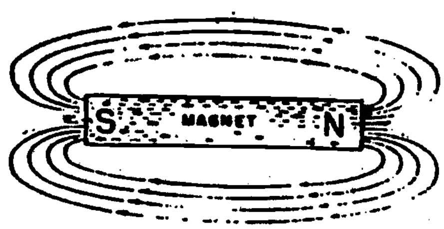
If 2 or more magnets are allowed to come together, with the North pole of one next to the South pole of the other, they act as one large magnet. Their magnetic strength will concentrate at the outer poles and is greater than one of the magnets alone.

MAGNETIC FIELDS

Magnetic force exists in the space surrounding a magnet and is capable of acting upon other magnets or magnetic substances. It is not necessary for an object to be in direct contact with a magnet in order to be influenced by it, however, the force is always stronger close to the magnet.

The magnetic field includes the area surrounding the magnet and the area occupied by the magnet.

CHARACTERISTICS OF THE MAGNETIC FIELD



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The magnetic field is made up of lines of force or flux lines. The direction of the lines of force in the external magnetic field is from the North to the South pole; inside the magnet, the direction of the lines of force is from the South to the North pole.

Forces Acting on the Flux Lines

R e p u l s i o n . Lines of force in the magnetic field exert their energy in the same direction, therefore, lines of force in the same magnetic field will repel each other.

Because of this mutual repelling force, they never cross one another, and tend to remain as far apart as possible. This causes the magnetic field around a magnet to expand and spread out to cover a wider area.

314

Attraction. Lines of force, in addition to repelling each other, are attracted to the South pole; because of the attraction, they take the shortest route from the North to the South pole.

These opposing forces account for the pattern they form around a magnet.

Flux Density. When the strength of a magnet is increased, the number of lines of force will also increase. This increased number causes the lines of force in the magnetic field to be pushed closer together. Therefore, as the magnetic strength increases, the field expands and becomes more dense.

Due to increased density of the flux lines, the magnetic force becomes stronger as you move toward the poles of the magnet.

The strength of the magnetic field is measured in terms of flux density. Flux density refers to the number of lines of force within a specific area in the magnetic field, and is expressed as lines of force per square inch or per square centimeter.

Magnetic and Nonmagnetic Materials. Only certain substances can be attracted by a magnet or become magnetized, these are called magnetic substances. They consist, for the most part, of iron and its various alloys such as steel. Cobalt, nickel, and manganese are to a lesser degree magnetic.

Relatively few substances are magnetic. Most substances such as wood, glass, stone, gold, silver, and copper are nonmagnetic.

Magnetic Induction. The process of magnetizing a piece of metal by bringing it into contact with a magnet is termed magnetic induction.

Retentivity and Residual Magnetism. The ability of a magnetic material to retain magnetism is called retentivity. The magnetism retained by a substance after its removal from the magnetizing force is called residual magnetism. Temporary magnets have little residual magnetism, while permanent magnets have a large amount.

Reluctance and Permeability. Highly retentive substances are not readily magnetized, their molecules are difficult to rearrange.

The term that refers to the opposition of a substance to become magnetized is reluctance. A material having high retentivity will also have high reluctance.

A substance in which the molecules change direction readily will be easy to magnetize. The term which refers to the ease with which a material can be magnetized is permeability.

The terms permeability and reluctance are opposites. A substance having a high permeability will have a low reluctance. For example, soft iron is easily magnetized, therefore, soft iron has high permeability and low reluctance.

Magnetic Shielding

. Permeability, in addition to referring to the ease with which a substance may be magnetized, is a measure of how readily it will conduct lines of magnetic force. A substance which can be magnetized easily can also readily conduct lines of force. For example, soft iron will conduct lines of force much more readily than air. Therefore, if this highly permeable material is placed within a magnetic field, the lines of force take the path of least resistance and are redirected. This principle is utilized to shield equipment from a magnetic field.

ELECTROMAGNETISM

Magnetism and electricity depend upon each other; when current flows through a wire, a magnetic field exists around that wire.

CHARACTERISTICS OF THE MAGNETIC FIELD AROUND A CURRENT-CARRYING CONDUCTOR

1. Forms concentric circles around the conductor.

2. Behaves as if under tension. Each line of force around the conductor acts like an elastic band. When current increases, more lines of force are produced, because they repel each other, the lines of force stretch farther away from the conductor. As current flow decreases, the lines collapse back toward the conductor.

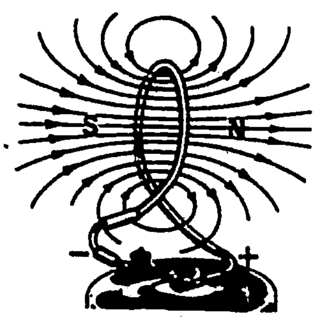
3. Exist along the full length of the conductor.

4. Form at right angles to the conductor.

Magnetic Field Around a Straight Conductor. The magnetic field around a straight conductor does not have a North or South pole. The lines are in circles rather than from North pole to the South pole.

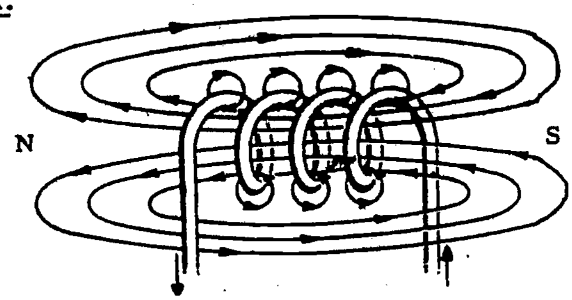
The direction current flows through a conductor determines the direction of the magnetic field around it. Therefore, although the magnetic field around a straight conductor has no North or South pole, it does have direction.

Magnetic Field Around a Coil.



When a conductor is bent into a loop, or coil, each line of force passes through the inside of the loop, then circles the outside of the loop to complete its path. In so doing, a North pole is created on one end of the coil and a South pole of the other. The direction of the lines of force around a coil of wire, therefore, are the same as that around a bar magnet.

Polarity of a Coil.



When the conductor is wound into a coil of many loops, or turns, the magnetic fields around the loops combine to form one large magnetic field. The magnetic poles are formed at the ends of the coil.

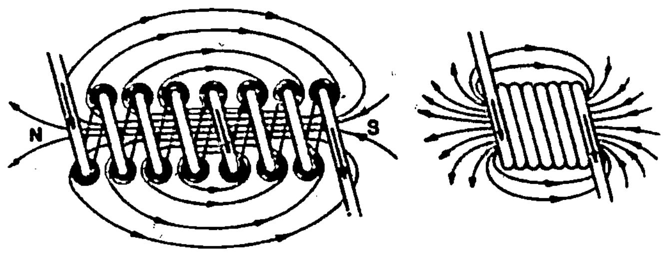
The direction of the current flow through the coil determines which end is the North pole and which is the South - or the polarity of the coil.

314

Factors Affecting the Magnetic Strength of a Coil.

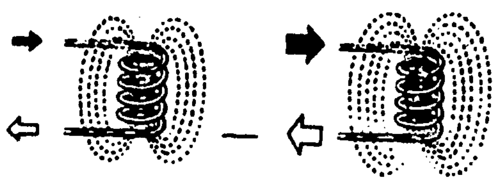
There are several factors that affect the strength of the magnetic field around a coil.

1. Number of Turns Per Inch.



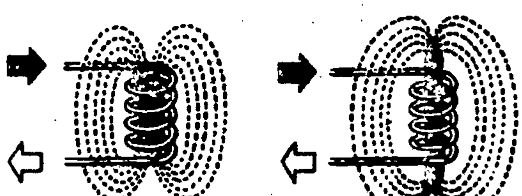
The relationship between magnetic strength and turns in a coil can be summed up as follows: The greater the number of turns per inch in a coil, the greater its magnetic strength will be.

2. Current.



If current through a coil increases, the strength of the magnetic field increases; if current decreases, the magnetic strength decreases. The magnetic force of a coil is dependent on the turns per inch and the current through the coil, this is called magnetomotive force. The unit of measurement for magnetomotive force is the ampere turn per inch, and is equal to the current (in amperes) multiplied by the number of turns per inch.

3. Core Material.



Another factor that affects the strength of the magnetic field around a coil is the permeability of the core material. The type of core material determines its ability to conduct or concentrate lines of force. Iron, for example, being more permeable than air will concentrate the lines of force within the iron, and add its magnetic strength to that of the coil.

ELECTROMAGNETS

A current-carrying coil which has a fixed iron core is called an electromagnet. An electromagnet usually has a soft iron core. A core with high permeability (low retentivity) is important because when the coil is de-energized, it must lose its magnetism quickly. Electromagnets are temporary magnets which loose their magnetism as soon as current flow to the coil is cut off.

Electromagnets are used extensively in the construction of switching devices for electronic circuitry.

ATC-SHEPPARD AFB TEX. 73-8439

Department of Medicine
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas

HANDOUT 3ALR91630-I-7c
March 1975

MASTER'S TEST

TABLE I

STANDARD NUMBER OF ASCENTS FOR MALES
(Steps should be doubled for double Master's)

Weight (lbs)	Age in Years												
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69
40-49	35	36											
50-59	33	35	32										
60-69	31	33	31										
70-79	28	32	30										
80-89	26	30	29	29	29	28	27	27	26	25	25	24	23
90-99	24	29	26	28	28	27	27	26	25	25	24	23	22
100-109	22	27	27	28	28	27	26	25	25	24	23	22	22
110-119	20	26	26	27	27	26	25	25	24	23	23	22	21
120-129	18	24	25	26	27	26	25	24	23	23	22	21	20
130-139	16	23	24	25	26	25	24	23	23	22	21	20	20
140-149		21	23	24	25	24	24	23	22	21	20	20	19
150-159		20	22	24	25	24	23	22	21	20	20	19	18
160-169		18	21	23	24	23	22	22	21	20	19	18	18
170-179			20	22	23	23	22	21	20	19	18	18	17
180-189			19	21	23	22	21	20	19	19	18	17	16
190-199			18	20	22	21	21	20	19	18	17	16	15
200-209				19	21	21	20	19	18	17	16	16	15
210-219				18	21	20	19	18	17	17	16	15	14
220-229				17	20	20	19	18	17	16	15	14	13

This supersedes HO 3ALR91630-I-5p, July 1973

TABLE II

STANDARD NUMBER OF ASCENTS FOR FEMALES

Weight (lbs)	Age in Years												
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69
40-49	35	35	35										
50-59	32	33	32										
60-69	31	32	30										
70-79	28	30	29										
80-89	26	28	28	28	28	27	26	24	23	22	21	21	20
90-99	24	27	26	27	26	25	24	23	22	22	21	20	19
100-109	22	25	25	26	26	25	24	23	22	21	20	19	18
110-119	20	23	23	25	25	24	23	22	21	20	19	18	18
120-129	18	22	22	24	24	23	22	21	20	19	19	18	17
130-139	16	20	20	23	23	22	21	20	19	19	18	17	16
140-149		18	19	22	22	21	20	19	19	18	17	16	16
150-159		17	17	21	20	20	19	19	19	17	16	16	15
160-169		15	16	20	19	19	18	18	17	16	16	15	14
170-179		13	14	19	18	18	17	17	16	16	15	14	13
180-189			13	18	17	17	17	16	16	15	14	14	13
190-199			12	17	16	16	16	15	15	14	13	13	12
200-209				16	15	15	15	14	14	13	13	12	11
210-219				15	14	14	14	13	13	13	12	11	11
220-229				14	13	13	13	13	12	12	11	11	10

320

Department of Medicine
School of Health Care Sciences

CARDIOPULMONARY LABORATORY SPECIALIST

BASIC MATHEMATICS - DECIMALS

July 1973

10-6

Sheppard Air Force Base, Texas

Original Material Prepared
by
Naval Air Technical Training Command
(2TPT-5111-02)

Designed For ATC Course Use

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The STUDY GUIDE (SG) presents the information you need to complete the unit of instruction, or makes assignments for you to read in other publications which contain the required information.

The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

The STUDY GUIDE AND WORKBOOK (SW) contains both SG and WB material under one cover. The two training publications are combined when the WB is not designed for you to write in, or when both SG and WB are issued for you to keep.

The PROGRAMMED TEXT (PT) presents information in planned steps with provisions for you to actively respond to each step. You are given immediate knowledge of the correctness of each response. PTs may either replace or augment SGs and WBs.

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Training publications are designed for ATC course use only. They are updated as necessary for training purposes, but are NOT to be used on the job as authoritative references in preference to Regulations, Manuals or other official publications.

ANSWERS TO SELF-TEST

DECIMALS

1. A decimal is a number that represents a fraction with a denominator that is a power of ten.

2. a. (30.04 thirty and four hundredths)

   b. (.379 three hundred seventy-nine thousandths)

   c. (1.46 one and forty-six hundredths)

   d. (90.001 ninety and one thousandths)

3.	a. 9.75	b. 12.3	c. 7.123	d. .0073
4.	a. .3	b. .8	c. .75	d. 2.5
5.	a. $\frac{1}{4}$	b. $\frac{9}{10}$	c. $\frac{21}{200}$	d. $\frac{7}{20}$
6.	a. .6	b. 13.85	c. .057	d. 1.6001
7.	a. 25.886	b. 180.553	c. 19.3925	
8.	a. 10.18	b. .6298	c. 446.37	
9.	a. .3093	b. .00284	c. .32012	
10.	a. 20	b. .001	c. .5	

323

INSTRUCTIONS

DECIMALS

This is a programmed lesson on DECIMALS. It is not a test as one might think, but an easy way to learn at your own rate of speed.

The two types of programming used in this lesson are:

a. Linear-- Information, in small amounts, will be presented in sequence. You will advance from frame to frame, using a provided cardboard to cover upcoming frames. Do not look ahead at answers. IF YOU MAKE AN ERROR, strike out the incorrect answer and correct it.

b. Branching-- The information given in these frames will be greater and you will be given a list of possible answers. Directions to turn to a page for each answer will be found next to the answers. FOLLOW THESE DIRECTIONS. Circle the answer you think is correct. If you have selected an incorrect answer, put an X through the incorrect response and circle another answer.

READ ALL INFORMATION CAREFULLY. Be sure you understand what is said before you attempt an answer.

If you wish, you may turn back to any part of the program to clarify some vague point.

While working problems in the program, if you are instructed to SHOW ALL WORK, you must work in the program. Otherwise, you may do the work EITHER on scratch paper or in the program.

Continue to page iii

324

DECIMALS

OBJECTIVES:

1. Write, in his own words, the definition of a decimal.
2. Demonstrate ability to read decimals by matching numerical decimals with the appropriate word decimals.
3. Write the numerical form of given word decimals.
4. Change given fractions to decimals.
5. Change given decimals to fractions. Reduce the fractions to lowest terms.
6. Round off given decimals.
7. Add given decimals.
8. Subtract given decimals.
9. Multiply given decimals.
10. Divide given decimals.

SUGGESTED READING TIME-- 62 MINUTES

NAME ______________ CLASS ______________

Continue to page 1.

32

	1. The definition of a decimal is: A number that represents a fraction with a denominator that is a power of ten. The definition of a decimal is: ________________________________ ________________________________.
a number that represents a fraction with a denominator that is a power of ten	2. Being a power of ten simply means that you can divide ten into the number evenly. The fraction $\frac{47}{100}$ has a denominator of one hundred and, of course, ten will divide evenly into it. We know that 100 is a power of ____________.
10 or ten	3. All decimals represent fractions and in every case the denominator is a power of ten. The decimal, .1, represents the fraction $\frac{1}{10}$. The denominator is a __________ of ____________.
power ten	4. The definition of a decimal is: A number that represents a fraction with a ____________ that is a ____________ of ____________.
denominator power ten	4A. Key words often help you remember hard to learn definitions. In the definition of DECIMAL, the words to remember as keys are: FRACTION, DENOMINATOR, and POWER OF TEN. Write the key words that will help you remember the definition of decimal. ____________, ____________, and ____________.

Continue to page 2.

fraction denominator power of ten	5. A decimal is a number that represents a ____________ with a ____________ that is ____________________.
fraction denominator a power of ten	6. Write, in your own words, the definition of a decimal ____________________ ____________________.
a number that represents a fraction with a denominator that is a power of ten (or a reasonable facsimile).	7. Each digit in a decimal has a place value and is read in a certain way. The places are as follows:

.12345

1 Tenths, 2 Hundredths, 3 Thousandths, 4 Ten Thousandths, 5 Hundred Thousandths

The 3 is in the thousandths place, the 5 is in the hundred thousandths place, and the 1 is in the ____________ place.

tenths	8. As you probably have noticed, the places to the right of the decimal point all end in "ths." In the decimal 2.46, the 6 is in the ____________ place.
hundredths	9. A decimal is read like this: (Example) 35.362-- "Thirty-five AND three hundred sixty-two thousandTHS". The 2 in this decimal is in the ____________ place.

Continue to page 3.

thousandths	10. When there is a whole number and a decimal, the decimal point is read "AND". For example: 6.02 is read "six AND two hundredths". When there is only a decimal (no whole number), it is read without using the word, "and". For example: .06 is read "six hundredths". How would "thirty-three THOUSANDTHS" be written as a decimal? ______________.
.033	11. REMEMBER-- When you are reading decimals, the decimal point is read "and" <u>except</u> when there is NO whole number. For example: .5 is read "five tenths". 3.22 is read "three AND twenty-two hundredths". Match the decimal in column A with the correct word decimal in column B, placing the correct letter by the word decimal. A a. 4.3 b. .006 c. 25.01 _________Six hundreds _________Twenty-five and one hundredth _________Six hundredths _________Four and three tenths _________Twenty-five and one tenth _________Six thousandths

Continue to page 5.

4A

Very good! You should be ready for a more difficult problem, so let's do this one:

Change $\frac{12}{23}$ to a decimal.

If your answer is:	Go to page:
.0052	6A
.52	8B

4B

Wrong!! You add only the number of zeros that there are digits in the decimal. There is only one digit in the decimal .7, so there will be only one zero in the fraction. The decimal .679 has three digits, so the denominator will have three zeros and look like:

If your answer is:	Go to page:
679/1000	16A
679/000	8C

a. 4.3 (four and three tenths)

b. .006 (six thousandths)

c. 25.01 (twenty-five and one hundredth)

12. Now, match column A with column B in the same manner.

A		B
a. .25	______	Two hundredths
b. .002	______	One and two hundred twenty-two thousandths
c. 20.05	______	Twenty-five hundredths
d. 1.222	______	Two thousandths
	______	Twenty and five hundredths
	______	Twenty-five hundred
	______	One and two hundred twenty-two thousands

a. .25 (twenty-five hundredths)

b. .002 (two thousandths)

c. 20.05 (twenty and five hundredths)

d. 1.222 (one and two hundred twenty two thousandths)

NOTE: Be certain the word decimal ends with "ths."

13. When writing a decimal, FIRST and MOST IMPORTANT, determine the "place" value (thousandths, tenths etc.). This will give you the number of digits you need to the right of the decimal point. For example: twenty-two thousandths will require three digits because it is to the thousandths place. It would be written: .022

Five and five tenths would be written: 5.5

(Remember, with a whole number, the decimal point is read AND.)

How would twenty-five and four thousandths be written? __________

Continue to page 7.

6A

Wrong. You set your division up incorrectly. The problem should have been set up like this: $23\overline{)12.000}$

Return to page 4A and do the division again and place the decimal point in the right position; then select the right answer and go to the page indicated.

6B

3/4 is not correct; .75=3/4. Return to page 10 and work the problem again. Then select the correct answer and continue with the program.

6C

You have misplaced the decimal point. The decimal point ALWAYS goes to the extreme right of the dividend. EXAMPLE: $\overline{)12.}$ not $\overline{)1.2}$, from $\frac{12}{7}$. Return to page 8B; rework the problem and continue with the program.

6D

Your division is right, but it is unnecessary to put the 0 at the end of the decimal. Turn to page 4A and continue the program.

33

25.004	14. Thirteen and four tenths would appear as 13.4 Nine and forty-four hundredths appear as: ____________
9.44	15. Four ten thousandths looks like ____________.
.0004	16. Write the numerical form of twenty-nine thousandths. ____________
.029	17. Write the numerical form of each of the following word decimals. a. Sixty-five hundredths ____________ b. Sixty and ninety-seven thousandths ____________ c. Three hundred and four tenths ____________ d. Seventy-five ten thousandths ____________ e. Fifty-eight and sixty-six hundredths ____________ f. Forty-nine thousandths ____________

Continue to page 9.

8A

$\frac{45}{1000}$ is correct for the first step, but each fraction must be in its lowest terms. 5 divides into 45 and 1000— thus it can be reduced. Go back to page 16A and reduce the fraction, choose the correct answer, and go to the page indicated.

8B

.52 is correct. You have been changing proper fractions to decimals, so now let's change an IMPROPER FRACTION to a decimal. It is done in the same manner, but NOW the answer will include a whole number. For example: $\frac{3}{2}$ changed to a decimal is

$$\begin{array}{r} 1.5 \\ 2\overline{)3.0} \\ \underline{2} \\ 1\,0 \\ \underline{1\,0} \end{array}$$

As you can see, an improper fraction will become a whole number and a decimal (1.5). Change $\frac{12}{7}$ to a decimal.

If your answer is:	Go to page:
.17	6C
1.7	18A

8C

You have the 3 zeros but what happened to the 1? The decimal .679 is read "six hundred seventy-nine thousandths," so the denominator becomes 1000. Return to page 4B and select the correct answer.

33

a. .65 b. 60.097 c. 300.4 d. .0075 e. 58.66 f. .049	18. All fractions can be changed to a decimal by dividing the numerator by the denominator. The decimal may be carried out as many places as the problem indicates. Example: $\frac{7}{8}$ to a decimal is

$$8\overline{)7.000}^{\;.875}$$

BROKEN INTO STEPS:

a. Divide the numerator (7) by the denominator (8).

b. Place the decimal point to the right of the numerator.

c. Add zeros to the right of the decimal point as needed.

d. Place a decimal point in the quotient DIRECTLY over the decimal point in the division bracket.

e. Carry the quotient out as far as necessary.

Change $\frac{1}{2}$ to a decimal.

If your answer is:	Go to page:
2.0	16B
.5	4A
5.0	18C

If you are reading this paragraph, then you are not following directions. From here on, you must follow the directions given in each frame VERY CAREFULLY. Return to the frame above and follow the directions given there.

ANSWERS TO PAGE 18A: a. .8 b. 5.2 c. .8 d. 1.3

You have learned how to change a fraction to a decimal, so let's change a decimal into a fraction. The FIRST thing to do is to make the digits of the decimal the NUMERATOR OF THE FRACTION. The denominator of the fraction will have a one (1) followed by the same number of zeros as there are digits in the decimal. For example, the decimal .27 becomes the fraction $\frac{27}{100}$. Notice how the digits 27 become the numerator and the denominator begins with a 1 and two zeros follow. There were two digits in the decimal, thus there are two zeros in the denominator.

Change .7 to a fraction.

If your answer is:	Go to page:
$\frac{7}{100}$	4B
$\frac{7}{10}$	16A
$\frac{3}{4}$	6B

11A

Fine. As you have done on this problem, make sure that any fraction you are working with is in its lowest terms. Change the following decimals to fractions. Remember, REDUCE each to its lowest terms. If you still are not certain of just how to change decimals to fractions, go back to page 10 and rapidly review.

Change these to fractions:

a. .7000--

b. .009--

c. .75--

d. .2--

Turn to page 12 for answers.

11B

You neglected the decimal point. You must place decimal points DIRECTLY UNDER EACH OTHER. The sum will have the decimal point carried right down into it from the column being added. Return to page 17A and do the problem again. Remember to put the decimal points under each other. EXAMPLE:

```
   18.6
     .015
 2056.11
+   1.1
 2075.825
```

ANSWERS TO PAGE 11A: a. $\frac{7}{10}$ b. $\frac{9}{1000}$ c. $\frac{3}{4}$ d. $\frac{1}{5}$

Continue your lesson in frame 19 below.

	19. In many cases, a large cumbersome decimal is not necessary. In those cases where a smaller decimal will do, you may ROUND OFF the decimal. To make a large decimal smaller and easier to use without losing a great deal of accuracy, you will ____________ ____________ the large decimal.
round off	20. Rounding off involves THREE steps. The FIRST TWO are: a. Determine the PLACE you want to round off to. (Tenths, hundredths, etc.) b. Look FIRST at the number (digit) DIRECTLY to the right of that place. Example: .176 To round to hundredths: First look at the number to the right of the hundredths place. In this case, it is a 6. The FIRST number that you will look at when rounding .265 to TENTHS is ________ (number).

Continue to page 13.

33

6	21. You have the decimal .27364, and you want to round it off to tenths. What number would you look at first? (Circle your choice.) a. 2 b. 7 c. 3 d. 6 e. 4
7	22. The THIRD STEP is: If the number to the right of the place you are rounding off is 5 OR MORE, you ADD (+1) one to the place and drop the remainder of numbers. For example: .176 This decimal rounded to tenths becomes .2 because the number to the right of the tenths place (7) is 5 or greater. Also note that the 7 and 6 were dropped. Round .0074 to the nearest HUNDREDTH. (Circle your answer.) a. .01 b. .007 c. .1 d. .08
.01	23. When the number to the right is LESS THEN 5, leave the place value as is and DROP THE REMAINDER OF THE NUMBERS. Round the decimal .7848 to hundredths. (Circle your answer.) a. .78 b. .79 c. .785 d. .7800

Continue to page 14.

338

.78	24. REMEMBER: a. FIRST, look at the number to the right of the place you are rounding off. b. If the number is 5 or more, add 1 to the place. c. If less then 5, do not add anything. d. Always drop the remainder of digits to the right of the rounded off place. Round these decimals to the indicated places: Tenths: .408062 ________ Hundredths: .408062 ________ Thousandths: .408062 ________ Ten Thousandths: .408062 ________ Hundred Thousandths: 408062 ________
.4 .41 .408 .4081 .40806	25. Round off the following decimals: To Hundredths: 41.1145-- ________ .98509-- ________ To Tenths: .6419-- ________ To Ten Thousandths: .29826-- ________ 1.11181-- ________

Continue to page 15.

Hundredths
41.11
.99

Tenths.
.6

Ten Thousandths
.2983
1.1118

26. If you are NOT having trouble with rounding off, proceed to frame 27. If you are and your trouble is mainly knowing the "places", turn to page 2, frame 7, and review. If you do not understand how to round off, review or raise your hand for assistance.

When you have corrected your trouble, continue to frame 27.

* NO RESPONSE REQUIRED. *

27. Round off each of the following decimals to the indicated place.

To the nearest tenth:

a. .329-- __________

b. .05-- __________

To the nearest hundredth:

c. .10909-- __________

d. 8.3434-- __________

To the nearest thousandth:

e. .2551-- __________

f. 5.9738-- __________

To the nearest ten thousandth:

g. 7.777774-- __________

h. .000891-- __________

To the nearest hundred thousandth:

i. .0980653-- __________

j. 3.000051-- __________

Turn to page 17A for answers.

16A

Very good. The next thing to remember is: Make sure the fraction is in its lowest terms. For example, changing the decimal .5 to a fraction, it first becomes $\frac{5}{10}$. Is this in the lowest terms possible? Of course, the answer is no. In its lowest terms, it would be $\frac{1}{2}$. Always check the fraction and be sure it is in its lowest terms. Try this one now. Change .045 to a fraction.

If your answer is:	Go to page:
$\frac{9}{200}$	11A
$\frac{45}{1000}$	8A
$\frac{45}{100}$	21B

16B

In order to change a fraction to a decimal, you divide the numerator by the denominator. You did not do this. In the case of $\frac{1}{2}$, the denominator (2) is divided into the numerator (1) like this:

$$2\overline{)1.0}\quad .5$$
$$10$$

$\frac{1}{2}$ changed to a decimal is therefore .5 . ALL fractions are changed to decimals in the same manner.

Change $\frac{3}{4}$ to a decimal.

If your answer is:	Go to page:
.750	6D
.75	4A

34

17A ANSWERS TO PAGE 15 FRAME 27:

a. .3 b. .1 c. .11 d. 8.34 e. .255 f. 5.974

g. 7.7778 h. .0009 i. .09807 j. 3.00005

You will now learn the last four objectives-- How to ADD, SUBTRACT, MULTIPLY, AND DIVIDE decimals. Continue below.

Adding decimals is much the same as simple whole number addition. The difference is that there is a decimal point to keep in mind. The decimals are put in a column and decimal points are under decimal points (see example). The decimal point is brought down to the sum and the addition is carried on just as it is in whole number addition.

EXAMPLE:

$$\begin{array}{r} 6.3 \\ .01 \\ \underline{22.22} \\ 28.53 \end{array}$$

Add these decimals. 33.79 + .97 + 2.2 =

If your answer is:	Go to page:
36.96	19A
3498	11B

17B

Wrong. The number to the right of the division sign is always the divisor.

.064 ÷ 3.2 (3.2 is the divisor, not .064)

Return to page 26 and select the correct answer.

18A

Right. If you want to review before you do the problems below, return to page 9, frame 18, read the rules, and then come back and solve the problems. If you think you are ready now, then change each of the fractions below to decimals.

a. $\frac{4}{5}$

b. $\frac{52}{10}$

c. $\frac{9}{11}$

d. $\frac{13}{10}$

Turn to page 10 to check answers and continue from there.

18B

No. Move the decimal point in the dividend the same number of places as you did in the divisor. Example: $3.2\overline{)\,.064}$ because $32.\overline{)\,0.64}$.

Return to page 26 and select the correct answer.

18C

You set up your problem incorrectly and had the decimal in the wrong place. This is what you should have set up for your division: $2\overline{)\,1.00}$. Return to page 9, frame 18, and determine the correct answer. Then turn to the correct answer page.

19A

Right. The main thing to remember is to keep the decimal points lined up under each other. Now let's subtract decimals. The rules are the same as they are in the subtraction of whole numbers. Just as in the addition of decimals, the decimal points must be lined up under each other. You must also remember that the smaller of the numbers must go under the larger.

Solve this problem: 729.75308 - .0077=

If your answer is:	Go to page:
729.75231	20B
729.74538	22

19B

ANSWERS TO PAGE 24A: a. 66.42 b. .825 If your answers are not correct, make the corrections and continue below.

Now let's divide decimals. The most important factor is that the divisor must be "made" a whole number before division is started. This is done by moving the decimal in the divisor all the way to the right.

Ex: $.25\overline{)\quad}$ becomes $25.\overline{)\quad}$. Then move the decimal in the dividend the same number of places to the right. Ex: $.25\overline{)1.25}$ becomes $25.\overline{)125.}$ Move the decimal point in the following division problem and solve.

$$3.3\overline{).66}$$

Turn to page 24B.

20A

Right. REMEMBER: The divisor is to the right of the division sign.

Solve these problems and show your work.

a. 4.9 ÷ .007= b. 1179 ÷ 13.1= c. .02925 ÷ 2.25=

WORK HERE - -

a. b. c.

Go to page 23B for answers.

20B

Remember when you were told that decimal points must go under decimal points? Well, the error you made was because of the decimal placement. A good way to remember the decimal points is put them on the paper first (in a column) and then put the numbers down. Also remember to put the decimal in the answer DIRECTLY under those in the column.

Go back to page 19A and do the problem again.

20C

No. DO NOT ADD an extra zero on the right of any answer. If you need zeros to make your digit count correct, they must go to the left of the answers. For example: .2 x .002 will equal .0004, not .4000.

Return to page 23A and select the correct answer.

21A

Your decimal point should have been placed like this:

```
   3.217
 x  .471
    3217
   22519
  12868
1.515207
```

If you had it any place else, return to page 22 and read the rules again.

If you did it correctly, do the following problems by placing the decimal points correctly in the product.

a.
```
  .0035
x  3.28
    280
    70
  105
  11480
```

b.
```
 22.222
x   .11
  22222
 22222
 244442
```

Turn to page 23A.

21B

There are more than two digits in the decimal .045. Zero IS a digit. That makes three digits in this decimal. You should use the same number of zeros as there are digits and make the denominator 1000. Return to page 16A and select the correct answer.

Right. You are now ready for multiplication. Decimals are multiplied just as whole numbers are, except you have a decimal point to put in the final answer (product). DISREGARD the decimal point in the first two steps. A sample problem is broken into steps to clarify the process.

PROBLEM: .15 x 1.10 =

a. Place the larger number OVER the smaller. Ex.

```
  1.10
x  .15
```

b. Multiply just as you do in whole numbers. Ex.

```
  1.10
x  .15
   550
  110
  1650
```

c. Count the number of digits to the right of the decimal points in the factors of the problem. Ex. 1.10 and .15 = 4 digits to the right in this case.

d. Count off 4 places FROM THE RIGHT in the PRODUCT, and place a decimal point. Ex. .1650 (product of this problem)

- -

Another example: 3.1 x 10.21 (would be set up and solved like this):

```
  10.21
x   3.1
   1021
  3063
 31.651   product
```

- -

Place the DECIMAL POINT in the product of this problem:

```
   3.217
x   .471
    3217
  22519
 12868
 1515207
```

Turn to page 21A.

23A

ANSWERS TO PAGE 21A: a. .011480 or .01148 b. 2.44442

Let's try another to make sure that you have the decimal point placement down pat. Solve this one: .55 x .003 =

If your answer is:	Go to page:
.01650	20C
.00165	24A

23B

ANSWERS TO PAGE 20A: a. 700 b. 90 c. .013

Solve these problems: (SHOW ANSWERS.)

a. 289.0038 + .992763 =

b. .3928 - .02867 =

c. .42 x 3.7 =

d. 4.32 + .0036 =

WORK ON SCRATCH PAPER.

Turn to page 25.

24A

Very good. Care must be taken with your arithmetic. It is always a good idea to CHECK your multiplication and addition. This is where most of the errors are made, with a few being made on the placement of the decimal point.

Let's try two more. After completing them, check your arithmetic and decimal placement.

a. 332.1 x .2 = b. .55 x 1.5 =

TURN TO PAGE 19B.

24B

$3.3\overline{).66}$ becomes $33.\overline{)6.6}$ with .2 above, by moving the decimal point one place. When the divisor IS a whole number and the dividend is a decimal, such as $33\overline{)6.4}$, you do not move the decimal point. Simply place the decimal point up in the quotient directly over the decimal point in the dividend; then divide. For example: $275\overline{)3.44}$

Solve this: $26\overline{)7.8}$

The answer to the problem above is: (Circle your answer.)

a. 3

b. .3

c. .03

Turn to page 26.

ANSWERS TO PAGE 23B

a.
$$\begin{array}{r} 289.003800 \\ +\ \underline{.992763} \\ 289.996563 \end{array}$$

b.
$$\begin{array}{r} .39280 \\ -\ \underline{.02867} \\ .36413 \end{array}$$

c.
$$\begin{array}{r} .42 \\ \underline{\times 3.7} \\ 294 \\ \underline{126} \\ 1.554 \end{array}$$

d.
$$\begin{array}{r} 1200 \\ 36\overline{)43200.} \\ \underline{36} \\ 72 \\ \underline{72} \end{array}$$

If you missed any of these problems, go to the part of the program that teaches that type of problem and read the rules again. THEN correct your error. The pages that teach each function are listed below.

ADDITION (Page 17A)

SUBTRACTION (Page 19A)

MULTIPLICATION (Page 22)

DIVISION (Pages 19B & 26)

This completes your lesson in decimals. Working partial numbers is easier when you use decimals rather than fractions, so this lesson is very important.

A Self-Test begins on page 27.

$26\overline{)7.8}$ solved is: $26\overline{)7.8}^{\,.3}$

If the dividend IS a whole number, Ex: $1.32\overline{)25.}$, add zeros and move the decimal point. Ex: $1.32\overline{)25.00}$. When the decimal has been moved as appropriate, then place a decimal point in the quotient directly over the point in the dividend, Ex: $2.5\overline{).1\uparrow00}$ and solve.

$$\text{Example: } \begin{array}{r} .04 \\ 2.5\overline{).1\uparrow00} \end{array}$$

NOTICE HOW THE QUOTIENT IS .04 AND NOT .4. THIS IS BECAUSE 25 GOES INTO 10 ZERO TIMES, AND INTO 100 FOUR TIMES.

Solve the problem below:

$.064 \div 3.2 =$

Note: ÷ is the sign for division and the number on the right is always the divisor.

If your answer is:	Go to page:
$\begin{array}{r} 50. \\ .064\overline{)3.200.} \end{array}$	17B
$\begin{array}{r} .2 \\ 3.2\overline{).064} \end{array}$	18B
$\begin{array}{r} .02 \\ 3.2\overline{).064} \end{array}$	20A

35

SELF-TEST

DECIMALS

1. Write, in your own words, the definition of a decimal.

____

____

2. Match the numerical decimals in Column A with the appropriate word decimals in Column B. Place the letter from Column A in the blank next to the correct word decimal in Column B.

A	B
a. 30.04	_____ One hundred forty-six
b. .379	_____ Three hundred seventy-nine thousandths
c. 1.46	_____ Thirty and four hundredths
d. 90.001	_____ Ninety-one thousands
	_____ Three hundred seventy-nine thousand
	_____ One and forty-six hundredths
	_____ Thirty-four hundredths
	_____ Ninety and one thousandths

3. Write the numerical form of the following word decimals:

   a. Nine and seventy-five hundredths _________

   b. Twelve and three tenths _________

   c. Seven and one hundred twenty-three thousandths _________

   d. Seventy-three ten thousandths _________

4. Change the fractions below to decimals.

a. $\frac{3}{10}$ =

c. $\frac{3}{4}$ =

b. $\frac{4}{5}$ =

d. $\frac{5}{2}$ =

5. Change the decimals below to fractions. REDUCE TO LOWEST TERMS.

a. .25 =

c. .105 =

b. .9 =

d. .35 =

6. Round off the following decimals as directed.

NEAREST TENTH:

a. .6354 -

NEAREST HUNDREDTH:

b. 13.8467 -

NEAREST THOUSANDTH:

c. .05671 -

NEAREST TEN THOUSANDTH:

d. 1.60006 -

7. Add the following decimals:

a. 9.37 + 15.756 + .76 =

b. 69.333 + .12 + 111.1 =

c. .0055 + 7.02 + 12.367 =

8. Subtract the following decimals:

a. 13.14 - 2.96 =

b. .7068 - .077 =

c. 447.3 - .93 =

9. Multiply the following decimals:

a. .03 x 10.31 =

b. .71 x .004 =

c. 1.51 x .212 =

10. Divide the following decimals:

a. .08 ÷ .004 =

b. .00344 ÷ 3.44 =

c. .04 ÷ .08 =

END

Answers to the Self-Test are found on page i in the front of the text.

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CARDIOVASCULAR DRUGS

Drug	Usual Dose	Uses	Toxicity
LANOXIN, TM DIGOXIN	Digitalizing dose: 2.0-3.0 mg. orally 1.0-2.0 mg. I.V.	Congestive heart failure control ventricular rate in atrial flutter fibrillation	VPC's, A-V Conduction disturbance nausea, vomiting, yellow vision and other CNS symptoms.
DIGITOXIN	Digitalizing 1.0-200 mg. orally	Same as digoxin but slower action and prolonged effect	Same as digoxin; toxicity more prolonged.
XYLOCAINE, TM LIDOCAINE	70-100 mg. I.V. x 3; 1.0-4.0 mg/min. I.V. drip.	Ventricular arrhythmias	Seizures, A-V block
PRONESTYL, TM PROCAINE AMIDE	0.5 Gm. q 6h orally; 100 mg.	Atrial and ventricular arrhythmias.	Hypotension, diarrhea, intraventricular conduction delay ventricular arrhythmias, skin rash, systemic lupus erythematosis.
QUINIDINE	0.2-0.4 Gm q 4h orally 100 mg. I.V. q 5 min. x 5.	Atrial and ventricular arrhythmias	GI symptoms, tinnitus, fever syncope, thrombocytopenia, hypotension, intraventricular conduction delay, ventricular arrhythmias.

400

This SG supersedes SHO 3ALR91630, dated July 1972

401

EDECRIN, TM ETHACRYNIC ACID	25-50 mg. I.V. 50-400 mg. orally divided doses	Acute pulmonary edema; congestive heart failure	Potassium depletion; alkalosis; excess diuresis; acute gout; thrombocytopenia
LASIX, TM FUROSEMIDE	10-20 mg. I.V.; orally	Same as ethacrynic acid	Potassium depletion; alkalosis; excess diuresis.
GLUCAGON	2.5 mg. I.V.	Shock: acute heart failure	Nausea
ARAMINE, TM METARAMINOL	50-200 mg./L; give 2-3 cc./min I.V.	Shock	Use body's own catecholamines, so may need increasing dose; ventricular arrhythmias; excessive vasopressor response persists 20-60 min.
LEVOPHED, TM NOREPINEPHRINE	1-4 ampules (4-16 mg. Levophed base) per liter, 20-30 drops per min.	Shock	Cutaneous necrosis (treat with Regitine); reduction of blood volume; ventricular arrhythmias.
WYAMINE, TM NOREPINEPHRINE	1000 mg./L; give 1-3 cc/min.	Shock	CNS stimulation.
HEPARIN	5000-15000 units 10,000-20,000 units subcutaneously	Decrease blood clotting tendency, prevent thrombi and emboli; control dose with clotting time.	Bleeding. Antidote: protamine sulfate or fresh blood.
COUMADIN, TM PANWARFIN, TM	30-60 mg. initially initially, 2-10 mg daily	Same as heparin. Control dose with prothrombin time	Bleeding. Antidote: Vitamin K (Mephyton, TM).

DILANTIN, TM DIPHENYLHYDANTOIN	250 mg., diluted in 5 cc. solution, I.V. slowly over 5 min., 100 mg q.i.d. orally	Arrhythmias due to digitalis toxicity. Prophylactically prior to cardioversion.	Local thrombophlebitis Respiratory Arrest.
INDERAL, TM PROPRANOLOL	10-50 mg. q 6 h orally; 1-10 mg. q 4-6 h I.V., given 1 mg./min.	Angina, atrial and ventricular arrhythmias	Heart failure, shock asthma, A-V block
ISUPREL, TM ISOPROTERENOL	0.2-1.0 mg. in 500 cc I.V. drip; 10 mg sublingual	Bradycardia, 3^{o} A-V Block.	Tachycardia, ventricular arrhythmias, myocardial necrosis.
ATROPINE	1.0-2.0 mg. I.V.	Sinus bradycardia, A-V block	May slow ventricular rate in 2^{o} A-V block, glaucoma, urinary retention, delerium, fever.
EPINEPHRINE	1.0 mg. (1 cc. of 1:1000) I.V.	Ventricular fibrillation when to response to precordial shock	Tachycardia, ventricular Arrhythmias
SODIUM BICARBONATE, 5%	50 cc. initially, repeated every 5 of circulatory arrest.	Correction of acidosis due to circulatory arrest or shock.	Local thrombophlebitis

Department of Medicine
School of Health Care Sciences

Technical Training

CARDIOPULMONARY LABORATORY SPECIALIST

VECTORS AND TRIGONOMETRIC FUNCTIONS

July 1973

10-6

SHEPPARD AIR FORCE BASE

Original Material Prepared
by
Naval Air Technical Training Command
(2TPT-5113-01)

Designed For ATC Course Use

DO NOT USE ON THE JOB

358

ASSIGNMENT SHEET

This assignment sheet should be used when.

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by page and/or frame)	REVIEW QUESTIONS (by No)

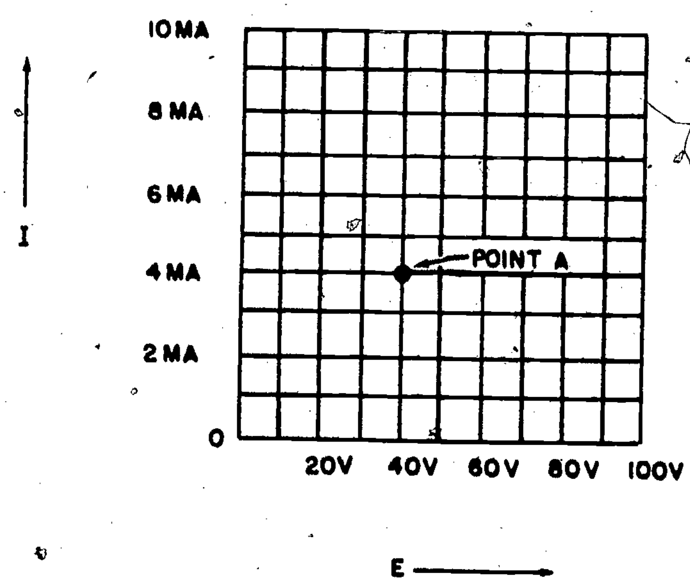
What is a GRAPH?	1. A GRAPH is a pictorial representation of the relationship between two or more quantities. A pictorial representation between two or more quantities is a ______.
graph	2. Basically, all graphs fall into two types: (a) those representing a LINEAR function and (b) those representing a NONLINEAR function. A <u>straight line</u> is the graph of a ______ function.
linear	3. A curved line is the graph of a ______ function.
nonlinear	4. The sine wave is a graph of a nonlinear function; it forms a ______ line.
curved	5. What is the difference between the graph of a linear function and the graph of a nonlinear function? ______ ______ ______

Turn to Page 2 and continue.

THE ANSWER:

A linear graph is a STRAIGHT line; a nonlinear graph is a curved line.

To graph Ohm's Law ($I = \frac{E}{R}$) on the set of coordinate lines below, we mark voltage values on the horizontal line (see E ⟶) and current values on the vertical line (see I ↑). Moving horizontally, each vertical line represents 10 volts. Moving vertically, each horizontal line represents 1 milliamp. By holding the resistance constant at a given value, we can find the resulting current value for any applied voltage between 0 and 100v. Any pair of voltage and current values can be represented by a point marked on the graph. (Example: 4 ma and 40 volts.) This point is found by moving across the graph paper on the line representing 4 ma of current, and up on the line representing 40 volts (see pt. A). Where the two lines cross, mark the point. Repeat this procedure with other values of E and I until you have marked several points. Then connect the points together with a line. This line is the graph.



Continue on page 3A

3A

On the set of coordinate lines in Figure 3B, plot the values of current and voltage given in the table, Figure 3A. (This table was made using Ohm's Law with a constant 10k Ω resistor.)

E	I
100 V	10 MA
50 V	5 MA
20 V	2 MA
10 V	1 MA

Figure 3A.

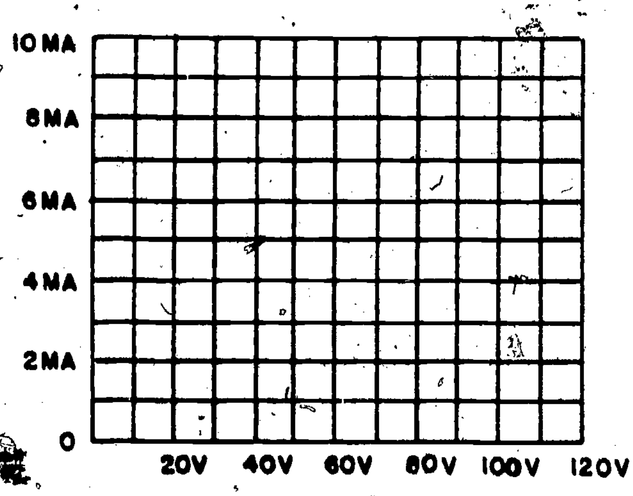


Figure 3B.

After you have plotted the 4 points, connect them to complete your graph.

What type of graph is this?

Linear. Turn to page 4.

Nonlinear. Turn to page 5.

3B

YOUR ANSWER: Linear
(From P-4)

Friend, you were a little hasty; your answer is wrong.

We are using the power formula ($P = I^2R$) in this problem. Since the current is squared, the graph cannot be a linear one. Go back to page 4 and plot the points correctly. If your graph is still a straight line, see your instructor for help.

YOUR ANSWER: Linear
(From P-3A or P-5)

Right you are. For a quick check, compare your graph with Figure 4A.

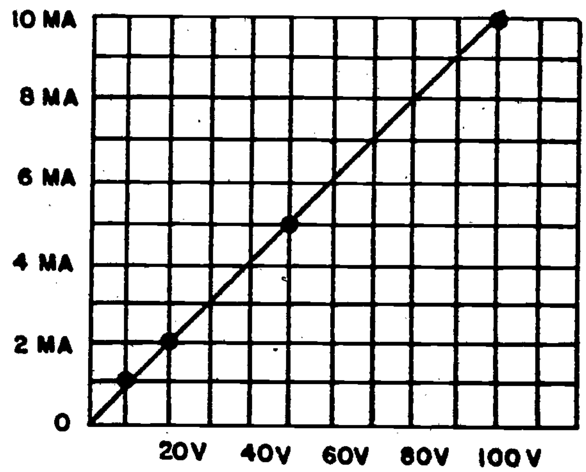


Figure 4A.

Now, let's hold the resistance constant, and see what happens to the power as the current is changed. On the set of coordinates in Figure 4B, plot the pairs of values listed in the table below. ($R = 5k\Omega$)

I	P
0 MA	0 W
1 MA	5 W
2 MA	20 W
3 MA	45 W
4 MA	80 W

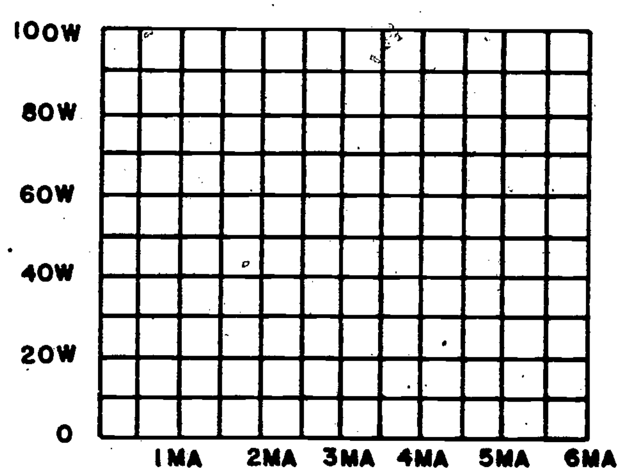


Figure 4B.

After plotting the 5 points, connect them together to form a graph.

What type of graph is this?

Linear. Turn to page 3B.

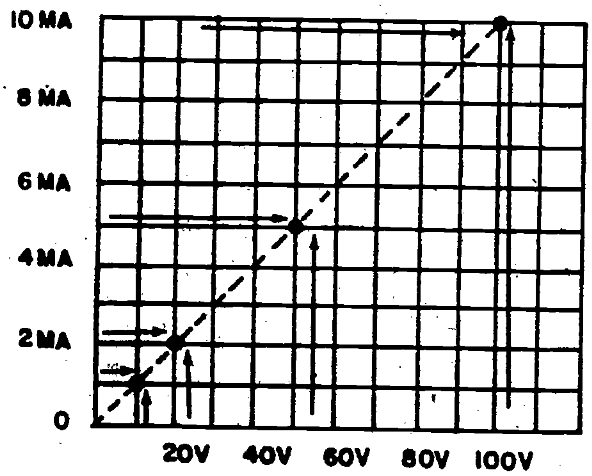
Nonlinear. Turn to page 6.

YOUR ANSWER. Nonlinear
(From P-3A)

You're wrong on this answer. Your graph should be a straight line. Let's go over the procedure a little slower and find the mistake.

Here's the table again. Each pair of voltage and current values can be represented by a point on the graph.

E	I
100V	10 MA
50V	5 MA
20V	2 MA
10V	1 MA

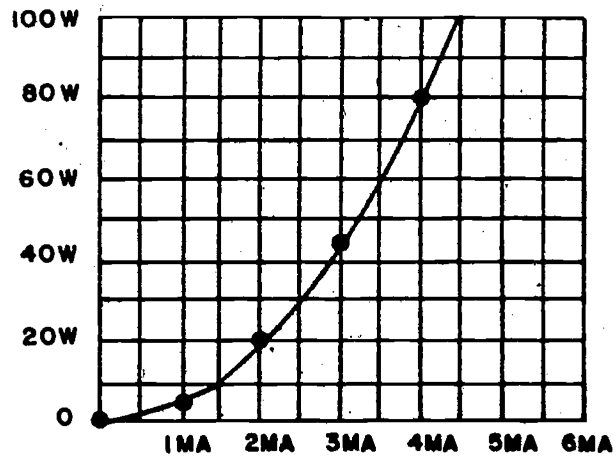


Go up the vertical line representing 100v, and across the horizontal line representing 10ma (this procedure is shown by arrows on the graph, above). Where the two lines meet, mark a point. Repeat this operation for each pair of values listed in the table; then connect the points together. The resultant graph is a straight line. It is a ________________ graph.
linear/nonlinear

Continue at the top of page 4.

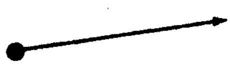
YOUR ANSWER: Nonlinear
(From P-4)

You're right again. However, check your graph against this correct graph to make sure we agree.



Let's talk about vectors.

1. A VECTOR can be defined as a straight line that indicates both magnitude and direction of a quantity. The straight line below has a certain length and is pointing in a certain direction.



This line is a ____________.

vector	2. A vector indicates both MAGNITUDE and DIRECTION of a quantity. The length of the line indicates the ____________ of the quantity.
magnitude	3. The arrowhead indicates the ____________ of the quantity.
direction	4. A vector is a ____________ line that indicates both ____________ and ____________ of a quantity.
straight magnitude direction	

Continue on page 7.

365

5. Define a vector. ______________________________

____

THE ANSWER: A vector is a straight line that indicates both magnitude and direction of a quantity.

Vectors must be used with a known reference. By using coordinate lines, such as we used previously, we can establish a known reference for our vectors. Actually, the graphs that we have constructed so far have been plotted on only 1/4th of a coordinate system, as shown by the area filled in with grid lines in Figure 7A. A complete coordinate system consists of two perpendicular lines that cross each other at a point called the zero point. (Check Figure 7A.) The zero point is also called the POINT OF ORIGIN. All vectors we will use will start from this point. The horizontal and vertical lines that pass through this point of origin are known as the "X" and "Y" AXES. Both the X and Y axes are divided at the zero point into positive and negative values. The horizontal line is the X axis. All values to the RIGHT of the zero point are POSITIVE (+); all values to the LEFT are NEGATIVE (–). The vertical line is the Y axis. All values above the zero point are positive, while values below are negative. Figure 7B shows the labeling of the two axes in the coordinate system.

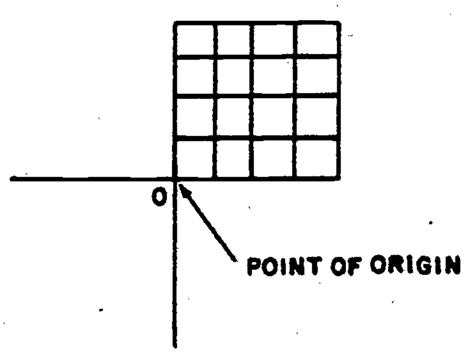


Figure 7A.

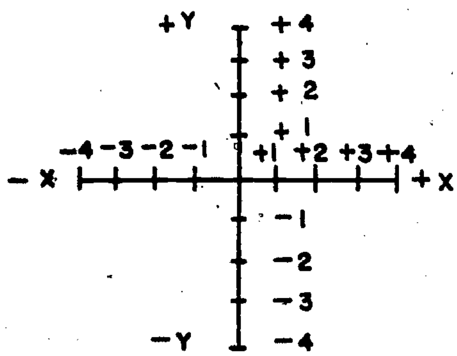
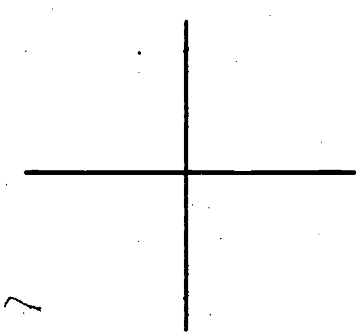


Figure 7B.

Continue on the top of page 8.

	1. The horizontal line passing through the point of origin is labeled the ________ ________.
X axis	2. The values on the X axis to the RIGHT of the zero point are ________.
positive (+)	3. The values on the X axis to the LEFT of the zero point are ________.
negative (–)	4. The vertical line passing through the zero point is labeled the ________ ________.
Y axis	5. Values on the Y axis BELOW the zero point are ________.
negative (–)	6. Values on the Y axis ABOVE the zero point are ________.
positive (+)	7. Label the "X" and "Y" axes and the polarity of each on the following coordinate lines: 

Turn to page 9 and continue.

367

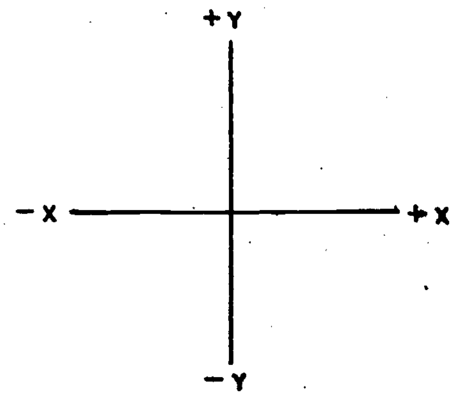


Figure 9A.

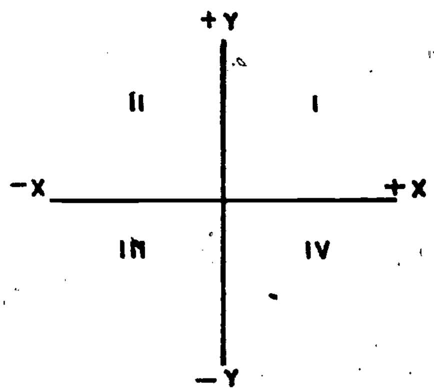


Figure 9B.

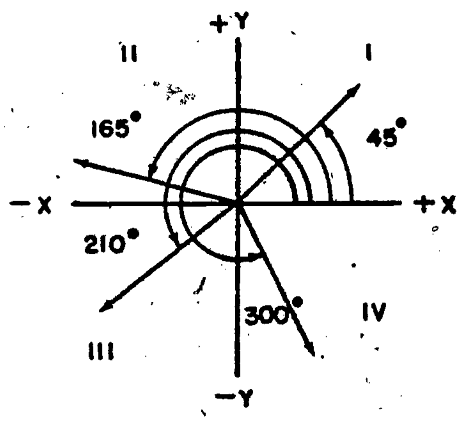


Figure 9C.

Check your labeling with Figure 9A. By crossing the X and Y axes at the zero point, the entire coordinate system is divided into 4 equal parts, called QUADRANTS. These quadrants are numbered with Roman numerals, beginning with the quadrant to the right of the Y axis and above the +X axis. The numerals increase in a counter-clockwise direction (See Figure 9B).

Some graphs use only one quadrant, while others use two, three, or all four quadrants.

Vectors always start from the point of origin. Their angle, used to denote vector direction, is measured COUNTERCLOCKWISE starting from the +X axis. Angles between 0° and 90° are in first quadrant (I). Angles between 90° and 180° fall into the second quadrant (II). The third quadrant (III) includes angles between 180° and 270°. The fourth and final quadrant (IV) completes the circle and includes angles between 270° and 360° (see Figure 9C).

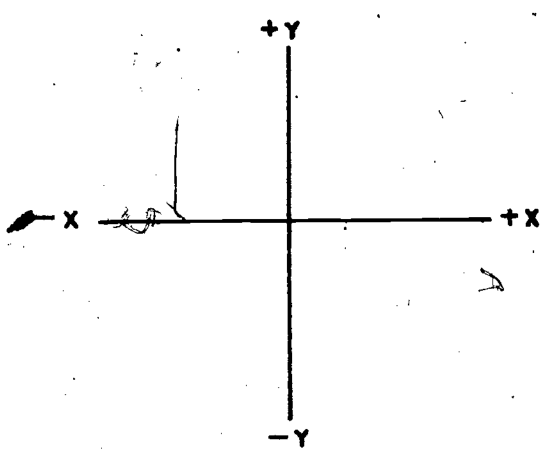
No response required.

Continue on the top of page 10.

Let's review.

1. Vectors start from the __________ of __________.

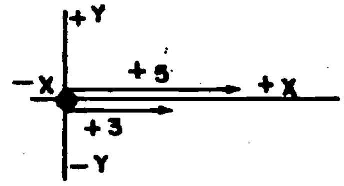
point origin	2. To draw a vector correctly, the end of the vector that gives direction must have an ____________ drawn on it.
arrowhead	3. The angle which denotes the direction of the vector is measured from the ____________ axis to the vector.
+X	4. The number of degrees in the angle is measured ____________________ from the +X axis. (clockwise/counterclockwise)
counter-clockwise	5. A vector having a direction of 220° is in the __________ __________ quadrant.
third or III	6. A vector having a direction of 120° is in the ____________ quadrant.
second or II	7. Label the 4 quadrants formed by the following coordinate lines:

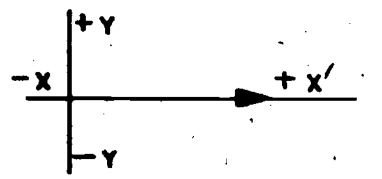


Continue on page 11.

369

II | I III | IV	8. Vectors are straight lines that indicate both ______ and ______ of a quantity.
magnitude direction	9. Two or more vectors can be added together and become a single vector, called the RESULTANT vector. If vectors are parallel to each other, they can be added algebraically. For example, if you have two vectors, a +3 and a +4, both on the X axis, their sum +7 is called the ______ vector.
resultant	10. All vectors start from the point of origin. When they are on the same axis, or are parallel to each other, the resultant vector equals the ALGEBRAIC sum of the vectors. Graphically, the vectors look like this: Two vectors on the same axis: Their resultant vector:
+8	11. The values of vectors pointing in the SAME direction are ADDED together to give the magnitude of the resultant vector. The values of vectors pointing in the OPPOSITE direction are subtracted from each other to give the magnitude of the resultant vector. When subtracting, the resultant vector has the sign of the larger vector.



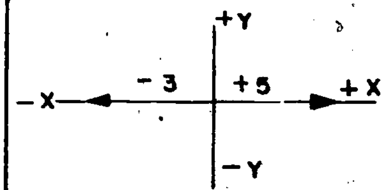


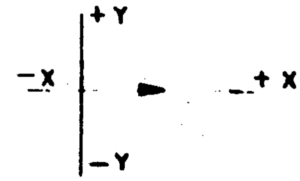
The value of the resultant vector is ______ on the X axis.

Continue on page 12.

No answer required

12. Two vectors on the same axis: The resultant vector:

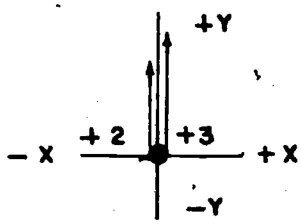


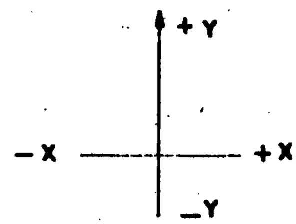


The magnitude of the resultant vector is ________ on the X axis.

+2

13. Two vectors on the same axis: The resultant vector:



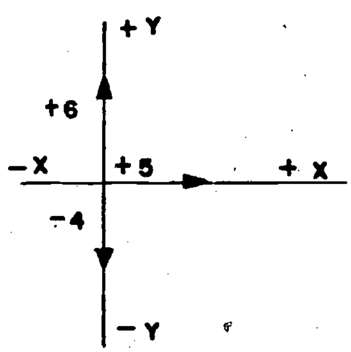


The magnitude of the resultant vector is ________ on the ________ axis.

+5

Y

14. In electronic problems, you will often solve for the resultant of three vectors. Two of the vectors will be on the Y axis; the third vector on the X axis. For example, to combine the 3 vectors below, we first solve for the resultant of the <u>two</u> vectors on the Y axis.



The resultant vector on the Y axis is ____________.

Continue on page 13.

371

·2

Next, we solve for the resultant of the x and y vectors. When two vectors are at right angles (along the X and Y axes), we cannot simply add the two vectors algebraically; we must add them vectorially. To add them, the vectors are drawn and solved as sides of an equivalent right triangle. Before we do some actual vectorial addition, let's review a few facts about the right triangle. Figure 13A shows a vector diagram and its equivalent right triangle.

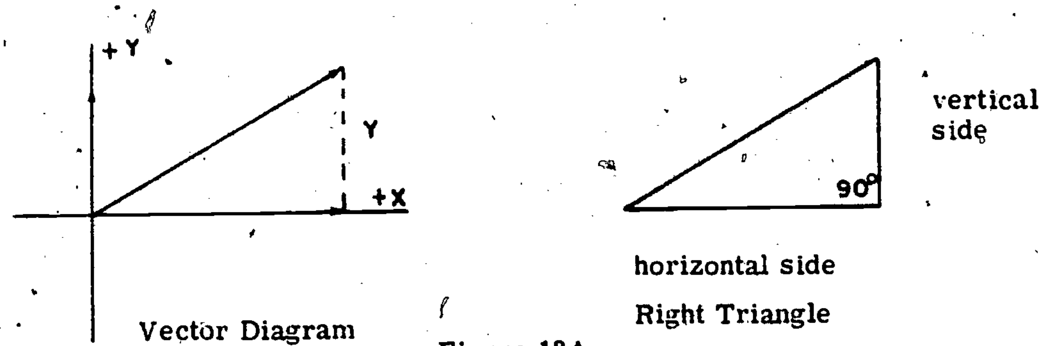
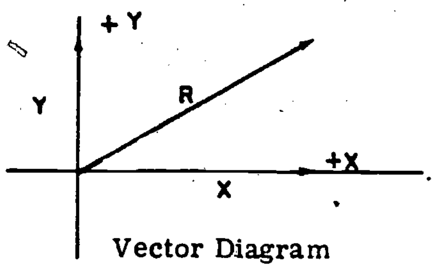


Figure 13A.

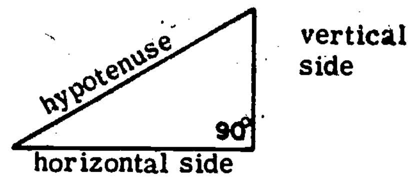
A triangle has three sides. The horizontal side of the right triangle is equivalent to the x vector (the vector drawn on the X axis). Make a small x by the correct vector in the vector diagram above. The vertical side of the right triangle is equivalent to the y vector (the vector drawn on the Y axis). Make a small y by the correct vector in the vector diagram above. The third side of the right triangle is the longest side; it is opposite the 90° angle. This side is called the HYPOTENUSE (pronounced hī pŏt'n o͞os). In a vector diagram, the r vector (the resultant vector) is equivalent to the hypotenuse of the right triangle. Write the word, HYPOTENUSE, by the correct side of the right triangle above; then, make a small r by the correct vector in the vector diagram.

Turn to page 14 and continue.

Did you label the right triangle and vector diagram like the ones below?



Vector Diagram



Right Triangle

(Cover the answers)

	1. The vertical side of the right triangle is equivalent to the ______________ vector.
y	2. The horizontal side of the right triangle is equivalent to the ______________ vector.
x	3. The side of the right triangle opposite the 90° angle is called the ______________________.
hypotenuse	4. The hypotenuse is equivalent to the _________ vector.
r (resultant)	5. In addition to having three sides, all triangles have three angles. The sum of these three angles is always 180°. In a right triangle, since one angle is 90°, the sum of the other two angles must equal _______________.
90°	6. If one of these two angles (other than the 90° angle) equals 30°, the third angle equals ______________.

Continue on page 15.

 373

60°

An easy way to solve for both the sides and angles of a right triangle is to use trigonometry. To the extent we use it, "trig", as it is sometimes called, is not complicated.

Either of the two unknown angles in a right triangle can be found by (1) dividing one known side by the other known side; then (2) looking up their quotient (answer) in a Table of Natural Functions. In this Table, angles (in degrees) are listed opposite the Function values.

NOTE: For your convenience in solving trig problems, the last page of this program has a Table of Natural Functions. Take a quick glance at it now; then continue on this page.

The angle that we use in solving trigonometry problems is the angle formed by the hypotenuse and the horizontal side (see Figure 15A). This angle is Theta (pronounced thā´ tȧ). Its symbol is θ. The symbol $\angle\theta$ means "angle theta."

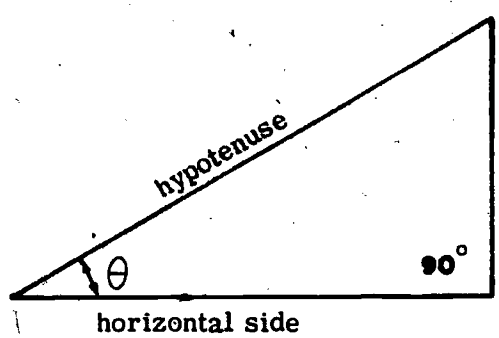
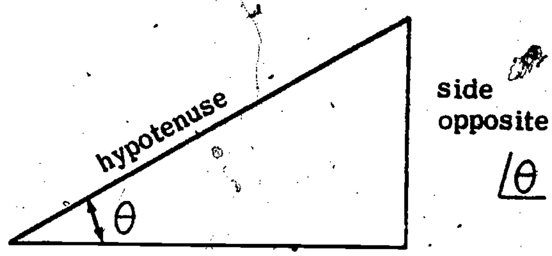


Figure 15A.

We will use three trigonometric functions in this program: the sine, the cosine, and the tangent. These functions are abbreviated sin, cos, and tan respectively.

Continue on page 16.

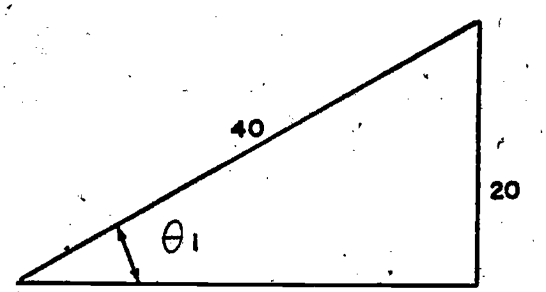
1. As we said, one of the trig functions we use is the SINE function. The sine function is the ratio of the opposite side to the hypotenuse. This means that the sine θ equals the opposite side divided by the hypotenuse.

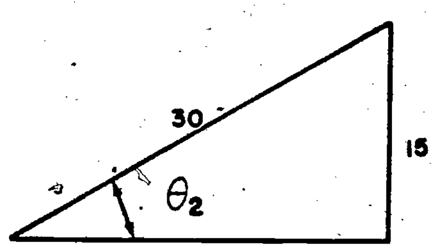


Complete the following formula: sin θ =

$\sin\theta = \dfrac{opp}{hyp}$

2. The sine function is the ratio of the opposite side to the hypotenuse. This ratio remains the same as long as the angle does not change. Solve for the sin θ in each of the two triangles below.

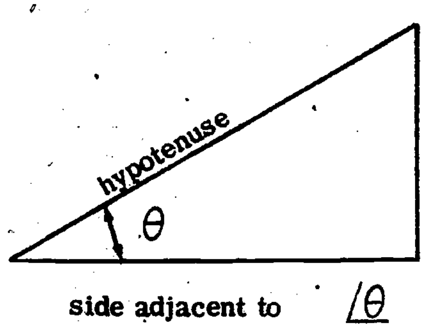




sin θ_1 = ____________ sin θ_2 = ____________

Continue on page 17.

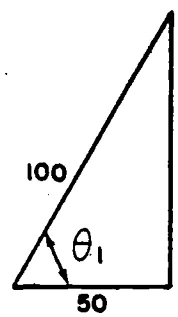
 375

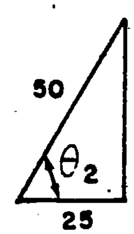
Both $\sin\ \theta = .500$ Solution: $\sin\ \theta = \frac{opp}{hyp}$ $\sin\ \theta_1 = \frac{20}{40}$ $\sin\ \theta_2 = \frac{15}{30}$ $\sin\ \theta_1 = .5$ $\sin\ \theta_2 = .5$	3. To find the number of degrees in the $\angle\theta$, you must turn to trig tables (Table of Natural Functions) on the last page of the program. It shows that the $\sin\ \theta = .5000$ NOTE: The sine function is never greater than one. Now, go down the first SIN column to .5000 at the bottom of the page. The size of the angle is found opposite the .5000 in the DEG column. DEG. — SIN. 29.0 — .4848 29.5 — .4924 30.0 ← .5000 When $\sin\ \theta = .5000$, $\angle\theta$ = __________.
$\angle\theta = 30.0^{o}$	4. Another trig function we use is the COSINE function. The cosine function is the ratio of the adjacent side to the hypotenuse. Stated another way, the cosine θ equals the adjacent side divided by the hypotenuse.  Complete the following formula: $\cos\ \theta =$

Continue on page 18.

$\cos\ \theta\ \frac{adj}{hyp}$

5. The cosine function is the ratio of the adjacent side of the hypotenuse. This ratio remains the same as long as the angle does not change. Solve for the cos θ in the following triangle:





$\cos\ \theta_1 =$ ______ $\cos\ \theta_2 =$ ______

$\cos\ \theta_1 = .500$

$\cos\ \theta_2 = .500$

6. To find the number of degrees in $\angle\theta$, again use the trig tables on the last page. We find that $\cos\ \theta = .5$ (the cosine function is never greater than one). This time go down the column marked <u>COS</u> until the cosine value is found. Opposite this value, in the column marked "DEG," you will find the number of degrees in $\angle\theta$.

When $\cos\ \theta = .5000$, $\angle\theta =$ __________.

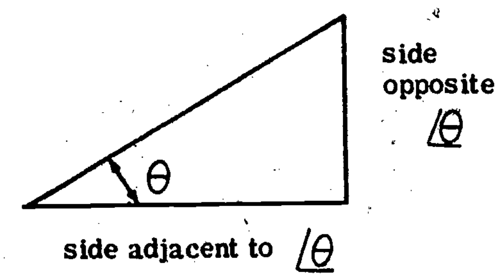
Continue on page 19.

 377

$\angle\theta = 60^\circ$

DEG	SIN	COS
59.0	.8572	.5150
59.5	.8616	.5075
60.0	.8660	.5000

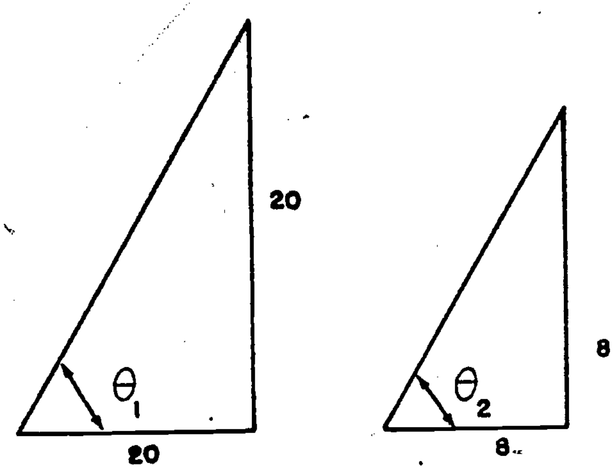
7. The third trig function we use is the TANGENT function. The tangent function is the ratio of the opposite side to the adjacent side. Stated another way, the tangent θ equals the opposite side divided by the adjacent side.



Complete the following formula: $\tan \angle\theta =$.

$\tan \theta = \frac{opp}{adj}$

8. The tangent function is the ratio of the opposite side to the adjacent side. This ratio also does not change as long as the angle does not change. Solve for the tan θ in the following triangle:



$\tan \theta_1 =$ _______ $\tan \theta_2 =$ _______

Continue on page 20.

tan θ_1 = 1.000

tan θ_2 = 1.000

9. To find the number of degrees in $\angle\theta$, turn again to the trig tables. Tan θ is 1.000. (NOTE: An angle less than 45° always has a tangent function less than 1; an angle greater than 45° always has a tangent function greater than 1.) This time go down the column marked TAN until the tangent value is found. Opposite this value, in the column marked "DEG," you will find the number of degrees in $\angle\theta$. When tan $\angle\theta$ = 1.000, $\angle\theta$ = _______.

45°

Solution:

DEG	SIN	COS	TAN
44.0	.6947	.7193	.9657
44.5	.7009	.7133	.9827
45.0	.7071	.7133	1.000

10. Trying to memorize formulas such as the trig functions can be difficult. However, you are required to know them. As a memory "crutch," here is a little saying that you may use to help you remember them:

"Oscar Had A Heap Of Apples"

Take the underlined capital letters, and group them vertically as in Fig. 20A. Each ratio is equal to a trig function. The functions are listed in the order in which you learned them. Complete Fig 20A by writing the correct function in each blank.

(Opposite) / (Hypotenuse)	$\frac{O}{H}$ =	____ θ
(Adjacent) / (Hypotenuse)	$\frac{A}{H}$	____ θ
(Opposite) / (Adjacent)	$\frac{O}{A}$ =	____ θ

Figure 20A

Continue on page 21.

Figure 20A

$\frac{0}{H}$ · $\underline{\sin}$ θ

$\frac{A}{H}$ $\underline{\cos}$ θ

$\frac{0}{A} = \underline{\tan}$ θ

11. Remember:

"Oscar Had A Heap Of Apples"

Complete these formulas:

Sin θ =

Cos θ =

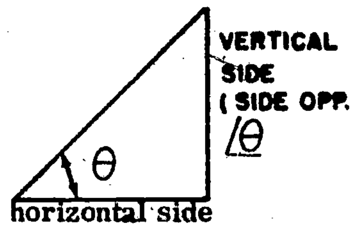
Tan θ =

$\sin\theta = \frac{0}{H}$

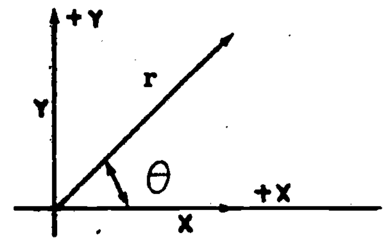
$\cos\theta = \frac{A}{H}$

$\tan\theta = \frac{0}{A}$

12. As we previously mentioned, we substitute vectors for the sides in a right triangle. For example:



Right Triangle



Vector Diagram

The angle θ in a right triangle is formed by the horizontal side and the hypotenuse. When vectors are used as sides, the angle θ is formed by the ________ vector and the ________ vector.

---

x

r

13. The side opposite /θ in a triangle is represented by the ________ vector.

---

y

14. The adjacent side of /θ in the triangle is represented by the ________ vector.

---

x

15. In a right triangle having vectors for the sides, the hypotenuse represents the ________ vector.

Continue on page 22.

r or
resultant

16. Each time you work a trig problem, remember the saying:

"___scar___ad___ ___eap___f___pples"

Complete these formulas:

__________ $\theta = \frac{O}{H}$

__________ $\theta = \frac{A}{H}$

__________ $\theta = \frac{O}{A}$

O, H, A, H,

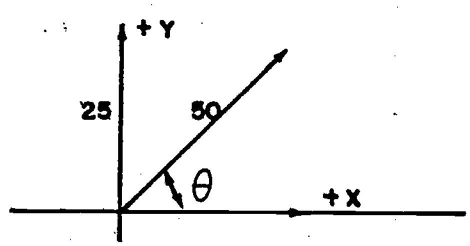
O, A.

sin, cos, tan

17. When working trig problems in this program, we want you to round off all numbers to 3 figures, and find angles to the nearest 1/2°.

On the vector diagram below, we are given the values for the y vector and the r vector. How many degrees are in $\angle\theta$? (Insert answer in blank below.)

Hint: When the opposite side and the hypotenuse are given, we use the sine function.



Use function formula: $\sin\theta \; \frac{O}{H}$ or $\frac{y}{r}$

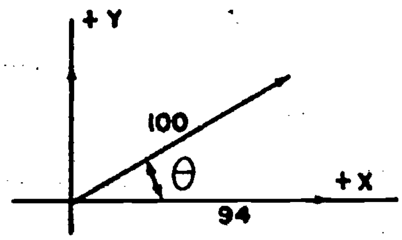
Substitute in values: $\sin\theta$ = __________

Solve problem: $\sin\theta$ = __________

Use trig tables: $\angle\theta$ = __________

Continue on page 23.

381

$\sin\ \theta = \frac{25}{50}$ $\sin\ \theta = .5$ $\angle\theta = 30^{\circ}$	18. This time, we are given values for the x vector and the r vector, and are asked to solve for $\angle\theta$. When the adjacent side and the hypotenuse are given, we use the COSINE function. Solve for $\angle\theta$: (Remember, find angles to the nearest $1/2^{\circ}$.)  Use function formula: $\cos\ \theta = \frac{x}{r}$ or $\frac{A}{H}$ Substitute in values: $\cos\ \theta =$ ________ Solve problem: $\cos\ \theta =$ ________ Use trig tables: $\angle\theta =$ ________
$\cos\ \theta = \frac{94}{100}$ $\cos\ \theta = .94$ $\angle\theta = 20^{\circ}$	19. Write the three commonly used trig functions and the formula for each: ________ $\theta =$ ________ ________ $\theta =$ ________ ________ $\theta =$ ________

Continue on page 24.

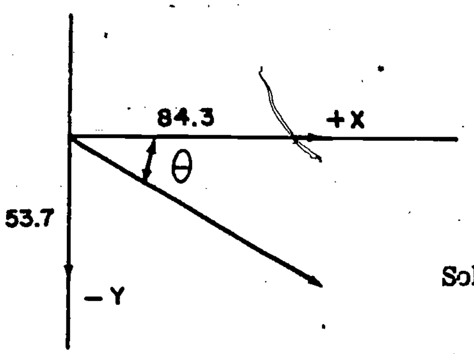
$\sin\theta = \frac{opp}{hyp}$

$\cos\theta = \frac{adj}{hyp}$

$\tan\theta = \frac{opp}{adj}$

20. On the vector diagram below, we are given values for the y vector and the x vector and asked to solve for $\angle\theta$. When the opposite side and the adjacent side are given, we use the TANGENT function.

NOTE: These vectors are in the IV quadrant and are treated in the same manner as vectors in the first quadrant. In both quadrants, the angle θ is the angle between the x vector and the r vector, and the y vector is the opposite side.



Solve for $\angle\theta$.

Use function formula: $\tan\theta = \frac{y}{x}$

Substitute in values: $\tan\theta =$ ______

Solve problem: $\tan\theta =$ ______

Use trig tables: $\angle\theta =$ ______

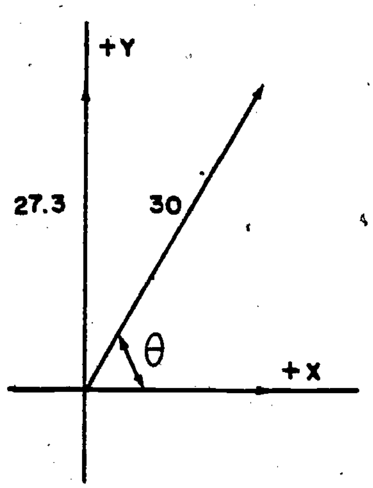
$\tan\theta = \frac{53.7}{84.3}$

$\tan\theta = .637$

$\angle\theta = 32.5^{\circ}$

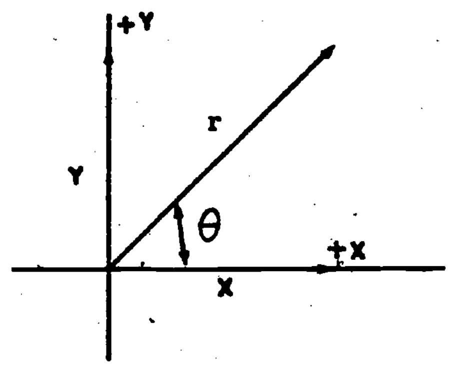
21. Solve for $\angle\theta$. Which function formula do we use?

____

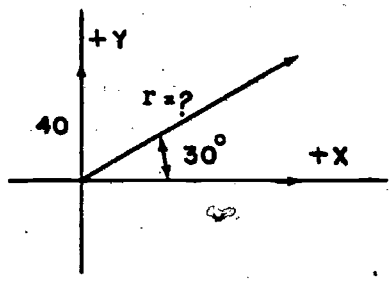
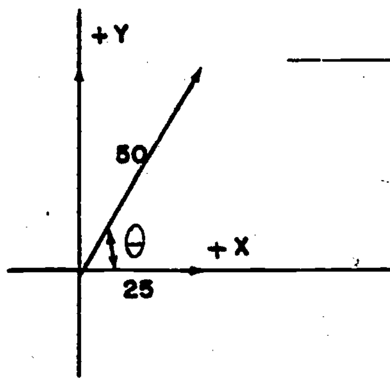
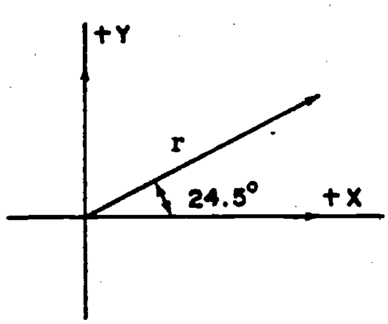


$\angle\theta =$ __________

Continue on page 25.

$\sin\ \theta = \frac{y}{r}$ $\angle\theta\ = 65.5^{o}$	22. So far, we have solved for the angle θ by knowing 2 sides and using the 3 trig functions. As you will find, it is just as easy to solve for the unknown sides of a right triangle when the angle θ and one side are known. Here is the procedure to follow: 1. Look the problem over to see what is given and what you are asked to find. 2. Choose the function formula (sin, cos, or tan formula) that uses both the given values and the unknown value you are asked to find. 3. Transpose the formula so the unknown value can be found. 4. Using the trig tables, solve for the unknown value.
No response required	23.  To solve for r, when the $\angle\theta$ and y vector are given, we would use the function formula: $\sin\ \theta = \frac{y}{r}$ Transpose for r: r = ________________

Continue on page 26.

$r = \dfrac{y}{\sin\ \theta}$	24. What is the value of r?  Use formula: $\sin\ \theta\ \dfrac{y}{r}$ Transposed formula: $r = \dfrac{y}{\sin\ \theta}$ Substitute in values: $r = \dfrac{40}{\sin\ 30^{\circ}}$ Use trig tables: $r = \dfrac{40}{.5}$ r = ______
r = 80	25. Solve for $\angle\theta$. Which function formula do we use? ______  $\angle\theta$ = ______
$\cos\ \theta = \dfrac{x}{r}$ $\angle\theta = 60^{\circ}$	26. To solve for r when the $\angle\theta$ and the x vector are given, use the function formula: $\cos\ \theta = \dfrac{x}{r}$ Transpose formula: r = ______
$r = \dfrac{x}{\cos\ \theta}$	27. Solve for the r vector.  Use formula: $\cos\ \theta = \dfrac{x}{r}$ Transposed formula: $r = \dfrac{x}{\cos\ \theta}$ Substitute in values: r = ______ Use trig tables: r = ______ Solve for r: r = 200 — — — — — — — Turn to page 28. r = 7.43 — — — — — — — Turn to page 29.

This is the way the completed sine wave should look.

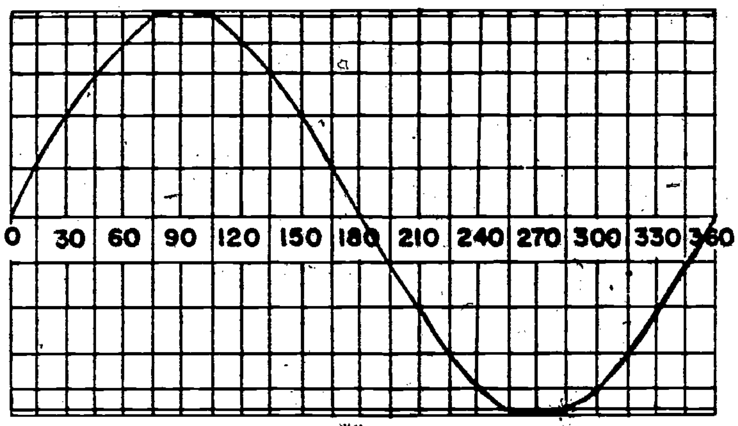


Figure 27A.

We have not assigned a magnitude to the y vector plotted on the graph in Fig. 27A; however, if the "Y" axis were marked off in units, such as in volts, a magnitude (value) of the "y" vector could be found at any point along the sine wave in Fig 27A.

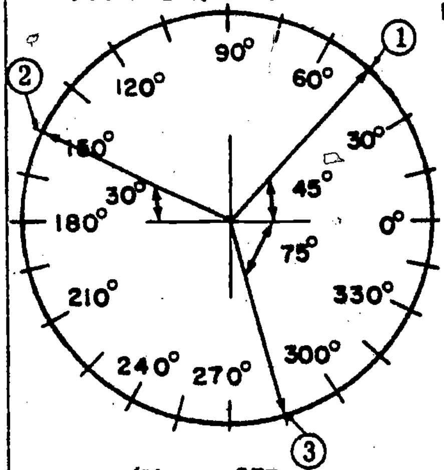


Figure 27B.

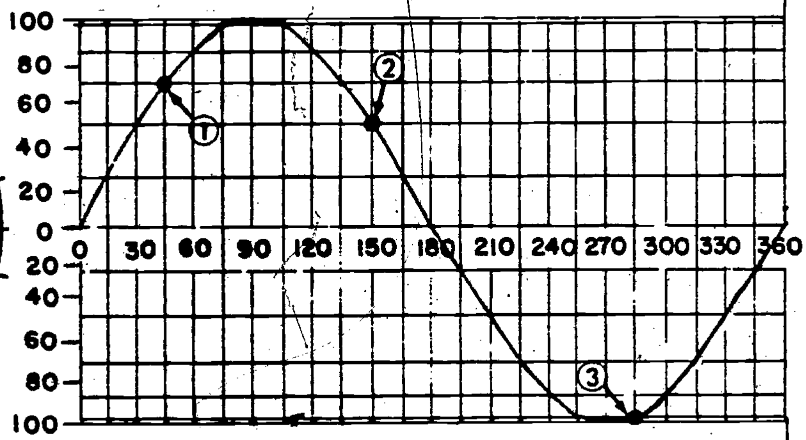


Figure 27C.

Compare positions ①, ②, and ③ of the rotating vector in Fig. 27B with points ①, ②, and ③ on the corresponding sine wave in Fig. 27C.

Notice that the angle used for trig solutions is always less than 90°, and that this angle is formed by the X axis (x vector) and the rotating vector.

Point No. 1 at 45° measures approximately = 71 volts.

Point No. 2 at 150° (sin 30°) measures = 50 volts.

Point No. 3 at 285° (sin 75°) measures approximately - 97 volts. You would get these same values by solving for "y" using trigonometry.

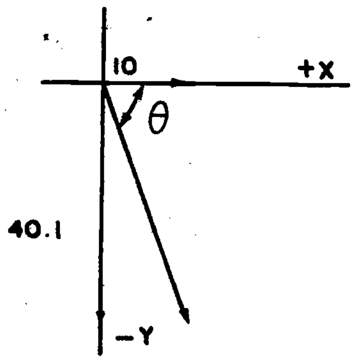
You have completed the program on "Generation of a Sine Wave". Look at the objectives on the front page again, to ensure that you understand them.

Then check with your instructor.

YOUR ANSWER: r = 200
(from P-26 and P-29)

Right you are. Continue with frame 28.

28. Solve for $\underline{/\theta}$. Which function formula do we use?



$\underline{/\theta}$ = ____________

$\tan \theta = \frac{y}{x}$

$\underline{/\theta} = 76.0^{0}$

29. To solve for x when the $\underline{/\theta}$ and the r vector are given, use the function formula: $\cos \theta = \frac{x}{r}$

The transposed formula is: x = ____________

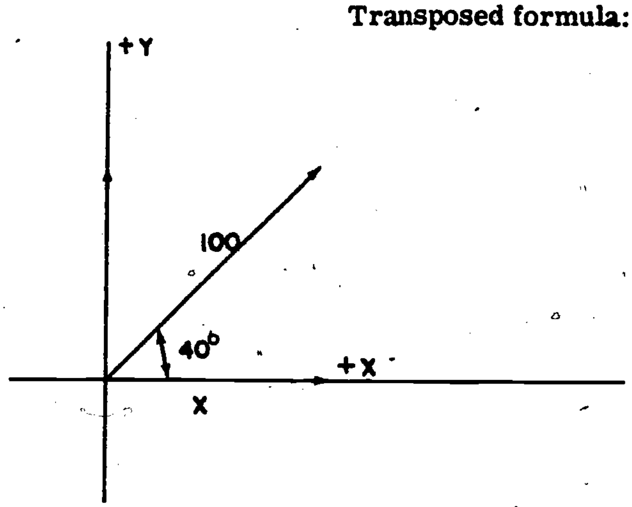
$x = \cos \theta \cdot r$

30. Solve for the x vector.

The function formula to use is:

$\cos \theta = \frac{x}{r}$

Transposed formula: $x = \cos \theta \cdot r$



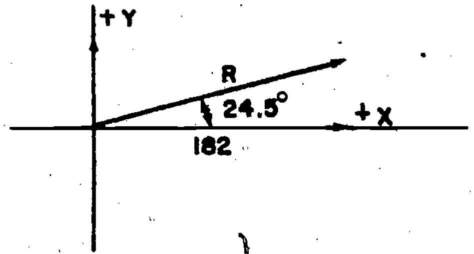
x = ____________

Turn to page 30 and continue.

YOUR ANSWER: $r = 7.43$
(From P-26)

Don't turn back for the other answer! You are wrong. Let's see why.

Here's the problem again. Solve for the r vector.



Use function formula: $\cos\theta = \frac{x}{r}$

Transposed formula: $r = \frac{x}{\cos\theta}$

Substitute in values: $r = \frac{182}{\cos 24.5^{\circ}}$

Now, the cos 24.5° IS NOT the same as the $\angle 24.5^{\circ}$. The cos 24.5° is a decimal value found in the trig tables.

For each angle of θ, there are 3 function values: sin, cos, and tan. The value you use depends on the function formula you are solving.

Let's try three quick problems. (Cover the answers in the margin.)

	1. sin 24.5° = ________
.4147 or .415	2. tan 24.5° = ________
.4557 or .456	3. cos 24.5° = ________
.9100 or .910	4. Complete the original problem. $r = \frac{182}{\cos 24.5} =$ $r =$ ________

Turn to page 28 for your answer and continue.

x = 76.6

At this point in the program, you may have become confused by all the formulas. There are actually only 3 function formulas to use. These you must know:

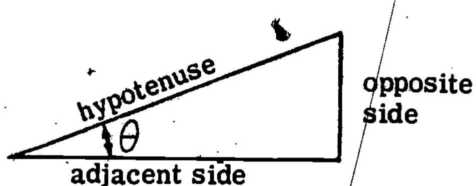
$$\sin\ \theta = \frac{opp}{hyp} \quad \text{or} \quad \frac{0}{H} \quad \text{or} \quad \frac{y}{r}$$

$$\cos\ \theta = \frac{adj}{hyp} \quad \text{or} \quad \frac{A}{H} \quad \text{or} \quad \frac{x}{r}$$

$$\tan\ \theta = \frac{opp}{adj} \quad \text{or} \quad \frac{0}{A} \quad \text{or} \quad \frac{y}{x}$$

Don't try to memorize all the variations of the formulas. As can be seen, there are only 4 values used in the formulas:

$\angle\theta$; opposite side, adjacent side, and hypotenuse.



Every function formula involves the $\angle\theta$ and 2 of the 3 sides. Now, which is the correct formula to use in solving a given problem?

We choose the function formula that uses the given values and the unknown value that we want to find.

We transpose this formula so the unknown value is by itself on one side of the equation. Then we are ready to solve for the unknown value.

If you aren't sure how to choose the correct function formula, consider this:

First, determine which side you are NOT interested in; namely, the side which is not given and which you are not asked to find.

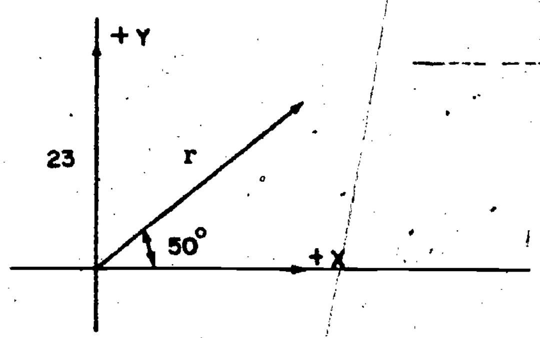
Now, ignore the two formulas that contain this side. The remaining formula is the one to use. Transpose this formula and solve as before.

Continue on page 31, frame 31.

380

31. Solve for "r" (round off to 3 figures).

Which function formula do we use? ______________________



r = __________

$\sin \theta = \frac{y}{r}$

r = 30.0

32. To solve for x with $\angle\theta$ and the y vector given, function formula is:

$$\tan \theta = \frac{y}{x}$$

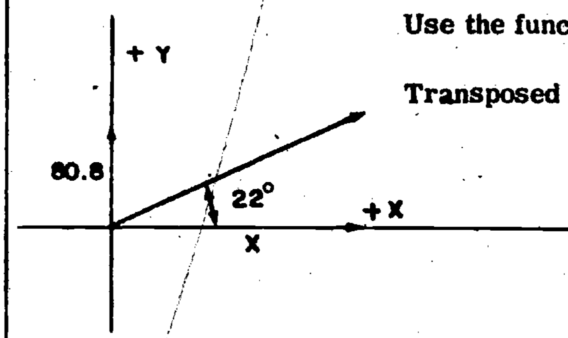
The transposed formula: x = ______________________

$x = \frac{y}{\tan \theta}$

33. Solve for the x vector.

Use the function formula: $\tan \theta = \frac{y}{x}$

Transposed formula: $x = \frac{y}{\tan \theta}$



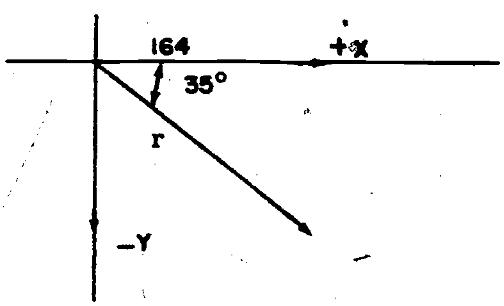
x = __________

---

x = 200

34. Solve for "r."

Function formula: __________



r = __________

Continue on page 32.

390

$\cos\theta \quad \frac{x}{r}$

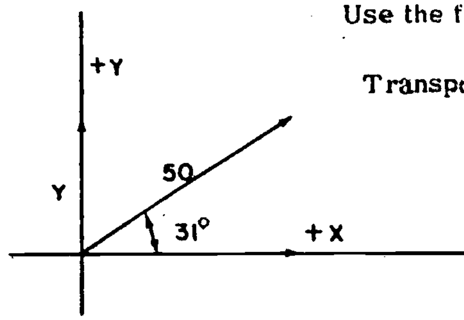
$r \quad 200$

35. To solve for y when the $\underline{/\theta}$ and the r vector are given, use the function formula: $\sin\theta \quad \frac{y}{r}$

The transposed formula is: y ______

$y \quad \sin\theta \cdot r$

36. Solve for the "y" vector.



Use the function formula: $\sin\theta \quad \frac{y}{r}$

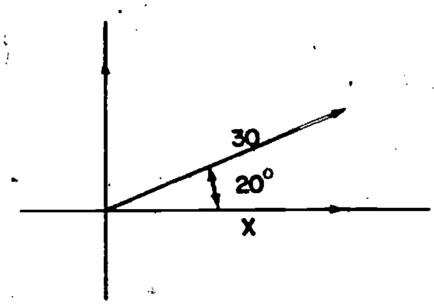
Transposed formula: $y \quad \sin\theta \cdot r$

y ______

$y = 25.8$

37. Solve for "x."

Function formula: ______



x ______

$\cos\theta \quad \frac{x}{r}$

$x \quad 28.2$

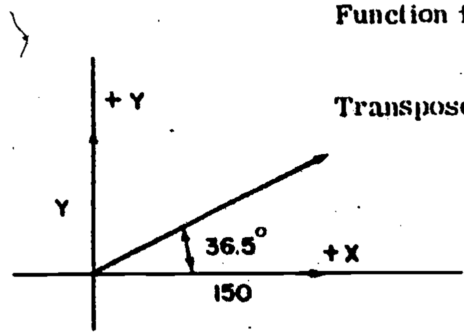
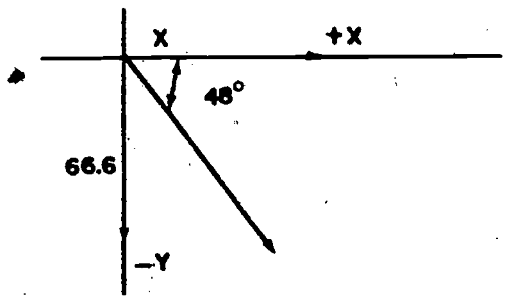
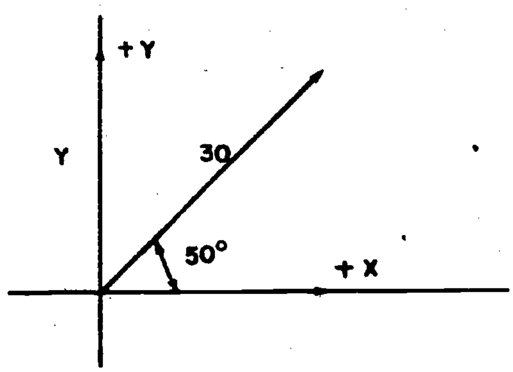
38. To solve for the "y" vector when $\underline{/\theta}$ and the x vector are given, use the function formula:

$\tan\theta \quad \frac{y}{x}$

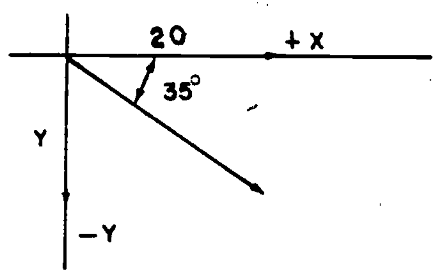
The transposed formula is: y ______

Continue on page 33.

391

$y \quad \tan\theta \cdot x$	39. Solve for the "y" vector. Function formula: $\tan\theta \quad \frac{y}{x}$ Transposed formula: $y \quad \tan\theta \cdot x$  y ______
$y \quad 111$	40. Solve for the x vector. Function formula: ______  x ______
$\tan\theta = \frac{y}{x}$ $x = 60$	41. Solve for the y vector. Function formula: ______  y = ______

Continue on page 34.

$\sin \theta \quad \frac{y}{r}$ $y \quad 23.0$	42. Solve for the y vector. Function formula: ________  y = ________
$\tan \theta = \frac{y}{x}$ $y = 14.0$	

The trig functions are used to solve for unknown values in right triangles. Given any two sides, $\angle\theta$ can be found. Given $\angle\theta$ and any one side, the other two sides can be found.

We will now show you how to draw the graph of a sine function, commonly called a sine curve, or a sine wave. When a resultant vector is rotated COUNTER-CLOCKWISE from 0° through 360° (4 quadrants), the opposite side (y vector) increases from zero to maximum positive magnitude in the first quadrant; decreases from maximum positive magnitude to zero in the second quadrant; increases to maximum negative magnitude in the third quadrant; and, finally, decreases back to 0 magnitude in the fourth quadrant. This variation in the y vector can easily be seen by plotting the magnitudes of the y vector above or below the X axis for each degree of rotation of the resultant vector.

Continue on page 35.

Figures 35A and 35B are sets of coordinate lines. Figure 35A shows the four quadrants and a rotating vector, and Figure 35B shows an X axis marked off in degrees. Now, on Figure 35A, notice the varying magnitude (height) of the arrowhead above the X axis. This height represents the magnitude of the y vector. For each 15° rotation of the resultant vector in a counterclockwise direction, plot a point above or below the corresponding degrees on the X axis of Figure 35B. We have already plotted the first 4 points. You are to plot the other points through one complete cycle (0° through 360°); then connect them together to form a curve.

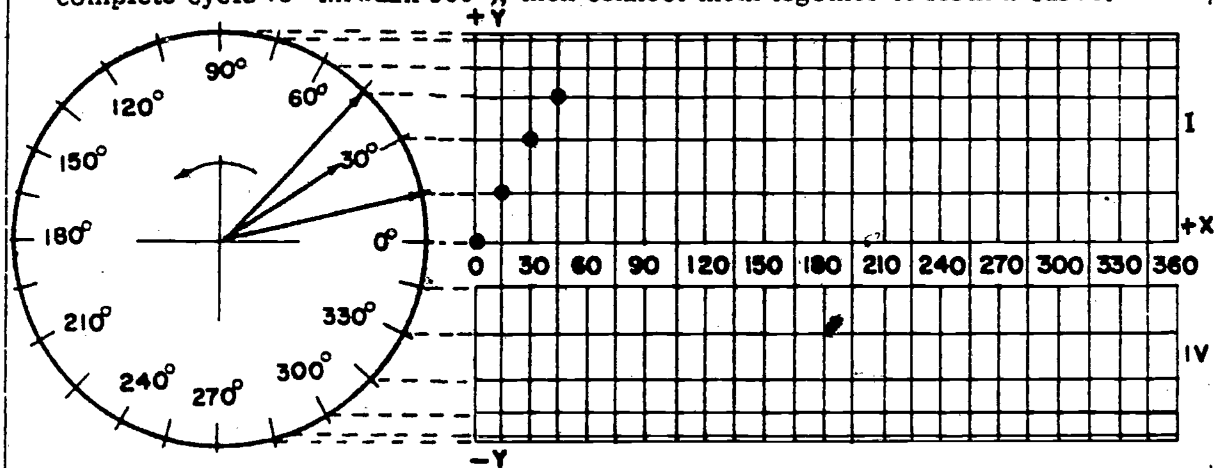


Figure 35A.

Figure 35B.

This curve is a sine wave; it represents the change in magnitude of the sine function during one complete cycle.

Turn back to page 27 and compare your sine wave against the sine wave on that page.

TABLE OF NATURAL FUNCTIONS

DEG.	SIN.	COS.	TAN.	DEG.	SIN.	COS.	TAN.
.5	.0087	1.0000	.0087	23.0	.3907	.9205	.4245
1.0	.0175	.9998	.0175	23.5	.3987	.9171	.4348
1.5	.0262	.9997	.0262	24.0	.4067	.9135	.4452
2.0	.0349	.9994	.0349	24.5	.4147	.9100	.4557
2.5	.0436	.9990	.0437	25.0	.4226	.9063	.4663
3.0	.0523	.9986	.0524	25.5	.4305	.9026	.4770
3.5	.0610	.9981	.0612	26.0	.4384	.8988	.4877
4.0	.0698	.9976	.0699	26.5	.4462	.8949	.4986
4.5	.0785	.9969	.0787	27.0	.4540	.8910	.5095
5.0	.0872	.9962	.0875	27.5	.4617	.8870	.5206
5.5	.0958	.9954	.0963	28.0	.4695	.8829	.5317
6.0	.1045	.9945	.1051	28.5	.4772	.8788	.5430
6.5	.1132	.9936	.1139	29.0	.4848	.8746	.5543
7.0	.1219	.9925	.1228	29.5	.4924	.8704	.5658
7.5	.1305	.9914	.1317	30.0	.5000	.8660	.5774
8.0	.1392	.9903	.1405	30.5	.5075	.8616	.5890
8.5	.1478	.9890	.1495	31.0	.5150	.8572	.6009
9.0	.1564	.9877	.1584	31.5	.5225	.8526	.6128
9.5	.1650	.9863	.1673	32.0	.5299	.8480	.6249
10.0	.1736	.9848	.1763	32.5	.5373	.8434	.6371
10.5	.1822	.9833	.1853	33.0	.5446	.8387	.6494
11.0	.1908	.9816	.1944	33.5	.5519	.8339	.6619
11.5	.1994	.9799	.2035	34.0	.5592	.8290	.6745
12.0	.2079	.9781	.2126	34.5	.5664	.8241	.6873
12.5	.2164	.9763	.2217	35.0	.5736	.8192	.7002
13.0	.2250	.9744	.2309	35.5	.5807	.8141	.7133
13.5	.2334	.9724	.2401	36.0	.5878	.8090	.7265
14.0	.2419	.9703	.2493	36.5	.5948	.8039	.7400
14.5	.2504	.9681	.2586	37.0	.6018	.7986	.7536
15.0	.2588	.9659	.2679	37.5	.6088	.7934	.7673
15.5	.2672	.9636	.2773	38.0	.6157	.7880	.7813
16.0	.2756	.9613	.2867	38.5	.6225	.7826	.7954
16.5	.2840	.9588	.2962	39.0	.6293	.7771	.8098
17.0	.2924	.9563	.3057	39.5	.6361	.7716	.8243
17.5	.3007	.9537	.3153	40.0	.6428	.7660	.8391
18.0	.3090	.9511	.3249	40.5	.6494	.7604	.8541
18.5	.3173	.9483	.3346	41.0	.6561	.7547	.8693
19.0	.3256	.9455	.3443	41.5	.6626	.7490	.8847
19.5	.3338	.9426	.3541	42.0	.6691	.7431	.9004
20.0	.3420	.9397	.3640	42.5	.6756	.7373	.9163
20.5	.3502	.9367	.3739	43.0	.6820	.7314	.9325
21.0	.3584	.9336	.3839	43.5	.6884	.7254	.9490
21.5	.3665	.9304	.3939	44.0	.6947	.7193	.9657
22.0	.3746	.9272	.4040	44.5	.7009	.7133	.9827
22.5	.3827	.9239	.4142	45.0	.7071	.7071	1.0000

TABLE OF NATURAL FUNCTIONS

DEG.	SIN.	COS.	TAN.	DEG.	SIN.	COS.	TAN.
45.5	.7133	.7009	1.0176	68.0	.9272	.3746	2.4751
46.0	.7193	.6947	1.0355	68.5	.9304	.3665	2.5386
46.5	.7254	.6884	1.0538	69.0	.9336	.3584	2.6051
47.0	.7314	.6820	1.0724	69.5	.9367	.3502	2.6746
47.5	.7373	.6756	1.0913	70.0	.9397	.3420	2.7475
48.0	.7431	.6691	1.1106	70.5	.9426	.3338	2.8239
48.5	.7490	.6626	1.1303	71.0	.9455	.3256	2.9042
49.0	.7547	.6561	1.1504	71.5	.9483	.3173	2.9887
49.5	.7604	.6494	1.1708	72.0	.9511	.3090	3.0777
50.0	.7660	.6428	1.1918	72.5	.9537	.3007	3.1716
50.5	.7716	.6361	1.2131	73.0	.9563	.2924	3.2709
51.0	.7771	.6293	1.2349	73.5	.9588	.2840	3.3759
51.5	.7826	.6225	1.2572	74.0	.9613	.2756	3.4874
52.0	.7880	.6157	1.2799	74.5	.9636	.2672	3.6059
52.5	.7934	.6088	1.3032	75.0	.9659	.2588	3.7321
53.0	.7986	.6018	1.3270	75.5	.9681	.2504	3.8667
53.5	.8039	.5948	1.3514	76.0	.9703	.2419	4.0108
54.0	.8090	.5878	1.3764	76.5	.9724	.2334	4.1653
54.5	.8141	.5807	1.4019	77.0	.9744	.2250	4.3315
55.0	.8192	.5736	1.4281	77.5	.9763	.2164	4.5107
55.5	.8241	.5664	1.4550	78.0	.9781	.2079	4.7046
56.0	.8290	.5592	1.4826	78.5	.9799	.1994	4.9152
56.5	.8339	.5519	1.5108	79.0	.9816	.1908	5.1446
57.0	.8387	.5446	1.5399	79.5	.9833	.1822	5.3955
57.5	.8434	.5373	1.5697	80.0	.9848	.1736	5.6713
58.0	.8480	.5299	1.6003	80.5	.9863	.1650	5.9758
58.5	.8526	.5225	1.6319	81.0	.9877	.1564	6.3138
59.0	.8572	.5150	1.6643	81.5	.9890	.1478	6.6912
59.5	.8616	.5075	1.6977	82.0	.9903	.1392	7.1154
60.0	.8660	.5000	1.7321	82.5	.9914	.1305	7.5958
60.5	.8704	.4924	1.7675	83.0	.9925	.1219	8.1443
61.0	.8746	.4848	1.8040	83.5	.9936	.1132	8.7769
61.5	.8788	.4772	1.8418	84.0	.9945	.1045	9.5144
62.0	.8829	.4695	1.8807	84.5	.9954	.0958	10.39
62.5	.8870	.4617	1.9210	85.0	.9962	.0872	11.43
63.0	.8910	.4540	1.9626	85.5	.9969	.0785	12.71
63.5	.8949	.4462	2.0057	86.0	.9976	.0698	14.30
64.0	.8988	.4384	2.0503	86.5	.9981	.0610	16.35
64.5	.9026	.4305	2.0965	87.0	.9986	.0523	19.08
65.0	.9063	.4226	2.1445	87.5	.9990	.0436	22.90
65.5	.9100	.4147	2.1943	88.0	.9994	.0349	28.64
66.0	.9135	.4067	2.2460	88.5	.9997	.0262	38.19
66.5	.9171	.3987	2.2998	89.0	.9998	.0175	57.29
67.0	.9205	.3907	2.3559	89.5	1.0000	.0087	114.6
67.5	.9239	.3827	2.4142	90.0	1.0000	.0000	INF.

REVIEW TEST

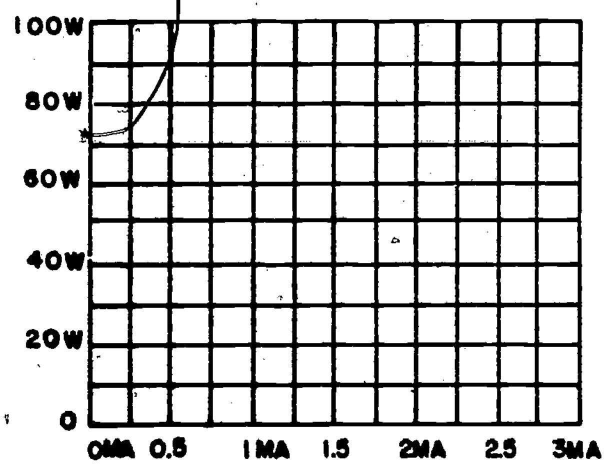
1. State, in writing, the difference between the graph of a linear function and the graph of nonlinear function.

____

____

2. On the following line graph, plot the values of current and power given in the chart; then, connect the points to show the appropriate graph.

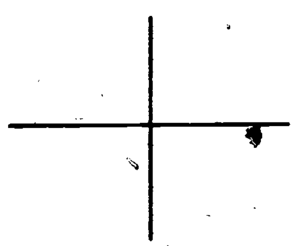
I	P
OMA	O W
1 MA	10 W
1.5 MA	22.5 W
2MA	40 W
2.5MA	62.5 W
3MA	90 W



3. Write the definition of a vector: ______________________________

____

4. Label the "X" and "Y" axes and the polarity of each axis on the following coordinate lines:



5. On the preceding coordinate lines, label the 4 quadrants formed by the axes.

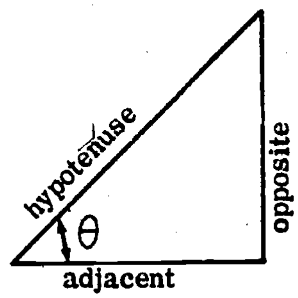
A

6. List the 3 most commonly used trigonometric functions and the formula to solve for each function.

a. ______________ 0 = ______________

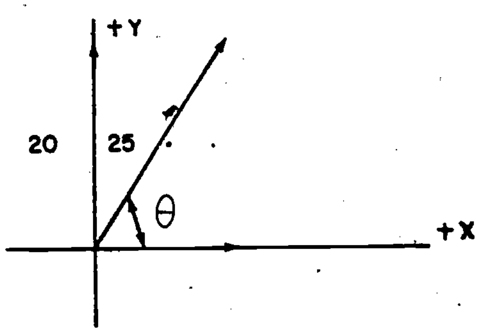
b. ______________ 0 = ______________

c. ______________ 0 = ______________



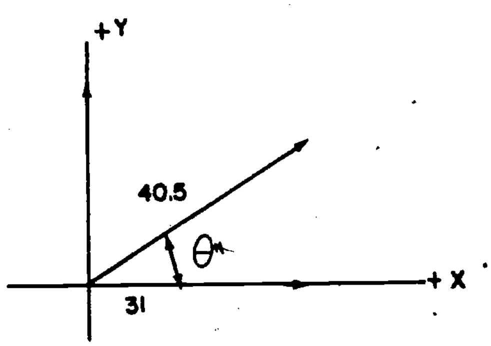
Using trigonometry, solve the following problems for the unknown vectors and angles as required. (Keep the numbers rounded off to 3 figures; solve angles to nearest 1/2°.) (Show your work on this paper.)

7.



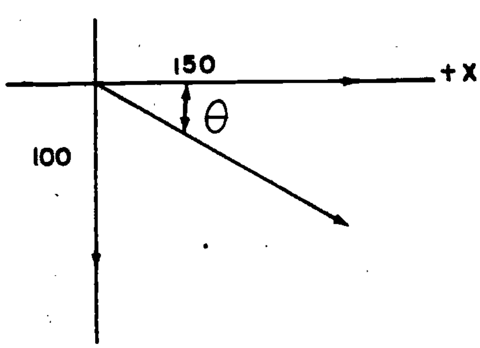
$\angle\theta$ = ________

8.



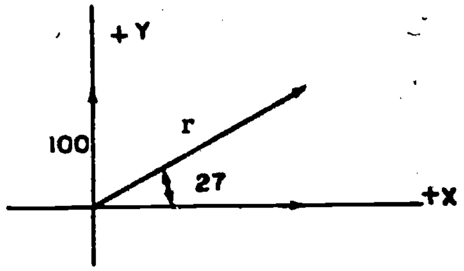
$\angle\theta$ = ________

9.



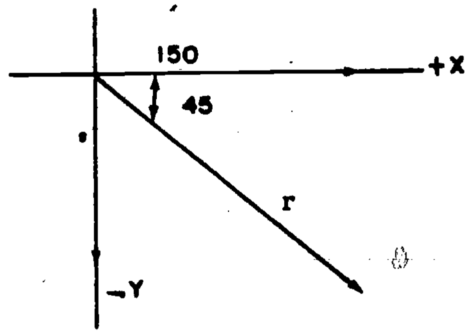
$\angle\theta$ = ________

10.



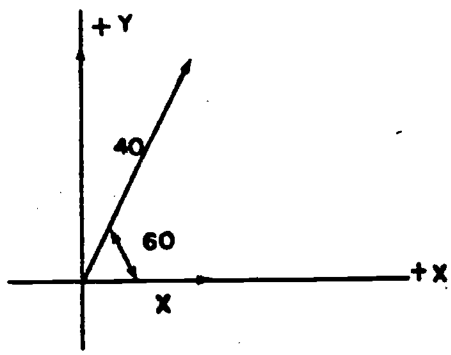
r = ________

11.



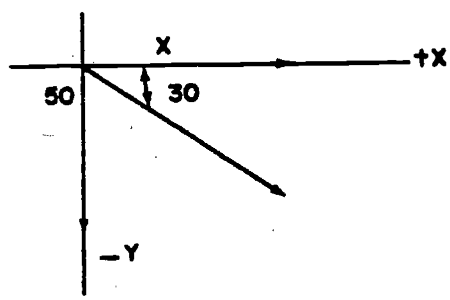
r = ________

12.



X = ________

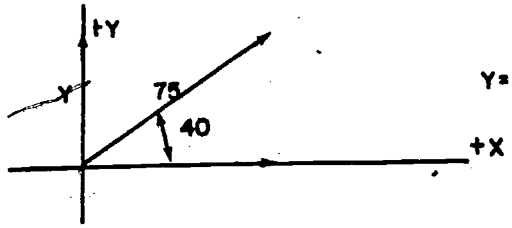
13.



X = ________

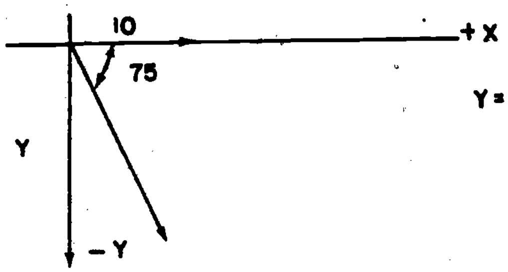
C

14.



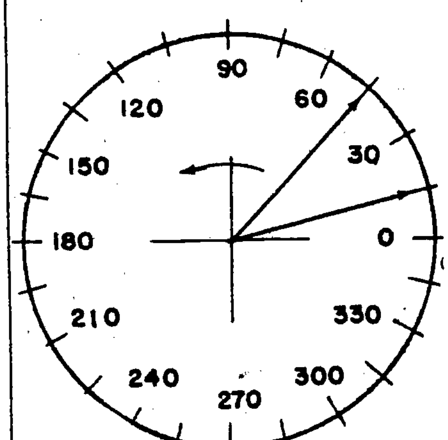
Y= ______

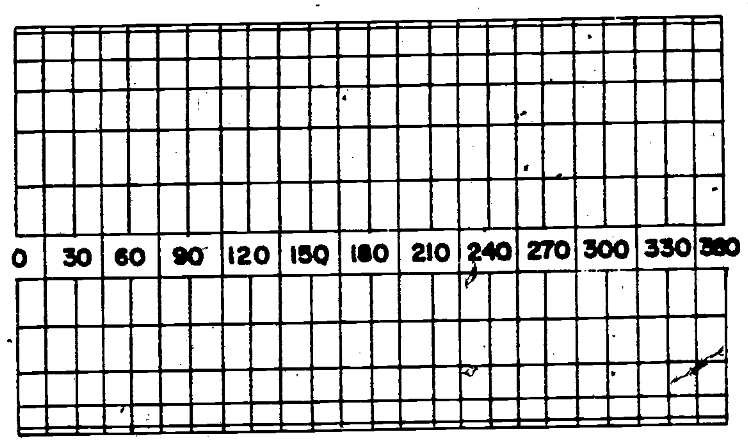
15.



Y= ______

16. At each 15^0 of rotation, take the amplitude of the sine function from the rotating vector graph and plot it on the graph with the "X" axis marked off in degrees; then, draw a sine wave by connecting the plotted points.





D

PREPARE THE MAN

401

PROGRAMMED TEXT 3ALR91630-I-6

Department of Medicine
School of Health Care Sciences

Technical Training

CARDIOPULMONARY LABORATORY SPECIALIST

BASIC MATHEMATICS - GRAPHS

July 1973

10-6

SHEPPARD AIR FORCE BASE

Original Material Prepared
by
Naval Air Technical Training Command
(2TPT-5111-08)

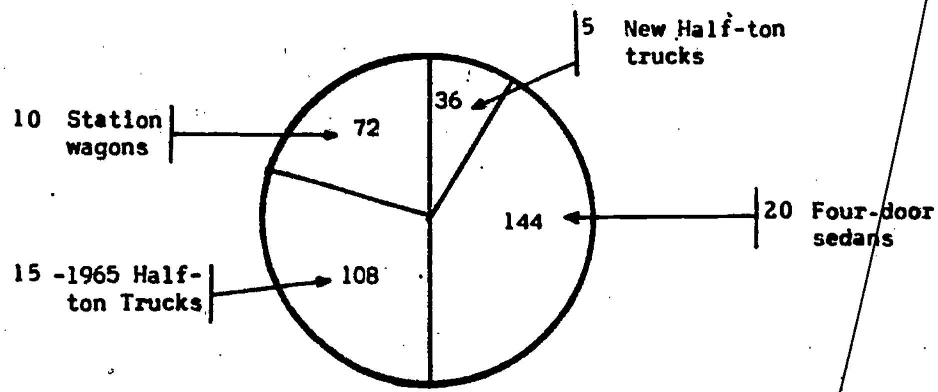
Designed For ATC Course Use

DO NOT USE ON THE JOB

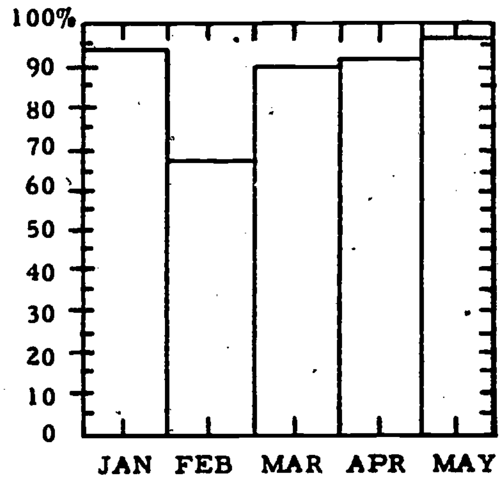
ANSWERS TO REVIEW TEST

1. A graph is a pictorial representation of related numerical facts.

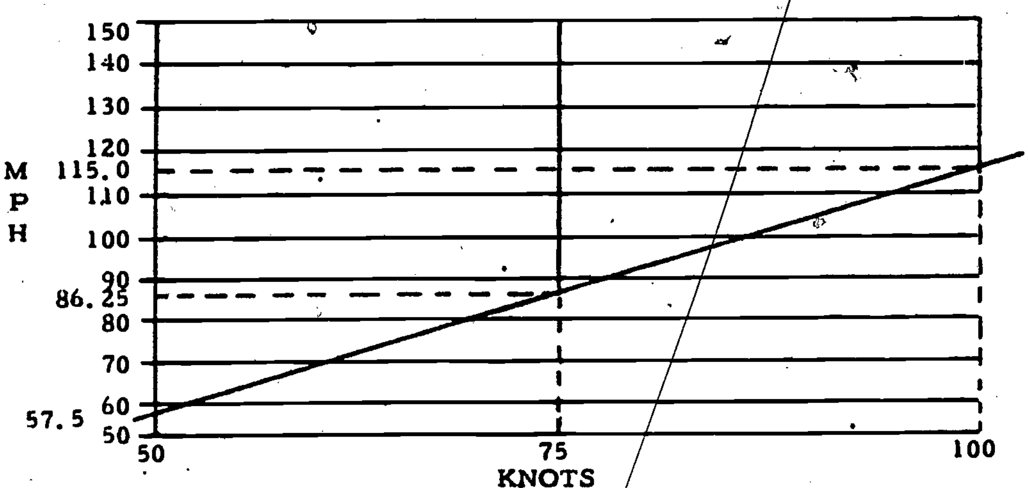
2.



3.



4. b. h. A.
d. g. B.
c. e. C.
a. f. D.



ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No.)	TEXT MATERIAL (by page and/or frame)	REVIEW QUESTIONS (by No.)

GRAPHS

OBJECTIVES:

- Write the definition of a graph.
- Construct a circle graph from a given problem. (3 out of 4 computations must be correct.)
- Construct a bar graph from a given problem. (4 parts out of 5 must be correct.)
- Identify from a given list the definitions of horizontal axis, vertical axis, point of origin, and resultant, as they apply to line graphs. (3 out of 4 must be correct.)
- Construct a line graph from a given problem. (3 out of the 3 computations must be correct. (The related coordinates and the resultant must also be drawn.)

Turn to page 1 and commence the program.

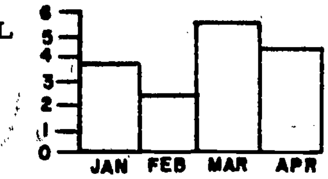
1. The definition of a graph is: A PICTORIAL REPRESENTATION OF RELATED NUMERICAL FACTS.

In any sentence or statement referring to the use of graphs, you would automatically know the definition of the term graphs is: ____________________

A pictorial representation of related numerical facts.

2. In simpler terms, a graph shows us a picture of certain RELATED numerical facts. BAR GRAPH

Example: RAINFALL IN INCHES



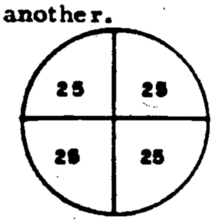
The above shows us that the first 4 months of the year had a certain amount of rainfall. These are related facts in that they all pertain to a specific year and concern rainfall.

As we have therefore said: A graph is a pictorial representation of ______________ numerical facts.

related

3. A graph always gives us a picture of related numerical facts; we can see the comparison of one numerical fact to another.

Example:



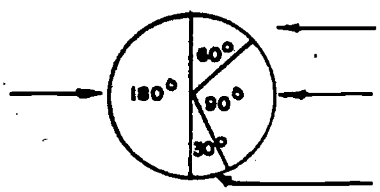
CIRCLE GRAPH

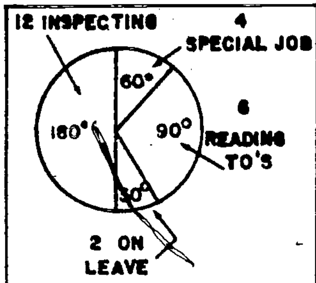
The above shows us that a group of 100 people were divided into four equal parts of 25 persons each.

It gives us a picture of related ______________ facts.

numerical	4.	A graph is a pictorial representation of related numerical facts. Remember, RELATED numerical facts. We can't show a relationship between the ocean and the moon. The facts must be related, such as having a total of 100 people divided into four groups. A graph, therefore, is a pictorial representation of ______________
related numerical facts.	5.	In your own words, write the definition of a graph. ______________
A pictorial representation of related numerical facts.	6.	A circle graph is used when we wish to show how certain items or parts are related to a WHOLE situation. Therefore, in almost all cases, we would use a circle graph to show how certain items or parts are related to a ______________ situation.
whole	7.	Example: There are 24 mechanics assigned to a Squadron. Six are reading TO's, 12 are performing inspections, four are assigned to a special job, and two are on leave. In the above example, the WHOLE situation or total is represented by the ______________ mechanics.
24	8.	The 6 men reading TOs, the 12 performing inspections, the 4 assigned to a special task, and the 2 on leave are all considered as ______________ of the whole situation.

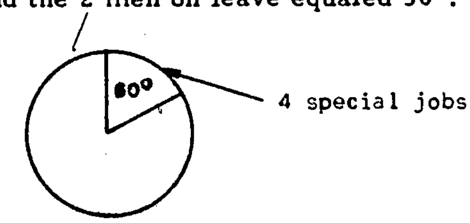
406

24 parts	9. We've determined that the 24 mechanics are the whole situation, and the 6, 12, 4, and 2 are the parts of the whole situation. We can now represent these parts as fractions, which would be: $\frac{\quad}{24}\ \frac{\quad}{24}\ \frac{\quad}{24}\ \frac{\quad}{24}$
$\frac{6}{24}\ \frac{12}{24}\ \frac{4}{24}\ \frac{2}{24}$	10. To determine the angles to be used in constructing a circle graph, we multiply each of these fractions by 360°, cancelling where applicable. (360° = a whole circle.) Example: $\frac{\overset{1}{\cancel{6}}}{\underset{4}{\cancel{24}}} \times \frac{360^\circ}{1} = \frac{1}{\underset{1}{\cancel{4}}} \times \frac{\overset{90}{\cancel{360^\circ}}}{1} = \frac{1}{1} \times \frac{90^\circ}{1} = \frac{90^\circ}{1} = 90^\circ$ What are the angles for the fractions below? (Use provided scratch paper to work problems.) $\frac{12}{24} \times \frac{360^\circ}{1} =$ __________ $\frac{4}{24} \times \frac{360^\circ}{1} =$ __________ $\frac{2}{24} \times \frac{360^\circ}{1} =$ __________
180° 60° 30°	11. All 4 angles, therefore, are: 90°, 180°, 60°, and 30°. We can now draw a circle graph, using the above angles to show the parts of the whole. The <u>six</u> men reading TOs equal 90°; the <u>twelve</u> men performing inspection equal 180°; the <u>four</u> men assigned to a special job equal 60°; and the <u>two</u> men on leave equal 30°. Example:  The above graph would be labeled with the appropriate number of MEN and their JOBS. Label each portion correctly.

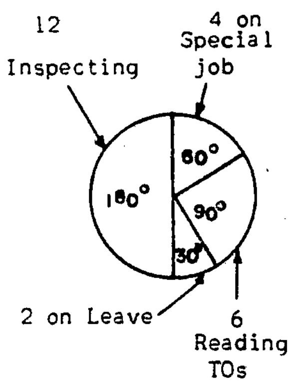
	12. Remember, we use a circle graph when we want to show how certain items or parts are related to a whole situation. The first step was to determine the whole situation. In this case, the 24 mechanics were the ______________ situation.
whole	13. The second step was to determine the parts of the whole. In this case, the 6, 12, 4, and 2 men were considered as the ______________________________ .
parts of the whole	14. The third step was to write these parts (6, 12, 4, and 2 men) of the whole and the whole amount (24 men) each as a fraction. These individual fractions were: __________ __________ __________ __________
6/24, 12/24 4/24, 2/24	15. The fourth step was to multiply each of these fractions by 360°. This was to determine the angles to be used in constructing the circle graph. Example: $6/24 \times 360^\circ/1$ The other three fractions set up for multiplication were: ___ x ___ ___ x ___ ___ x ___

$12/24 \times 360/1$
$4/24 \times 360/1$
$2/24 \times 360/1$

16. After multiplying each fraction by 360°, we obtained the answers 90°, 180°, 60°, and 30° respectively. After all the computations had been made we proceeded to construct a circle graph. The information to be used was: 4 men equaled 60°; 12 men equaled 180°; 6 men equaled 90°; and the 2 men on leave equaled 30°.



Complete the above circle graph, draw in the segments indicating the amount of degrees, and label each segment correctly. (The angles do not have to be drawn exactly; the number of degrees written in each segment must be correct.)



17. An easy way to prove that your computations are correct is add all the sectors together; the sum should equal a full circle or 360°.

Example:

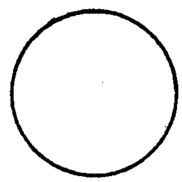
$$\begin{array}{r} 180^\circ \\ 60^\circ \\ 90^\circ \\ +\ \underline{30^\circ} \\ 360^\circ \end{array}$$

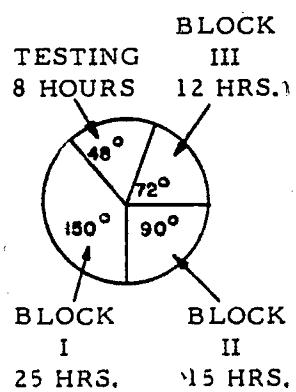
Therefore, as an added measure of proof, we would go ahead and add all the sectors together and the sum total should equal ________________.

360°

18. Construct a circle graph, using the information below. (The angles do not have to be drawn exactly; the number of degrees written in each segment must be correct.) Be sure to label each portion correctly with the number of hours and the block, etc.

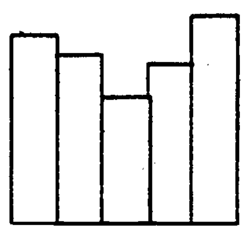
There are a total of 60 hours in a certain course. 25 hours are spent in Block I, 15 hours in Block II, 12 hours in Block III, and 8 hours of TESTING.





19. We've learned thus far that a circle graph is used to show how certain items or facts are related to a whole situation. A bar graph differs in that it is used to show a series of related facts.

Example:

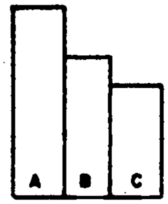


Therefore, whenever you see a bar graph, you know that it is showing a ________________ of related facts.

series

20. In construction of a bar graph, we show comparison by the DIFFERENT LENGTHS OF THE BARS.

Example:

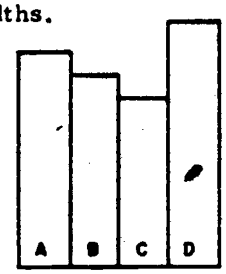


In the above example, we know that A is greater than B and C, and B is greater than C by the different ______________________.

lengths of the bars

21. In constructing a bar graph, all the bars should be of equal widths.

Example:

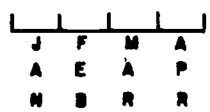


Bars A, B, C, and D are of equal __________.

widths

22. The following data can be represented by a bar graph: The upper air lab reports the maximum altitudes obtained during the first four months of this year as being 20, 23, 25, and 28 kilometers respectively.

Example:

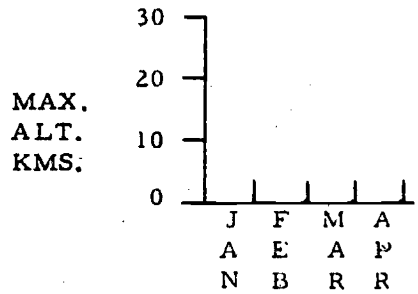


The four months go across the bottom of the graph, and the bars should be of ____________ widths.

equal

23. The altitude in kilometers is labeled in the "vertical," using any scale. (In this case, we used an interval of ten.)

Example:

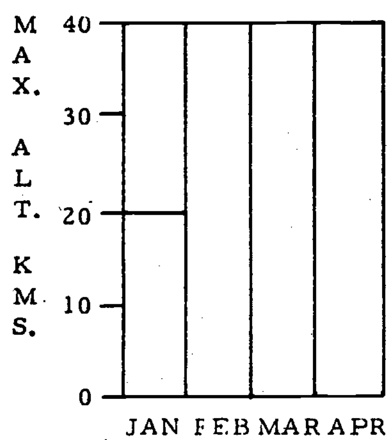


In the construction of this particular bar graph, the altitude in kilometers is labeled in the ____________, and the bars are of ________ ________.

vertical
equal widths

24. Combining these two bits of information (the 4 months and the kilometers) we can now construct our bar graph. In January, the maximum height was 20 kilometers. This is shown on the graph below.

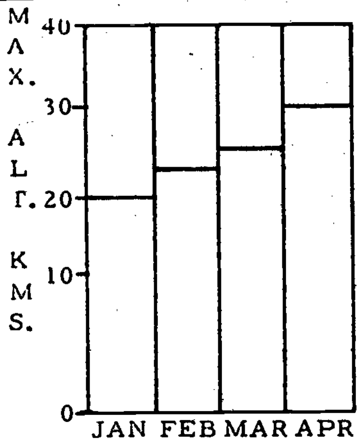
Example:



Complete the graph, showing a maximum altitude for February of 23 kms; March 25 kms; and April 28 kms.

412

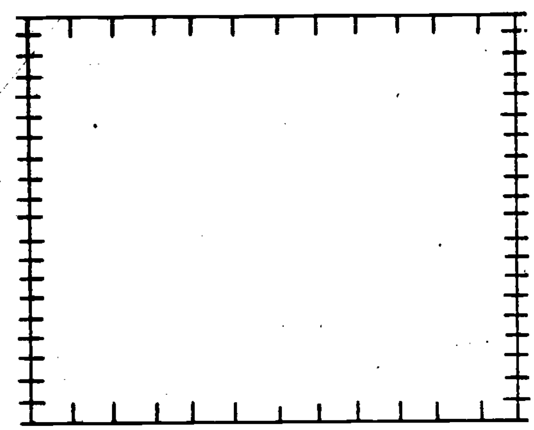
Answer to Frame 24



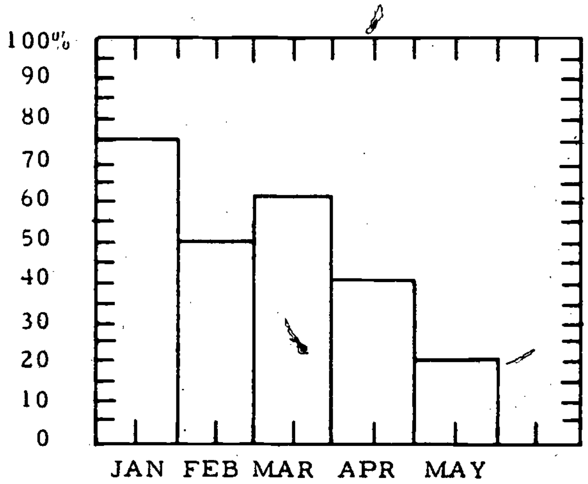
25. In constructing bar graphs, remember we can use any scale desired for showing altitude, amounts, percentage, etc., and these are usually shown on the graph in the ________________. We also want to remember that the bars themselves are of __________ __________.

vertical
equal widths

26. Sheppard Air Force Base is concerned with all winds coming out of the Northeast. Construct a bar graph from the following information: In January, the winds were from the Northeast 75% of the time; in February, 50% of the time; in March, 60% of the time; in April, 40% of the time; and in May, 20% of the time.

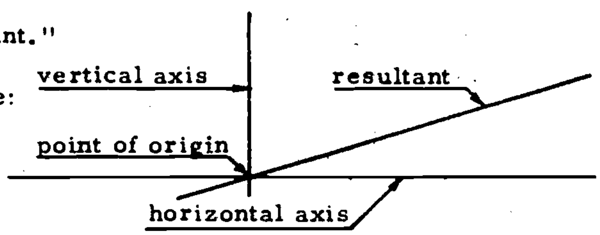


Answer to Frame 26:



27. In construction of a LINE GRAPH, there are four parts we must become familiar with: the "horizontal axis," the "vertical axis," the "point of origin," and the "resultant."

Example:

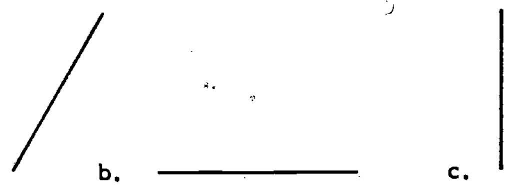


The four parts of a line graph we must have a basic knowledge of are the ________________, ________________, ________________, and the ________________.

horizontal axis vertical axis point of origin resultant (in any order)	28. Horizontal axis "X" axis or abscissa (independent variable) The horizontal axis which is shown above is commonly referred to as the "X" axis or abscissa (ab-sis'-a). On any line graph you see, you would know that the horizontal axis is also known as the __________ or __________.
"X" axis or abscissa	29. Example: Horizontal axis "X" axis or abscissa (independent variable) The "X" axis or abscissa is also known as the INDEPENDENT VARIABLE, which means that in the construction of a line graph, any facts or numbers placed along this line are completely independent of any other facts or numbers. Thus far we've learned that the horizontal axis, on a line graph, can also be called the __________ axis or __________, or an __________ variable. All four names are interchangeable and all apply to the same line.
"X" abscissa independent	30. In constructing a line graph, the "X" axis, the abscissa, and the independent variable are all interchangeable with the term __________ axis.

horizontal

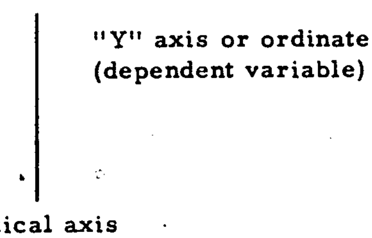
31. The horizontal axis, "X" axis, abscissa, and independent variable are all interchangeable terms which could be applied to which of the lines below? (Circle the correct answer.)



a. b. c.

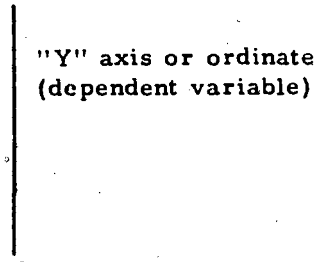
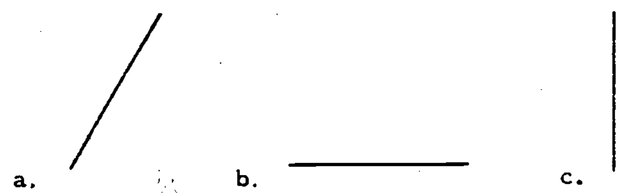
b.

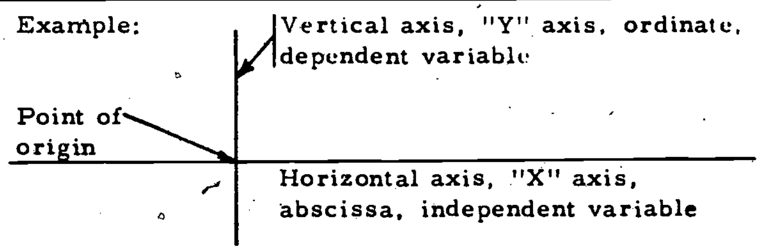
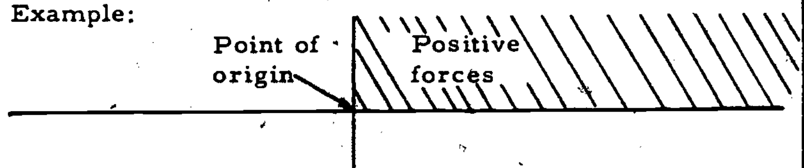
32. Example:



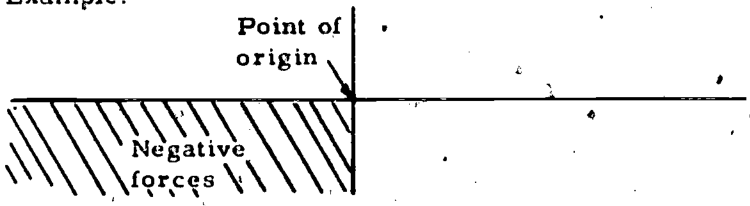
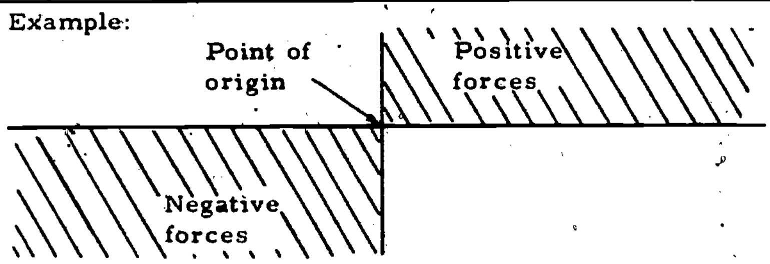
The vertical axis which is shown above is commonly referred to as the "Y" axis, or ordinate.

On any line graph you see, you would know that the vertical axis is also known as the ______________________ or __________________.

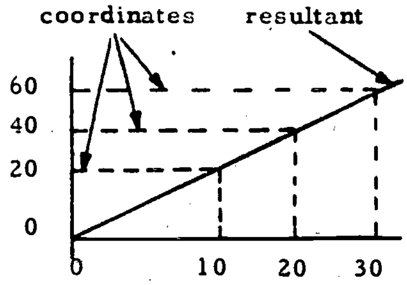
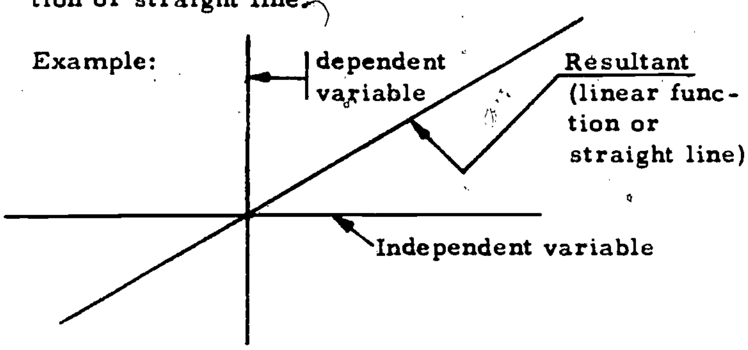
"Y" axis or ordinate	33. Example:  The "Y" axis or ordinate is also known as the DEPENDENT VARIABLE, which means that, in the construction of a line graph, any facts or numbers placed along this line are dependent on other facts or numbers within the graph. Thus far, we've learned that the vertical axis on a line graph can also be called the ______ axis or __________, or a __________ variable. All four names are interchangeable and all apply to the same line.
"Y" ordinate dependent	34. In constructing a line graph, the "Y" axis, the ordinate, and the dependent variable are all interchangeable with the term __________ axis.
vertical	35. The vertical axis, "Y" axis, ordinate, and dependent variable are all interchangeable terms which could be applied to which of the lines below? (Circle the correct answer.) 

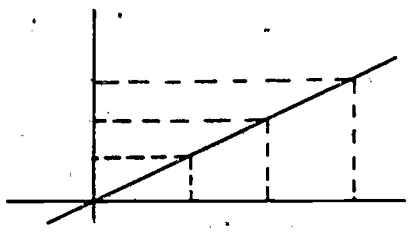
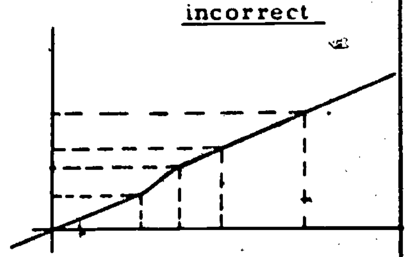
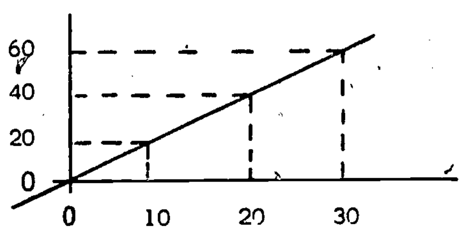
c.	36. Match the definitions in Column B to the correct term in Column A. **Column A** __ __ __ __ A. Horizontal axis __ __ __ __ B. Vertical axis **Column B** a. "Y" axis b. Ordinate c. Abscissa d. Dependent variable e. Independent variable f. "X" axis
f, e, c, A, a, b, d, B,	37. Example:  Thus far, we've discussed the horizontal axis and the vertical axis. Where these two lines meet is called the POINT OF ORIGIN. On any line graph, the point where the horizontal axis and the vertical axis meet is known as the ____________________.
point of origin	38. Example:  On all line graphs, points that are up and to the right of the point of origin are called positive forces. On all line graphs, any and all points that are up and to the right of the point of origin are called ____________________.

418

positive forces	39. Example:  On all line graphs, points that are down and to the left of the point of origin are called negative forces. On all line graphs, any and all points that are down and to the left of the point of origin are called ________________ and all points that are up and to the right of the point of origin are called ________________.
negative forces positive forces	40. We've thus far said that on a line graph, all positive forces are up and to the ________________ and all negative forces are down and to the ________.
right left	41. Example:  In a line graph, these positive forces and these negative forces all act toward the point of origin. In other words, the point of origin is a null point or zero. In a line graph, therefore, all forces act simultaneously on the point of ________________.

origin	42. In a line graph, we've said the horizontal axis is also known as the ______ axis, the ____________, or the ____________ variable. The vertical axis is known as the ________ axis, the ____________ or the ____________ variable.
"X" abscissa independent "Y" ordinate dependent	43. We've also said on a line graph all points that are up and to the right of the point of origin are called ____________ ________ and all points that are down and to the left of the point of origin are called ____________ ________.
positive forces negative forces	44. Also, all these forces act simultaneously on the ____________________________.
point of origin	45. Match the definitions in Column B to the correct terms in Column A. COLUMN A __ __ __ __ A. Horizontal axis __ __ __ __ B. Vertical axis __ __ __ __ C. Point of Origin COLUMN B a. Ordinate b. X and Y axis intersect c. "Y" axis d. Abscissa e. Positive forces act on the f. "X" axis g. Dependent variable h. Negative forces act on the i. Independent variable j. All forces act simultaneously on the

d. f. i. A a. c. g. B b. e. h. j. C	46. The fourth term we must learn concerning line graphs is the RESULTANT. The resultant is a linear function or a straight line connecting all related coordinates on a line graph.  In the line graph to the left, the 10 & 20, 20 & 40, 30 & 60, are the related coordinates of this graph. They are all connected by a straight line which is a linear function of the coordinates. On a line graph, the linear function or straight line connecting all related coordinates of the graph is called the______________.
resultant	47. The resultant is therefore known as a linear function or straight line. Example:  On any line graph, when you see the line labeled as the resultant, we know that it is a ________________ or a______________.

linear function straight line	48. The resultant must always be a straight line. It proves that the related coordinates have been plotted correctly. If the resultant has a bend or a kink in it, that point on the line graph has been plotted incorrectly. Example: correct  incorrect  To prove that the line graph is accurate, the resultant must always be a ________________.
straight line	49. We could also say that the resultant is a line which connects all related coordinates on a line graph. Example: The 10 & 20, 20 & 40, etc., are the related coordinates on this particular line graph.  C On a line graph, therefore, the resultant is a line which connects all ________________________, and this resultant must always be a ________________ ________________.

422

related coordinates

straight line

50. Remember, the resultant is also known as a linear function or straight line, and it connects related coordinates on a line graph.

Whenever you see the term resultant as it is applied to line graphs, you know that it can be called a ______ ____________ or ____________ ______, and that it connects ______ ____________ on a line graph.

---

linear function

straight line

related coordinates

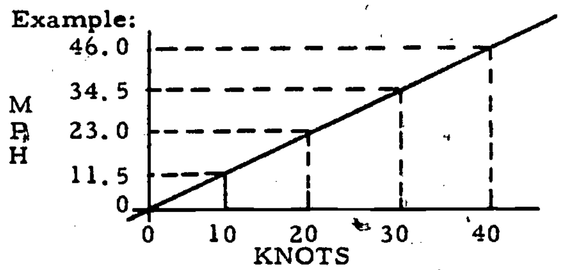
51. Match the definitions in Column B to those terms which apply to it in Column A.

COLUMN A		COLUMN B
______	A. Horizontal axis	a. "Y" axis or ordinate
______	B. Vertical axis	b. Positive and negative forces act on the
______	C. Point of Origin	c. Linear function or a straight line
______	D. Resultant	d. "X" axis or abscissa
		e. Dependent variable
		f. Line connecting related coordinates
		g. Independent variable
		h. Where X and Y axis intersect.

A - d. g.
B - a. e.
C - b. h.
D - c. f.

52. A line graph is used when we wish to show a <u>set</u> of related facts.

Example:



Whenever you see a line graph, you know that it is showing a ____________________________.

471

set of related facts

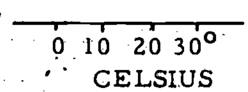
53. Since most mathematical equations are statements of "related facts," we could set up a line graph that would represent these mathematical equations.

The formula for converting Fahrenheit to Celsius is a mathematical equation and it can be set up as a line graph because it is a statement of ______________.

related facts

54. The first step in constructing a line graph is to number of "X" axis, which is the independent variable.

Example:

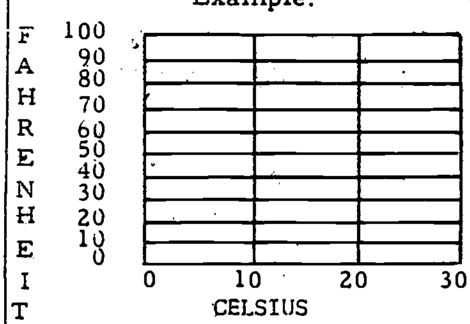


NOTE: As we've already learned, the independent variable is set up first because the numbers or facts on this line can be spaced independently of any other information on the graph. Either of the temperature scales could have been placed along this axis.

"X"
independent variable

55. The second step is to number the "Y" axis or dependent variable.

Example:



NOTE: Using ready-made graphs as we've done here simplifies the process of spacing the numbers. If we were to start from scratch, we would first have to compute the coordinates of the two scales to get the proper spacing for the "Y" axis which is dependent upon the "X" axis.

In constructing this line graph, the second step is to number the ____ axis or ______________ ____________.

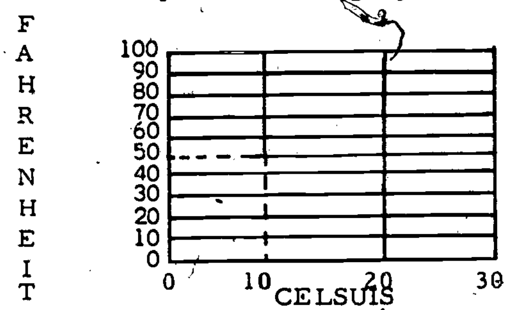
424

"Y" dependent variable	56. To compute the related coordinates of the line graph, we must now use the formula for converting Celsius to Fahrenheit, which is F = (C x 1.8) + 32. The formula for converting Celsius to Fahrenheit is ______________. This formula is used to compute the __________ _______________ of this particular line graph.
F = (C x 1.8) + 32 related coordinates	57. Using the formula F = (C x 1.8) + 32, find the equivalent Fahrenheit value of 10° Celsius. The steps would be as follows: F = (10 x 1.8) + 32 F = (18) + 32 This step simply involves removing F = 18 + 32 the parentheses. F = 50°·C. Thus, 10° Celsius is equal to 50° Fahrenheit. These two values are the related coordinates to be drawn on the line graph. Find the equivalent Fahrenheit value of 20° Celsius. F = (__ x 1.8) + 32 F = (__) + 32 F = __ + 32 Remove the parentheses. F = ____
20 (36) 36 F = 68°	58. Using the formula F = (C x 1.8 + 32), find the equivalent Fahrenheit value of 30° Celsius. Answer __________________.

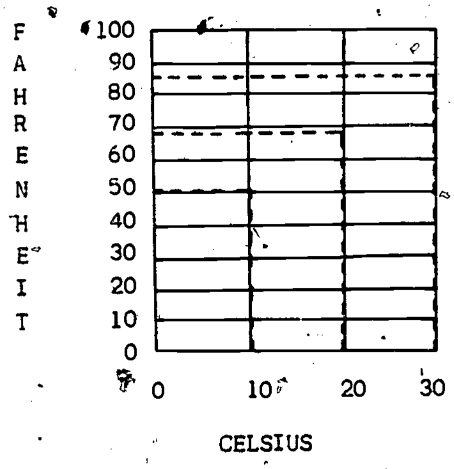
86° F

59. We've determined that 10° C. equals 50° F., 20° C. equals 68° F., and 30° C. equals 86° F. These are the related coordinates used for drawing the resultant. Remember, the resultant proves whether we've computed the coordinates correctly.

Example: The coordinates for 10° C. equals 50° F. have been plotted on the graph below.

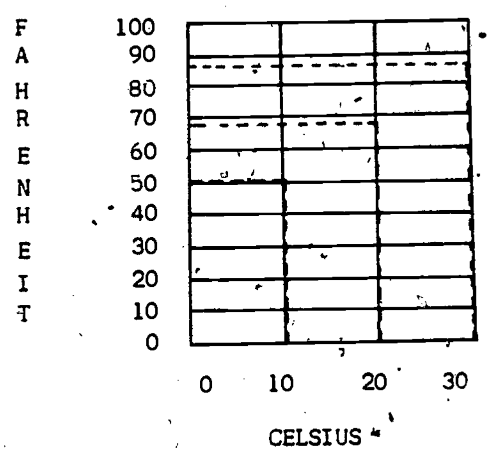


Draw the coordinates on the above graph for 20°C. equals 68° F. and 30° C. equals 86° F.

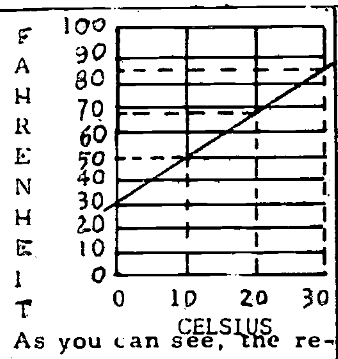


60. With the coordinates plotted on the graph, we now draw the resultant.

Example:

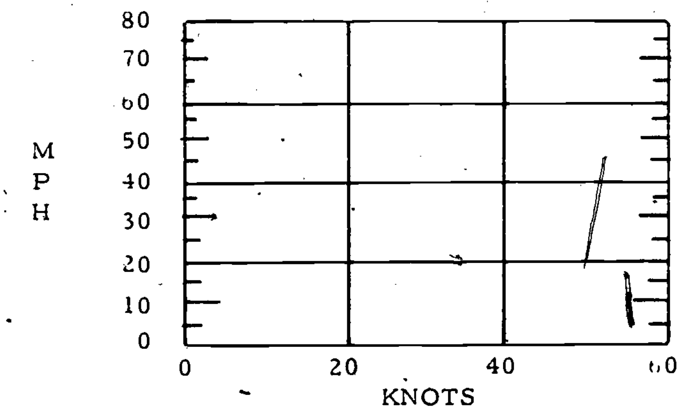


Draw the resultant or linear function of the related coordinates on the above graph.

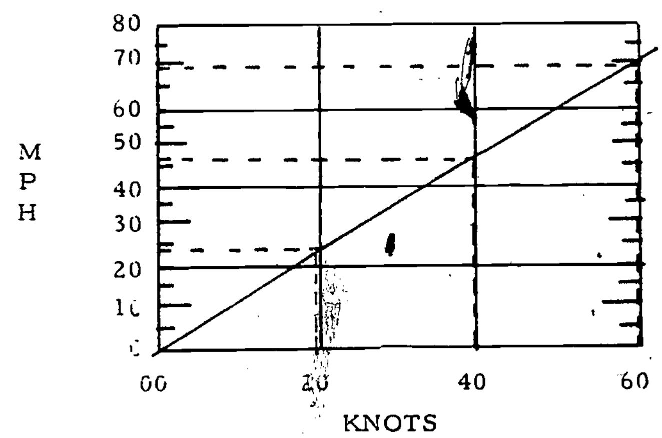
 As you can see, the resultant crosses the vertical axis at 32° F., which of course equals 0° C.	61. As you have already learned, the resultant must be a straight line. If it isn't, the coordinates on the line graph are plotted incorrectly. When constructing line graphs, the plotted resultant must be a ________ ________.
straight line	62. The first step in constructing a line graph was to place the facts or numbers (in this case, the Celsius temperatures) along the horizontal axis, which is the ____ axis or ____________ variable.
"X" independent	63. The second step was to place the second set of facts or numbers (Fahrenheit temperatures) along the vertical axis or ____ axis, which is the ________ variable.
"Y" dependent	64. The third step was to determine the equivalent Fahrenheit temperature for each Celsius temperature to obtain the related coordinates, using a given formula, which as we said is a methematical equation. As we've thus far said, the third step is to obtain the related __________, using a given formula which is a __________ ________.

coordinates mathematical equation	65. The fourth step is to prove the related co-ordinates are accurate by drawing the resultant, and we said this resultant must be a ______________ ______________.
straight line	

Using the formula: MPH = 1.15 x KNOTS, construct a line graph converting KNOTS to MPH, ranging from 0 to 60 knots, at 20-knot intervals, i.e., 0, 20, 40, and 60 knots. DRAW IN RELATED COORDINATES and the RESULTANT.



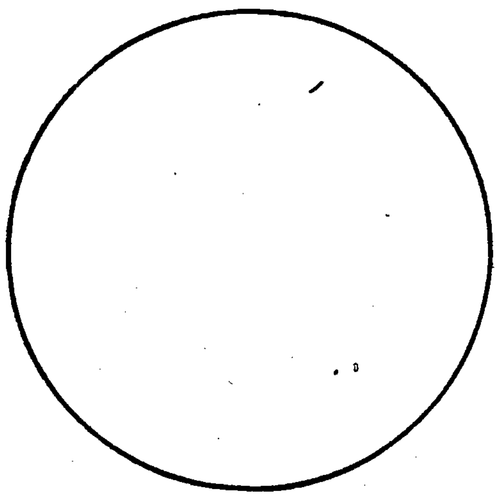
ANSWER



REVIEW TEST

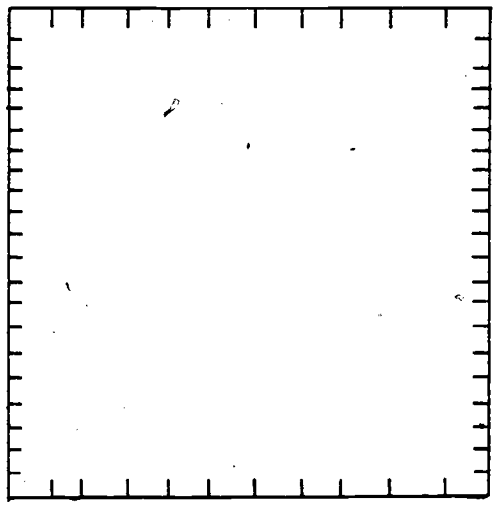
1. Write the definition of a graph.

2. Construct a circle graph using the following information: The motor pool has a total of 50 taxies. 15 are 1965 half-ton trucks; 5 are new half-ton trucks; 20 are four-door sedans, and 10 are station wagons. Indicate in each portion of the graph the type of taxi it represents and the amount of the angle in degrees. (The angles drawn do not have to be exact; the number of degrees indicated should be exact.) Be sure to label each sector.



429

3. Construct a bar graph using the following information: During the first 6 months of 1964, the accuracy of the surface observations was as follows: January 94%, February 73%, March 89%, April 92%, and May 98%.



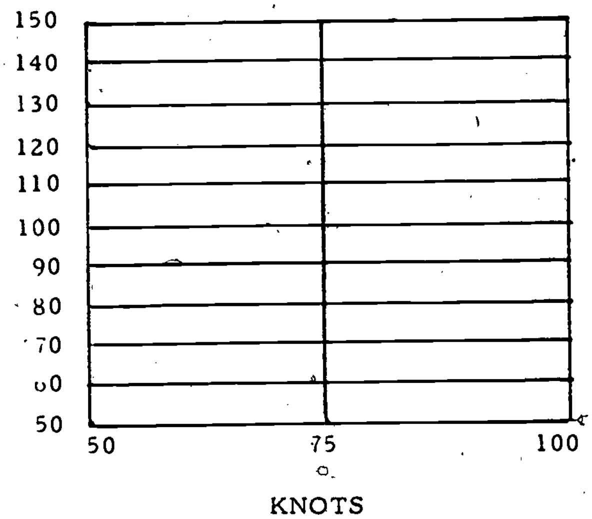
4. Match the definitions in Column B to those terms which apply to it in Column A.

COLUMN A	COLUMN B
______ A. Horizontal axis	a. Linear function or a straight line
	b. "X" axis or abscissa
______ B. Vertical axis	c. Positive and negative forces act on the
______ C. Point of origin	d. "Y" axis or ordinate
	e. Where the X and Y axis intersect
______ D. Resultant	f. Line connecting related coordinates
	g. Dependent variable
	h. Independent variable

478

430

5. Using the formula: MPH = 1.5 x KNOTS, construct a line graph converting KNOTS to MPH, ranging from 50 to 100 knots, at 25-knot intervals, i.e., 50, 75, and 100 knots.



Answers to Review Test are on page i.

ATC-SHEPPARD AFB TEX. 68-9418

431

PREPARE THE MAN SHO 3ALR91630-I

Department of Medicine
School of Health Care Sciences

Cardiopulmonary Laboratory Specialist

MAJOR ANTIARRHYTHMIA DRUGS

July 1972

10-6

SHEPPARD AIR FORCE BASE

Designed For ATC Course Use

DO NOT USE ON THE JOB

Department of Medicine
School of Health Care Sciences
Sheppard AFB, Texas

3ALR91630-I
Student Handout
July 1972

Introduction to Cardiology
MAJOR ANTIARRHYTHMIA DRUGS

1. Quinidine

a. Action

(1) Myocardial depressant

(a) Depresses excitability, conduction, speed, and contractility.

1 Decreases automaticity of myocardial tissue (the property of automatic rhythmic activity of the tissue, independent of innervation.)

2 Prolongs the refractoriness of atrial and ventricular myocardium (prolongs the period after a contraction during which the heart will not respond to another stimulus). Has little effect on normal pacemaker.

b. Uses

(1) Primarily: Atrial arrhythmias

(a) Atrial Fibrillation

(b) Atrial Flutter

(2) Also used to treat premature contractions, atrial and nodal tachycardia, and ventricular tachycardia and fibrillation.

c. Dosage

(1) Oral - Loading Dose: 400 mg.

Maintenance: 200 mg. q. 4 hours

(a) Effective in about 2 hours

(2) I.M. - Same as oral, and effects develop in about the same period of time.

(3) I.V. - Hazardous

d. Side Effects

(1) Cardiac (Cardiotoxic)

(a) Over-depression of atrioventricular conduction.

1 Creation of A-V block.

2 Intraventricular conduction delay.

(2) Extra-Cardiac

(a) Chinchonism

1 Anorexia (loss of appetite), nausea, vomiting, diarrhea, vertigo, tinnitus, headache, and visual disturbance.

(b) Has the potential to produce hypoprothrombinemic hemorrhage in patients receiving Coumadin.

e. Contra-Indications

(1) Conduction defects; especially complete heart block.

(2) Conditions in which conversion of atrial fibrillation to N.S.R. may result in embolism.

(3) Due to Quinidine's action on the refractory period, conduction, and automaticity, P.V.C.'s, ventricular tachycardia, and ventricular fibrillation can occur.

II. Procainamide (Pronestyl)

a. Action

(1) Myocardial depressant

(a) Similar to Quinidine's action.

b. Uses

(1) Ventricular arrhythmias - frequent P.V.C.'s and ventricular tachycardia.

(2) May be used for auricular fibbrillation but not as effective as Quinidine.

c. Dosage

(1) Oral

(a) 500-1,000 mg. q. 4 - 6 hours

(b) Effective in about 2 hours

(2) I.M.

(a) Dosage same as oral

(b) Effective in ½ - 1 hour

(3) I.V.

(a) 200 - 500 mg. (up to 1 Gm.) at a rate not exceeding 50-75 mg. per

(b) I.V., may cause hypotension.

1 Blood pressure related to infusion rate.

2 EKG and blood pressure monitoring required.

d. Side Effects

(1) Cardiac

(a) Toxicity similar to Quinidine.

(2) Extra-cardiac

(a) Anorexia, N & V, chills, fever and drug rashes.

(b) Agranulocytosis, lupus-like illness.

(c) I.V. - hypotension.

III. Lidocanine (Xylocaine)

a. Action

(1) Myocardial Depressant

(a) Depresses ventricular exitability.

(b) Little effect on sino-atrial node.

b. Ventricular Arrhythmias

(1) Drug of choice in Rx of P.V.C.'s and ventricular tachycardia.

(2) Effective for suppression of ventricular arrhythmias related to cardiac surgery, cardiac catheterization, myocardial infarction, and digitalis intoxication.

(3) Has not been found to be real effective on supraventricular arrhythmias.

c. Dosage

(1) I.V.

(a) Bolus - 1-2 mg. per kilogram of body weight (usually 50-100 mg.)

1 Effective within 45 seconds to 3 minutes and is dissipated within 4-15 minutes

(b) Continuous infusion

1 Should follow bolus at a rate to prevent rhythm disturbance.

2 Over 200 mg. per hour increases risk of side effects.

d. Side Effects

(1) Cardiac

(a) Over-depression of myocardial excitability.

(2) Extra-cardiac

(a) Therapeutic dose.

1 Drowsiness or "lightheadedness."

2 Numbness, confusion, disorientation, and muscular twitching.

3 All side effects disappear within 15-20 minutes when I.V. medication is stopped.

(b) Large doses

1 Seizures - Grand Mal and Petite Mal.

2 C.N.S., circulatory, and respiratory depression and death.

f. Contra-Indications

(1) The presence of heartblock with A V dissociation.

(2) Slow nodal or idioventricular pacemaker.

IV. Diphenylhydantoin (Dilantin)

a. Actions

(1) Decreases myocardial excitability.

(a) Thought to increase A-V conduction.

(b) Depresses ventricular automaticity.

b. Uses

(1) Ventricular arrhythmias.

(2) Especially useful in digitalis-induced atrial tachycardia and also digitalis-induced ventricular arrhythmias.

c. Dosage

(1) Oral - 200 - 400 mg. per day in divided doses.

(2) I.V. - not exceed 5 mg. per kg. body weight - over 5-15 minutes in dilute solution (100-250 mg.)

d. Side Effects

(1) Cardiac (I.V.)

(a) Bradycardia

(b) Hypotension

(2) Extra-cardiac

(a) Nervousness, ataxia, tremor, visual disturbance, skin rashes, thrombophlebitis at infusion site, and respiratory arrest.

(b) Oral administration on a long-term basis can cause hyperplasia of the gums.

e. Contra-Indications

(1) Severe bradycardia.

(2) High degree of A-V block.

(3) Use cautiously with patients with seriously impaired cardiac function, significant acidosis, and impaired liver function.

V. Propranolol Hydrochloride (Inderal)

a. Action

(1) Beta - Adrenergic Blocker

(a) Blocks the effects of sympathomimetic amines: It slows heart rate, decreases force of contraction (negative inotropic effect). Decreases A-V conduction.

(2) Antiarrhythmic property: maybe a Quinidine-like property unrelated to Beta-Adrenergic blockade.

b. Uses

(1) Tachyarrhythmias of Digitalis intoxication.

(2) Reduce ventricular response to atrial flutter or fibrillation.

(3) PAT, and sinus tachycardia and extrasystole.

(4) Effectiveness in ventricular rhythms is controversial.

(5) Being investigated for treatment of angina pectoris.

(a) Reduce myocardial oxygen demands by blocking the increase in cardiac contractility and heart rate produced by sympathetic stimulation.

(b) This resultant reduction in myocardial contractility could lead to cardiac enlargement and increase myocardial oxygen requirements.

c. Dosage

(1) Orally

(a) Preferred

1 10-30 mg. T.I.D. or Q.I.D.

(2) I.V.

(a) Need continuous monitoring.

1 1-3 mg. at 1 mg. per minute

d. Side Effects

(1) Cardiac

(a) Heart block and sinus bradycardia.

(2) Extra-Cardiac

(a) Nausea, vomiting, lightheadedness, mild diarrhea, constipation and mental depression.

e. Contra-Indications

(1) Congestive heart failure unless the failure is secondary to a tachyarrhythmai treatable with Propranolol.

(2) Bronchial asthma.

(3) Cardiogenic shock.

(4) Use with caution in patients susceptible to hypoglycemia since Inderal may prevent the appearance of premonitory signs and symptoms of acute hypoglycemia.

VI. Potassium

a. Action

(1) Along with Sodium, it is responsible for myocardial electro-mechanical activity.

(a) Myocardial fiber potential is dependent on K/Na- ration normally 1:35) in the resting cell and on the intracellular-to extra-cellular gradient of these ions.

(b) Major effect of K- is on the resting membrane potential (repolarization).

(2) Decreases the rate of spontaneous depolarization in all pacemaker fibers.

(a) Ectopic pacemakers are even more sensitive than the S-A node to this effect.

b. Uses

(1) Arrhythmias related to K+ depletion (3 mEq./L).

(a) Diuretic therapy.

(b) Loss with prolonged vomiting and diarrhea.

(c) Digitalis intoxication.

(2) Ectopic rhythms

(a) Supraventricular and ventricular rhythms and beats.

c. Signs and symptoms of hypokalemia

(1) Cardiac

(a) Lowering of the T-wave (slows repolarization).

(b) Development of a U wave.

(c) Slight widening of QRS (slows depolarization).

(d) Increase in myocardial irritability.

(2) Extra-cardiac.

(a) General symptoms of electrolyte depletion.

1 Vague weakness.

2 Apathy.

3 Mental confusion.

4 Anorexia, nausea, and vomiting.

5 Hypotension.

(b) Specific signs of hypokalemia.

1 Marked muscle weakness.

2 Abdominal distention due to intestinal atony.

(3) Serum Potassium levels.

(a) EKG signs usually evident at potassium levels less than

3 mEq./L.

d. Dosage

(1) Oral

(a) Tablet or liquid

(b) Usually 0.5-1.0 Gm. T.I.D. or Q.I.D.

(c) Use cautiously in presence of renal insufficiency.

(2) I.V.

(a) Should NEVER be given as a direct injection.

(b) 40 mEq. dissolved in 500-1,000 cc's of glucose solution given over a period of <u>at least 1-2 hours</u>.

1 Rapid potassium infusion produces bradycardia and myocardial depression, a potentially lethal combination.

VII. Insuproterenol (Isuprel)

a. Action

(1) Sympathomimetic Amine

(a) Acts on Beta nerve receptors.

1 Has a positive inotropic effect - increases the force of myocardial contractility.

2 Increases heart rate

a Stimulates S-A node, increases conduction through A-V node, and increases ectopic activity.

3 Causes vasodilation of coronary and systemic blood vessels.

b. Uses

(1) Cardiogenic Shock

(a) Increases cardiac output.

1 May result in an increase in blood pressure.

2 May further reduce blood pressure by vasodilation and further reduce perfusion of brain and heart.

(2) Heart block

(a) Increases the rate of nodal and ventricular pacemakers.

(3) Marked sinus bradycardia

(a) Stimulates the S-A node.

c. Dosage

(1) I.V.

(a) 1 mg. in 500 cc of glucose solution.

1 Give slowly with rate controlled according to response or occurrence of undersirable cardiac effects.

(2) Subcutaneous

(a) 0.2 mg. q. 3 hours.

(3) Sublingual

d. Side Effects

(1) Cardiac (Cardiotoxic)

(a) Increases myocardial irritability.

1 Development of ventricular tachycardia and ventricular fibrillation.

2 Palpitation.

(b) Precordial distress - anginal type pain.

(2) Extra-cardiac.

(a) Nervousness, tremor.

(b) Nausea and vomiting.

(c) Headache, dizziness, weakness.

(d) Flushing of skin.

VIII. Atropine

a. Action

(1) Cholinergic - blocking agent.

(a) Blocks cardiac actions of the vagus nerve.

1 This allows the sympathetic nervous system to gain control over the S-A node.

2 Since vagal fibers are distributed to atrial tissues and to both the S-A node and A-V node, rate of S-A node increases and A-V conduction is increased.

b. Uses

(1) Severe sinus bradycardia

(a) When bradycardia due to increased vagal actions.

(2) Occasionally 1^{o} - 2^{o} A-V block

(a) When block due to increased vagal actions.

(b) Occasionally, may aggravavate 2^{o} A-V block.

1 More sinus impulses will arrive at the already depressed A-V node.

(3) Antiarrhythmic properties probably indirect.

(a) Increased rate of normal pacemaker decreases ectopic activity.

c. Dosage

(1) I.V.

(a) Single, rapid injection of 0.5 mg. to 2.0 mg q 4-6 hours.

(2) I.M.

(a) 0.5 mg. - 2.0 mg. q. 4-6 hours.

d. Side Effects

(1) Induces urinary retention.

(a) Especially in elderly males with prostatic hypertrophy.

(2). Can precipitate acute glaucoma.

(3) Dryness of mouth and skin.

(4) Dilation of the pupil and paralysis of accommodation.

IX. Cardiac Glycosides ("Digitalis")

a. Action

(1) Postive inotropic action

(a) Increase the force of myocardial contractility

(2) Action

(a) Stimulates the vagus nerve to slow heart rate.

(b) Improvement of myocardial contraction and efficiency of circulation also contributes to cardiac slowing.

(3) Decreases conductivity.

b. Uses - 1. Supraventricular arrhythmias

(a) Atrial fibrillation and atrial flutter.

1 Decreases responsiveness of A-V node to the barrage of atrial stimuli

a Decreases ventricular rate.

2 Increases force of ventricular contractions.

3 Improves myocardial oxygenation thus frequently converts arrhythmia to sinus rhythm.

(b) Paroxysmal atrial tachycardia.

(2) Congestive heart failure

(a) More effective in low output congestive heart failure such as that accompanying myocardial infarction.

c. Types and Dosages

(1) Ouabain

(a) Clinically effective in 5-10 minutes.

(b) Parenteral only.

(c) Digitalization dose: 0.5 mg.

(2) Deslanoside (Cedilanid-D)

(a) Onset of action in 20-30 minutes.

(b) Typical effectiveness in 1-2 hours.

(c) Oral I.V., or I.M.

(d) Digitalization Dose: Oral - 5.0 mg. - 10.0 mg.

I.V. - ½ mg - 1.6 mg.

(e) Maintenance Dose: 0.5 mg. to 2. - mg.

(3) Digoxin

(a) Onset in less than 30 minutes.

(b) Typical effectiveness in 1½ to 3 hours.

(c) Oral, I.V., or I.M.

(d) Digitalization Dose: Oral - 1.0 mg. - 4 mg.

I.V. - .75mg - 1.0 mg.

Maintenance Dose: .25 mg. to 1.0 mg.

(e) Half time for urinary excretion is 46 hours.

(4) Digitoxin

(a) Speed of action about 1 hour

(b) Oral, I.V.

(c) Digitalization Dose: 1.0 mg. - 1.5 mg.

Maintenance: .05 mg. to 2.0 mg.

(d) Half-time for urinary excretion is 9 days.

(5) Whole leaf Digitalis

(a) Oral

(b) Digitalization Dose: 1.0 Gm. - 1.5 Gm.

Maintenance Dose: 0.1 Gm. daily

(6) Gitalin (Gitaligin)

(a) Oral

(b) Digitalization Dose: 4.0 - 8.0 mg.

Maintenance Dose: .25 mg. - 1.0 mg.

d. Side Effects

(1) Cardiac

(a) Cardiotoxic

1 Increased myocardial irritability.

a Frequent PVC's (often occuring as bigeminy).

b Any rapid rate arrhythmia with A-V block.

1 Paroxysmal atrial tachycardia with block is almost pathonomonic.

2 Varying degrees of S-A and A-V block and intraventricular conduction defects.

(b) Therapeutic doses.

1 Decreased heart rate.

2 Prolongation of the P-R interval.

3 Increases incidence of arrhythmais which occur when cardioversion used on digitalized patient.

a Lowers threshold of non-vulnerable period when the countershock is applied and ventricular fibrillation can be produced.

(2) Extra-cardiac

(a) Anorexia, nausea, vomiting and diarrhea.

1 Due to direct irritant effect on gastrointestinal mucosa and a central nervous system action on the emetic and, possibly,

vagal center.

(b) Confusion, drowsiness and occasionally a peculiar yellow vision.

e. Treatment of Side Effects and Toxicity.

(1) Discontinue Digitalis.

(2) Administration of potassium if hypokalemic.

(3) Administration of Atropine for slow rate.

(4) Chelation of calcium by use of EDTA (Ethylene-Diaminetetra-acetic Acid).

(5) Antiarrhythmic agents.

(a) Dilantin

(b) Inderal

f. Contra-Indications

(1) Digitalis toxicity.

(2) Incomplete heart block.

447

Department of Medicine
School of Health Care Sciences

Cardiopulmonary Laboratory Specialist

ANATOMY AND PHYSIOLOGY OF THE RESPIRATORY SYSTEM

July 1973

10-6

SHEPPARD AIR FORCE BASE, TEXAS

Designed For ATC Course Use

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449

Department of Medicine
Clinical Medicine Training Branch
Sheppard Air Force Base

SW 3ALR91630-II-1

July 1973

ANATOMY AND PHYSIOLOGY OF THE RESPIRATORY SYSTEM

OBJECTIVES:

1. Match structures which comprise the five thoracic borders with their anatomical location.

2. Label the muscles of respiration.

3. Match respiratory organs or structures with their function.

4. Label the major structures of a lung.

5. Complete statements pertaining to the physiology of respiration.

INTRODUCTION:

Several structures are known collectively as the respiratory system. This study guide is designed to familiarize you with the various structures.

INSTRUCTIONS:

1. All essential material is included in the summary; therefore, additional notes should not be necessary.

2. While the instructor is explaining the various organs of respiration, label the diagrams as indicated.

3. When directed by the instructor, complete each exercise.

4. Keep this study guide/workbook for future reference.

Label the following illustration as it is discussed.

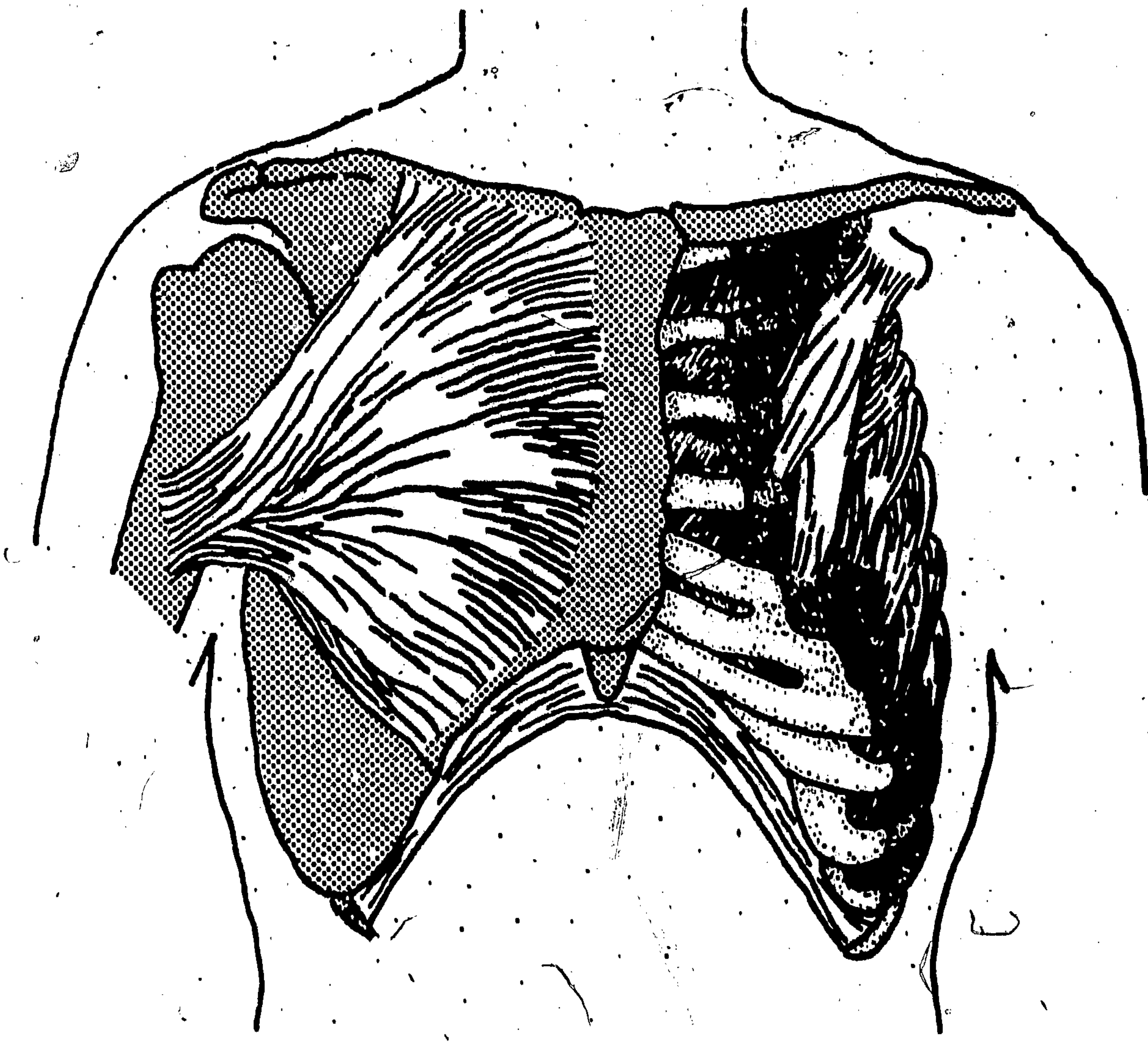
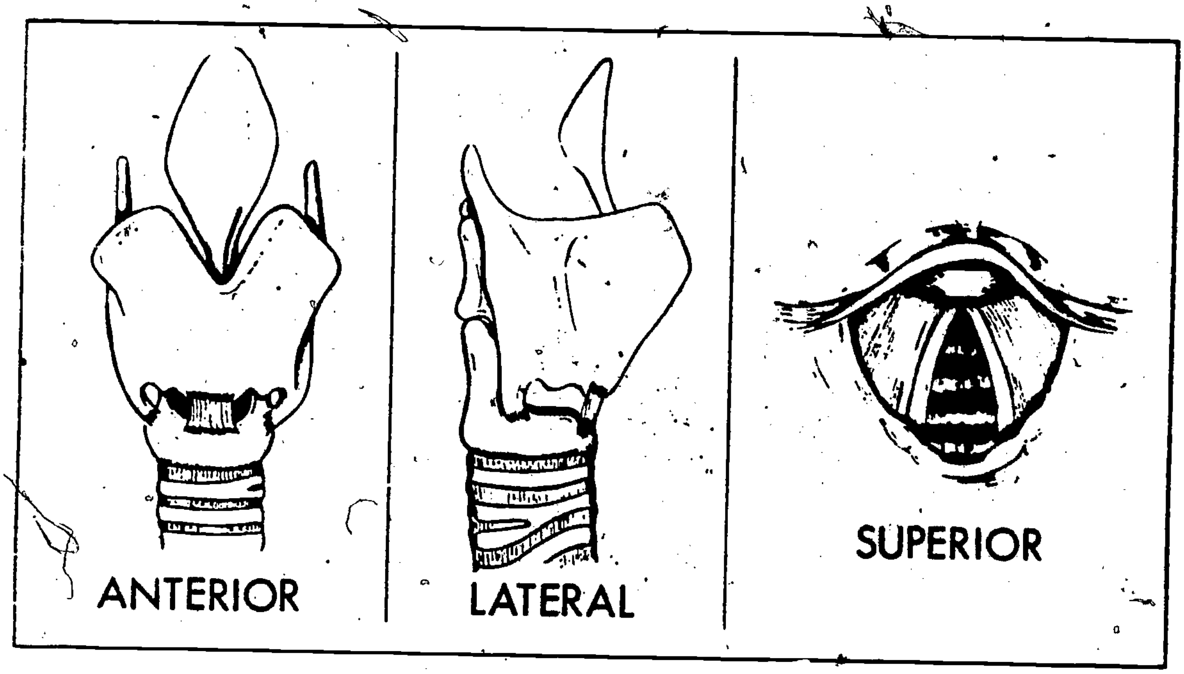


Figure 1

Label the following illustration as it is discussed

Figure 2

Label the following illustrations as they are discussed.



501

Figure 3

Label the following illustration as it is discussed

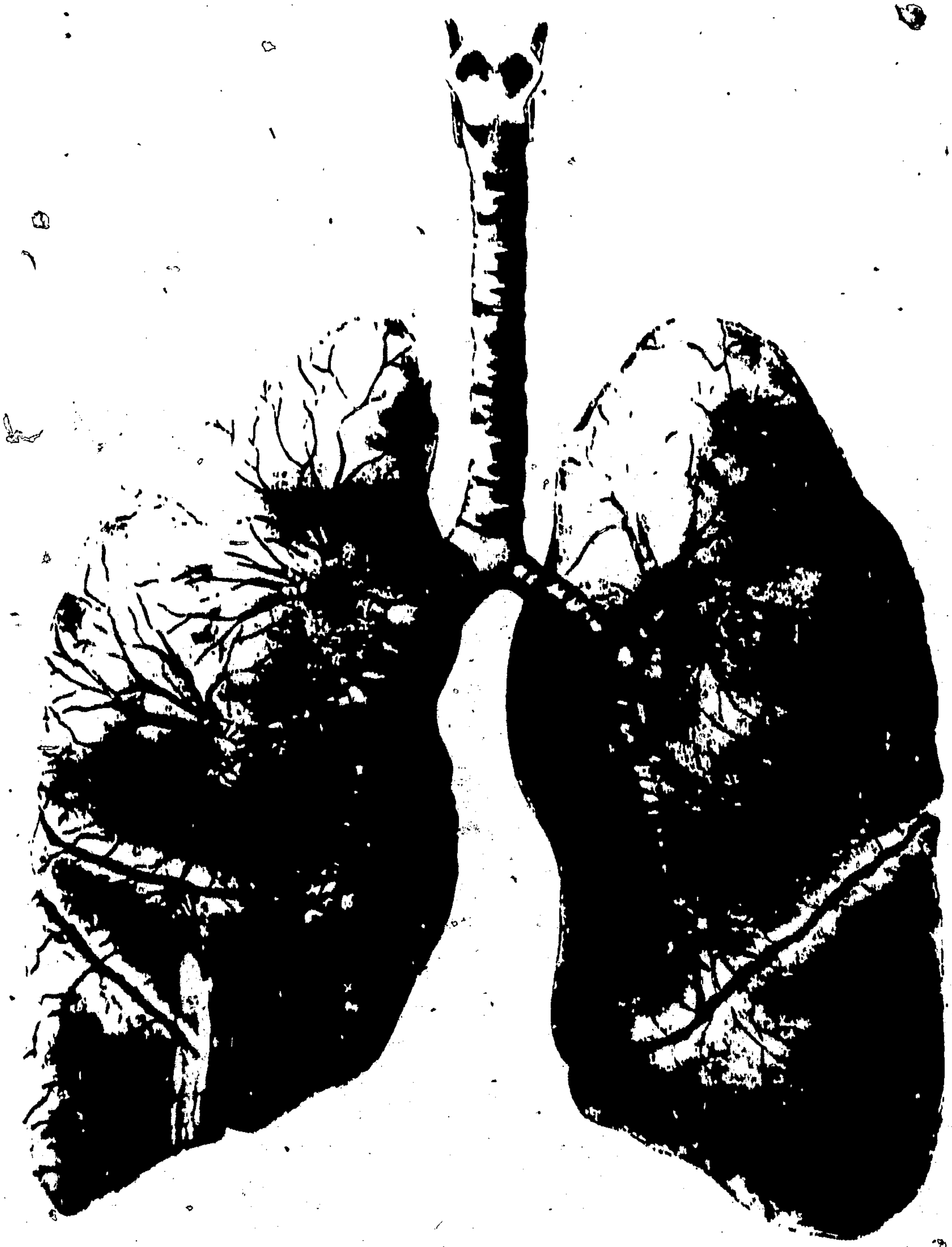


Figure 4

Label the following illustration as it is discussed

Figure 6

6

Label the following illustration as it is discussed.

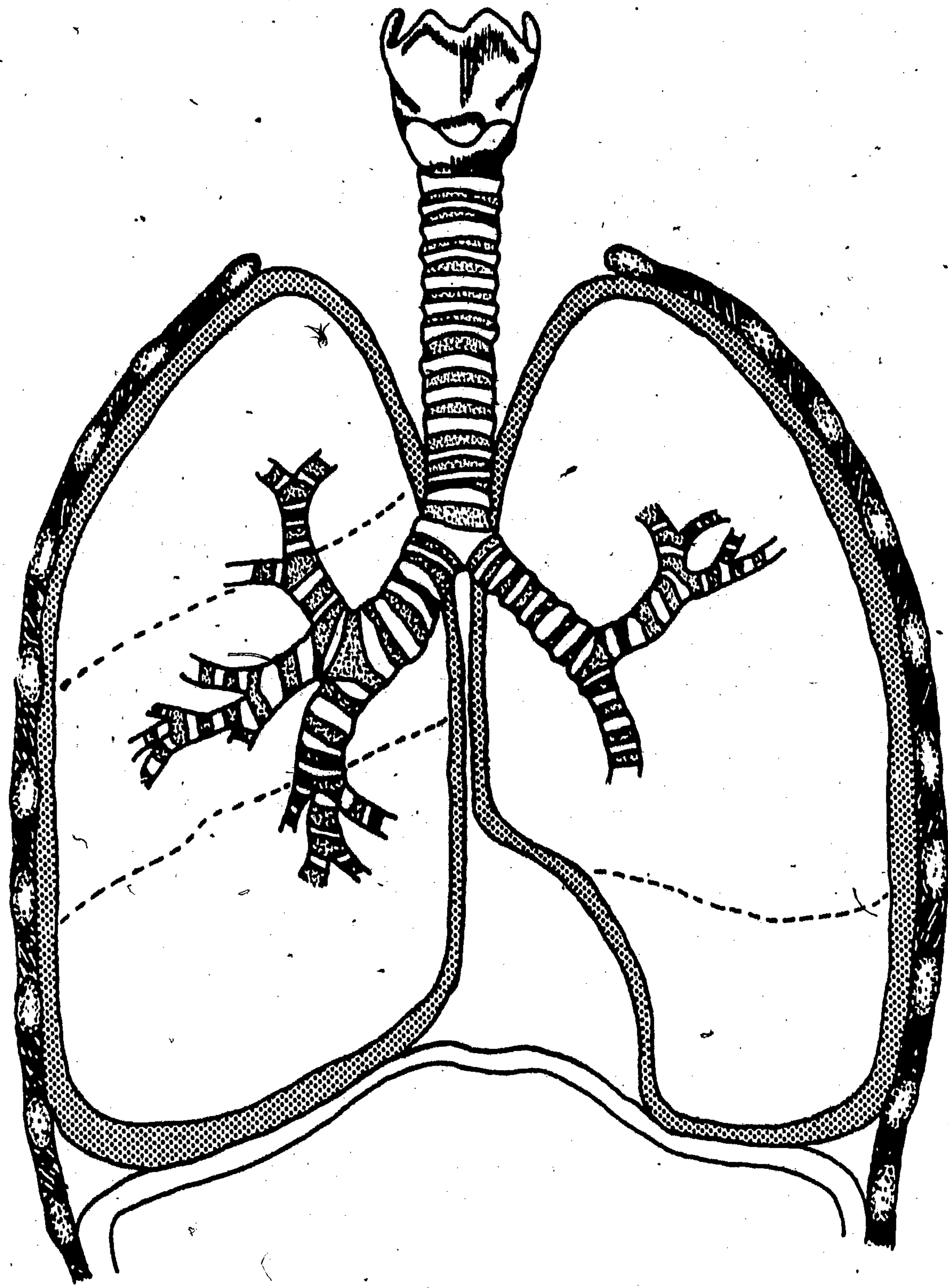


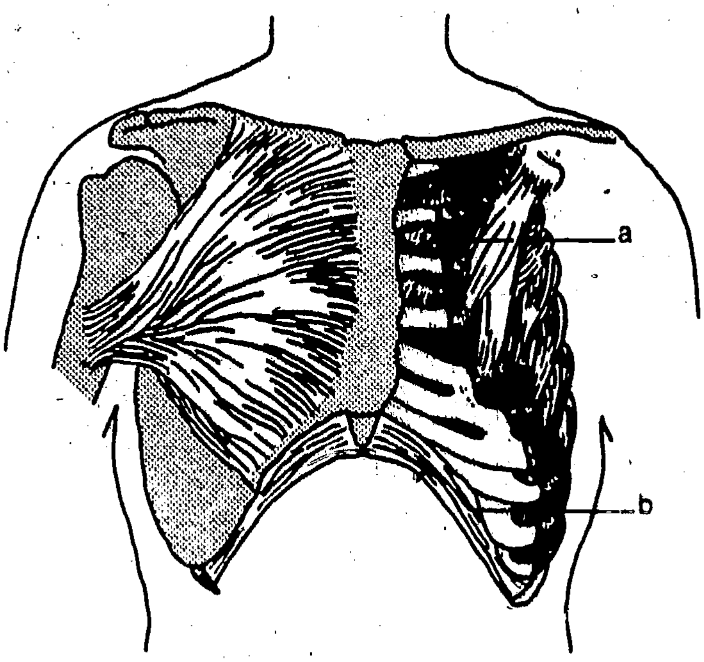
Figure 6

EXERCISE A.

1. Match each thoracic border in column A with its anatomical location from column B. Place the correct number in the blank.

A - Thoracic Border	B - Anatomical Location
___ a. Diaphragm	1. Posterior
___ b. First ribs	2. Lateral
___ c. Sternum	3. Inferior
___ d. Body of Ribs	4. Anterior
___ e. Vertebrae and Posterior ribs	5. Superior

2. Study the illustration below, then identify the area indicated. Write the correct name for each area or structure in the corresponding blank.



a. ______________ b. ______________

Figure 7

EXERCISE B.

1. Match the respiratory organ or structure in column A with its definition from column B. Place the correct number in the blank.

A - Organ/Structure	B - Definition
___a. Epiglottis	1. Divides the nasal cavity.
___b. Pharynx	2. Located posterior to the mouth, extending down to the level of the hyoid bone.
___c. Cilia	3. A slit-like structure which seals off the air passageway.
___d. Septum	4. Most inferior cartilage of the larynx.
___e. Nasopharynx	5. Filters the air as it passes through the nasal cavity.
___f. Cricoid	6. Lies below the upper edge of the epiglottis - opens into the larynx and esophagus.
___g. Thyroid cartilage	7. A flap-like structure - seals off the air passageway when swallowing food.
___h. Glottis	8. May be used as a radiographic landmark - lies at the level of C-4.
___i. Oral pharynx	9. Lies behind the nose and above the level of the soft palate - contains the opening for the eustachian tubes.
___j. Larynx	10. The "voice box".
___k. Laryngeal pharynx	11. The throat.

2. Study the illustration below, then identify the area indicated. Write the correct name for each area or structure in the corresponding blank.

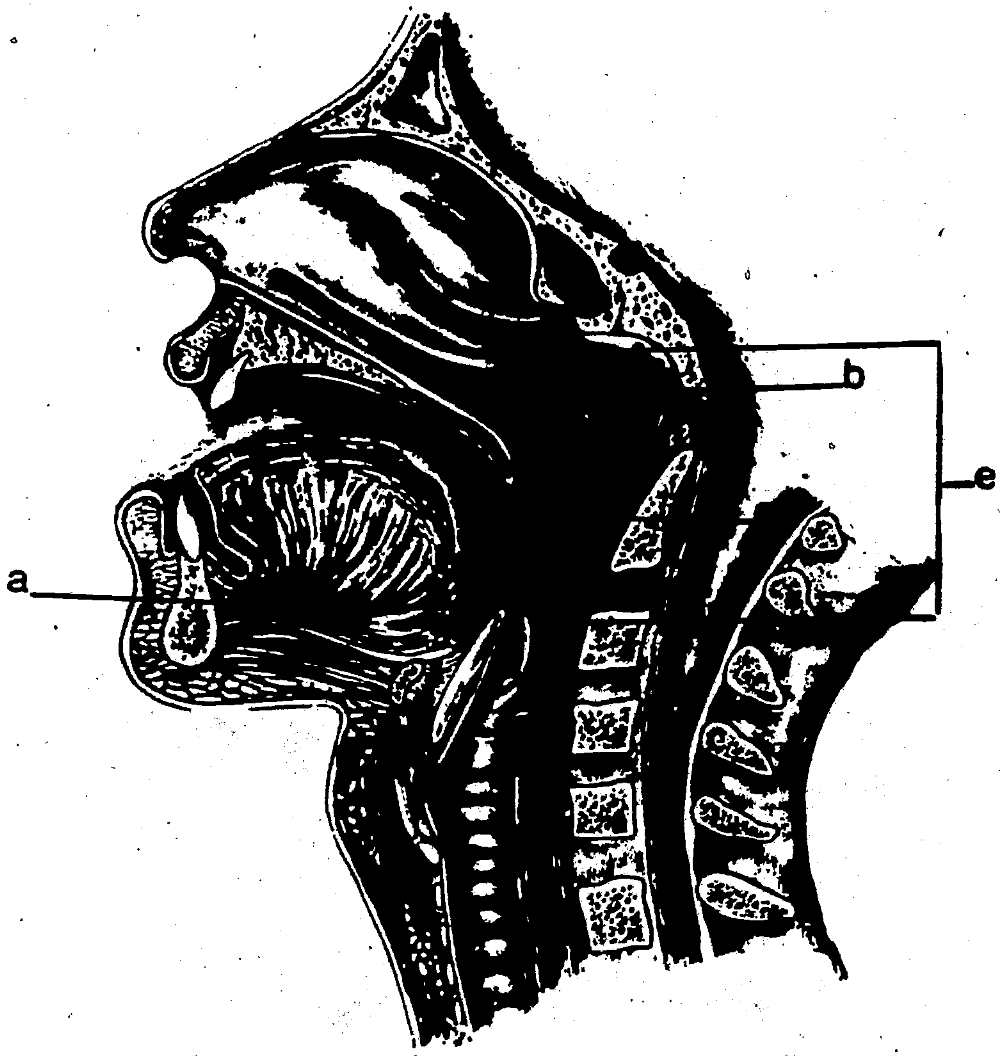


Figure 8

a. ____________ d. ____________

b. ____________ e. ____________

c. ____________

3. Study the illustrations below, then identify the area indicated. Write the correct name for each area or structure in the corresponding blank.

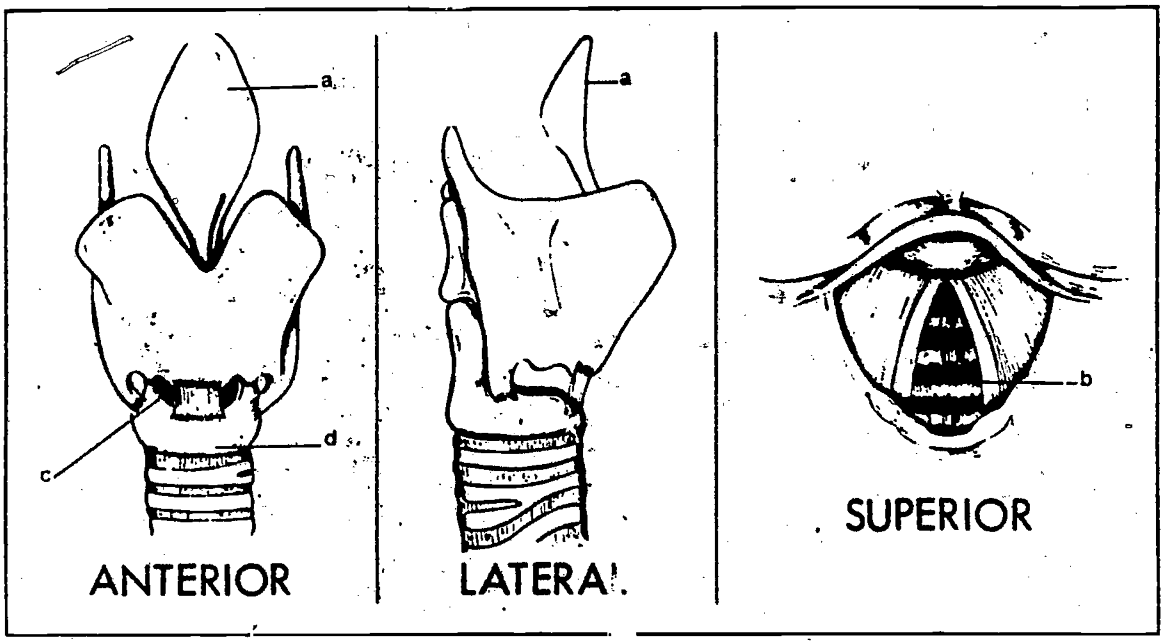


Figure 9

a. ____________________ c. ____________________

b. ____________________ d. ____________________

EXERCISE C.

1. Match each structure in column A with its descripton or definition from column B. Place the correct number in the blank.

A - Structure

___a. Hilum

___b. Trachea

___c. Right lung

___d. Bronchioles

___e. Alveolar sacs

___f. Secondary bronchi

___g. Right primary bronchus

___h. Left lung

B - Descripton/Definition

1. Has two lobes.
2. Has three lobes.
3. The functional units of lungs.
4. Made of "C" shaped cartilaginous rings.
5. An opening on the medial surface of the lungs.
6. Carries air into the lobes of the lungs.
7. Controls the amount of air which enters the alveolar sacs.
8. More vertical and larger in diameter than the left primary bronchus.

2. Study the illustration below, then identify the area indicated. Write the correct name for each area or structure in the corresponding blank.

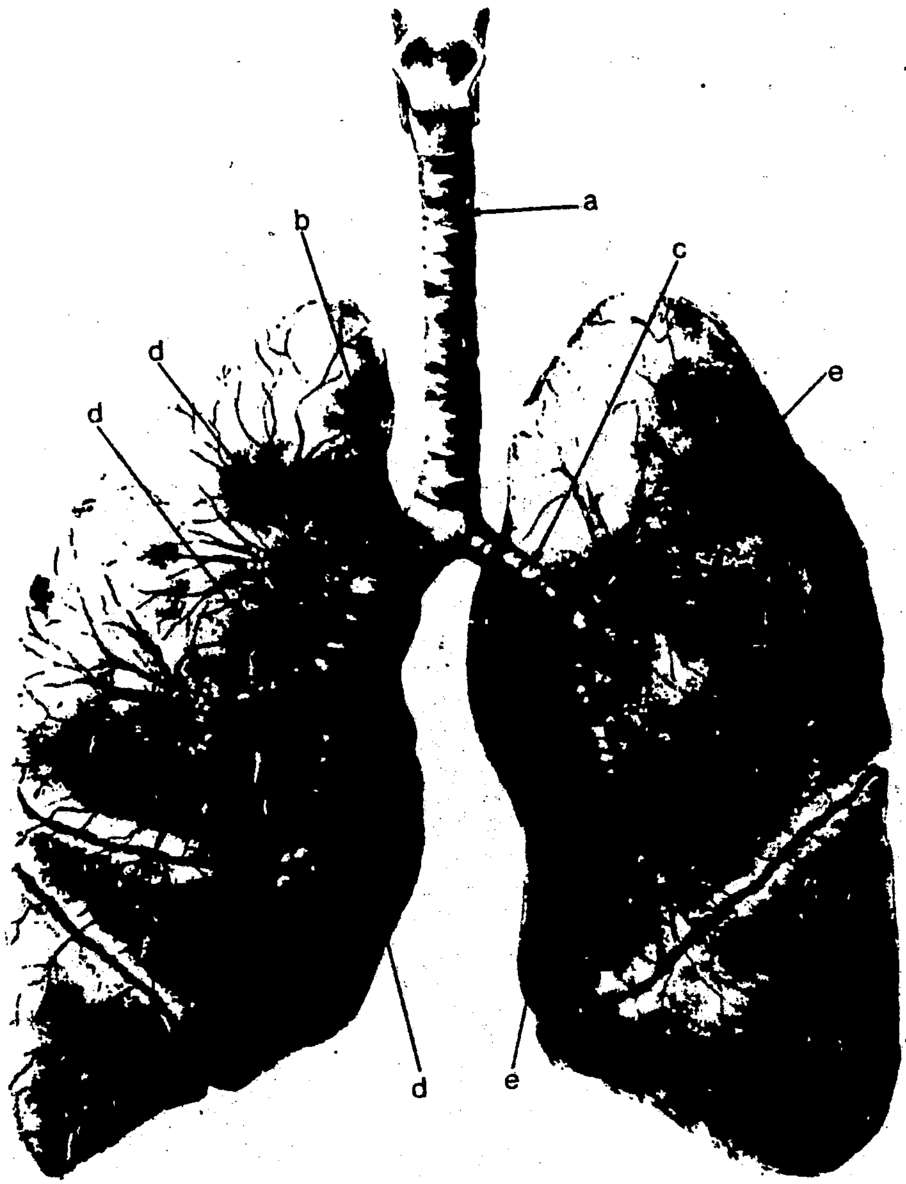


Figure 10

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

3. Study the illustration below, then identify the area indicated. Write the correct name for each area or structure in the corresponding blank.

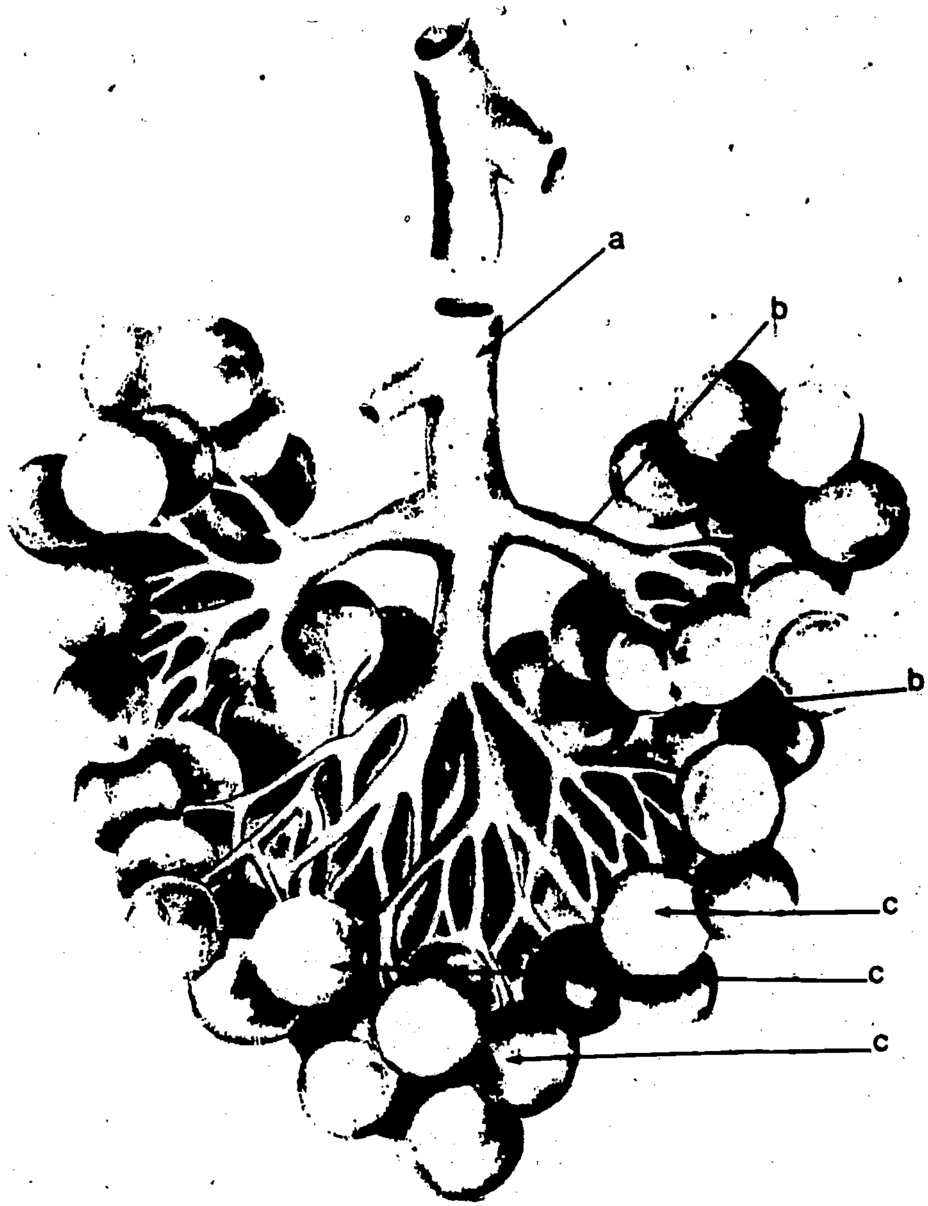


Figure 11

a. ____________ b. ____________ c. ____________

EXERCISE D.

1. Study the illustration below, then identify the area indicated. Write the correct name for the area or structure in the corresponding blank.

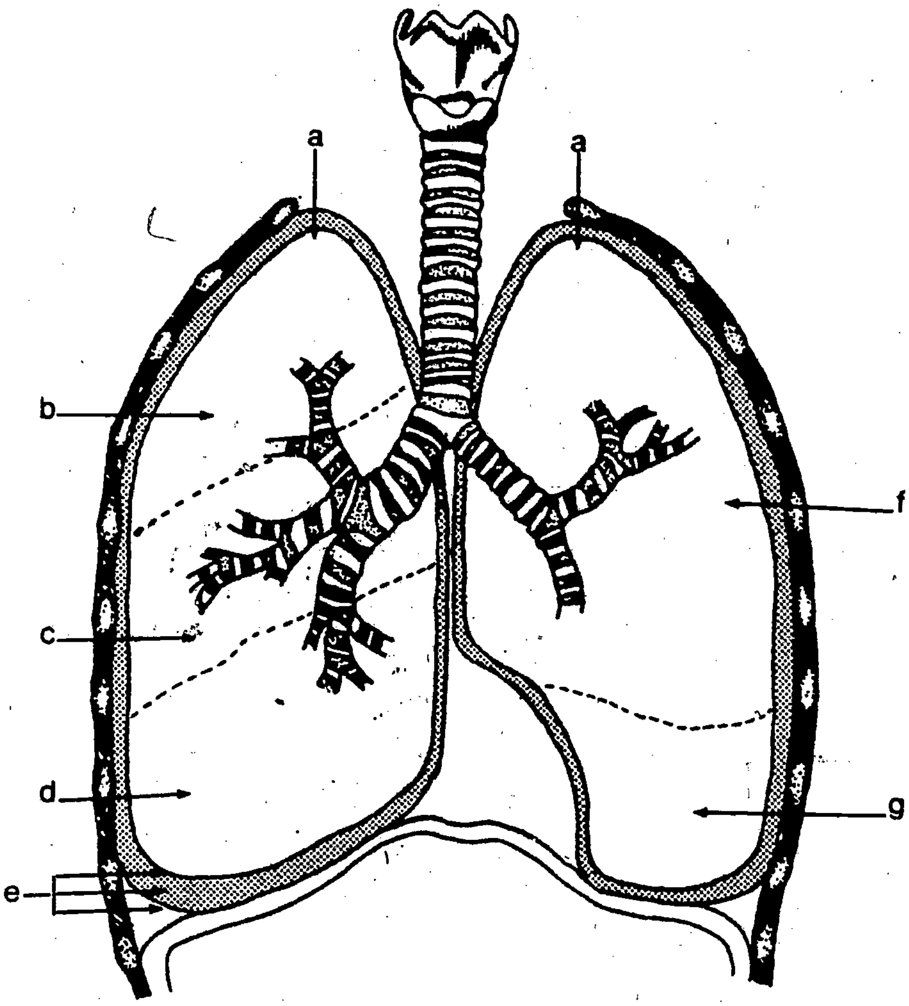


Figure 12

a. ____________ e. ____________

b. ____________ f. ____________

c. ____________ g. ____________

d. ____________

2. Complete the following statements.

   a. The exchange of gases across a semi-permeable membrane from an area of high concentration is called ________________.

   b. Internal respiration is the exchange of gases between the ________________ and ________________.

   c. External respiration is the exchange of gases between the ________________ and ________________.

   d. The double walled membrane which surrounds the lungs is called the ________________ membrane.

   e. The greater the amount of ________________ in the blood the faster and harder an individual breathes.

465

SUMMARY

THORACIC CAVITY - Houses the respiratory system and protects the respiratory and cardio-vascular organs such as the lungs, heart, great blood vessels, etc.

BOUNDARIES OF THE THORACIC CAVITY

Superiorly - first rib

Inferiorly - diaphragm

Anteriorly - sternum

Posteriorly - vertebrae and posterior ribs

Laterally - ribs

MUSCLES OF THE THORAX

<u>DIAPHRAGM</u> - When this dome-shaped muscle contracts, it flattens out, increasing the capacity of the lungs. The diaphragm is innervated (activated) by the phrenic nerve.

<u>INTERCOSTALS</u> - There are two sets of these muscles, the internal and the external, which lie between the ribs and aid in respiration. The intercostals are criss-crossed, with one set running in and down, and the other out and up. They expand the chest by lifting the thorax and are innervated by the 12 pairs of dorsal nerves which come off the thoracic region of the spinal cord.

<u>TOPOGRAPHICAL MUSCLES</u> - There are three muscles which may be activated during respiration. Because they do not initiate respiration, they are referred to as topographical.

1. PECTORALIS MAJOR (BREAST MUSCLE) - a large fan-shaped muscle which is attached to the humerus.
2. PECTORALIS MINOR - lies directly beneath the pectoralis major.
3. SERRATUS ANTERIOR - lies on the lateral aspect of the chest.

NOSE - In the nasal cavity, which is the point of origin of the respiratory system, the inspired air is warmed, filtered, and moistened.

<u>SEPTUM</u> - Divides the nasal cavity. It is lined with a highly vascular mucous membrane that secretes a thick, viscous fluid.

<u>CILIA</u> - Fine hairs in the nasal cavity which filter the air.

PARANASAL SINUSES - Located within the skull. They communicate directly with the nasal cavity and help to warm and moisten the inspired air.

PHARYNX (THROAT) - Air moves from the nose down into the pharynx. It is divided into three parts.

<u>NASOPHARYNX</u> - Lies behind the nose and above the level of the soft palate. It contains the openings for the Eustachian tubes which connect the middle ears with the throat.

<u>ORAL PHARYNX</u> - Portion of the pharynx located behind the mouth and extends down to the level of the hyoid bone. The palatine tonsils are found in this area.

<u>LARYNGEAL PHARYNX</u> - Lies below the upper edge of the epiglottis and opens into the larynx and esophagus.

LARYNX (VOICE BOX) - Made up of nine cartilages.

<u>EPIGLOTTIS</u> - A flap-like structure which seals off the air passageway while swallowing food.

<u>GLOTTIS</u> - A slit-like structure which is located deep in the larynx. Seals off the air passageway when a person holds his breath.

THYROID CARTILAGE - A shield-shaped cartilage with a "V" at the top which can be palpated. This largest cartilage of the larynx can be used as a landmark in radiographic positioning since it lies at approximately the level of C-4.

CRICOID - The most inferior cartilage of the larynx located about one-half inch below the thyroid cartilage. The cricothyroid foramen is located between the cricoid and thyroid cartilages. It can be used as a site of injection for a bronchogram.

TRACHEA (WINDPIPE) - Located just below the larynx and is about five inches long. It is made up of C-shaped cartilages which open posteriorly, allowing for expansion when food is swallowed. The trachea bifurcates when it reaches the lungs.

LUNGS - The right lung has three lobes and the left lung has two lobes. The lungs are cone-shaped and at birth they are normally pink in color.

HILUM - Opening at which all the tubes and vessels enter the lung.

APEX (PLEURAL APICES) - The top of a lung.

BASE - The lowest part of a lung.

PRIMARY BRONCHI - Through the left and right primary bronchi air enters the lungs. Foreign bodies are more likely to enter the right primary bronchus because it is larger and more vertical than the left.

SECONDARY BRONCHI - Take the inspired air into the lobes of the lungs.

TERTIARY (THIRD) BRONCHI - Passageways which take the inspired air into the segments of the lobes. Respiratory structures from the trachea to the tertiary bronchi are made up of a cartilage or cartilagenous rings designed to keep them from collapsing and blocking the airway.

BRONCHIOLES - Air passes from the tertiary bronchi down into the bronchioles which are made up of smooth muscle, not cartilage. They are made of muscle because by contracting or expanding, they control the amount of air which enters and leaves the alveolar sacs.

ALVEOLAR SACS - Are a group of alveoli which are the functional units of the lungs where the actual exchange of gases takes place between the lungs and the blood stream. A single alveoli is one cell thick and microscopic in size.

PLEURAL MEMBRANE - Covers the lungs and thoracic cage and secretes a thin, watery fluid to lubricate the lungs. It is made up of three major structures.

PARIETAL PLEURA - Lines the thoracic cage and and functions as a seal to keep air out of the thoracic cavity. If the parietal pleura were to be punctured, the lungs would collapse.

VISCERAL PLEURA - Surrounds the lungs themselves and functions to keep air within them.

PLEURAL CAVITY - Is the potential space between the parietal and visceral pleurae and contains a thin, watery fluid which lubricates the lungs. The fluid lubricates the pleurae to diminish friction.

RESPIRATORY SYSTEM - Function is to supply cells with oxygen and carry off carbon dioxide.

RESPIRATION - This term may be used to describe all the physiological activities concerned with the consumption of oxygen and the release of carbon dioxide.

INSPIRATION - Commonly called inhalation and is the phase of respiration when air enters the respiratory system. Inspiration is controlled by the brain, specifically the medulla oblongata, and by the amount of carbon dioxide (CO_2) in the blood stream.

EXPIRATION - Phase of respiration, also controlled by the brain, where the lungs are deflated and CO_2 is expired from the body.

EXTERNAL RESPIRATION - Refers to the exchange of gases between the alveolar sacs and the capillaries. The CO_2 goes to the alveolar sacs while the O_2 enters the blood stream. This process is called diffusion.

<u>DIFFUSION</u> - Process by which the exchange of gases takes place through a semi-permeable membrane. It is the equalization of gases as they move from an area of higher concentration to an area of lower concentration.

INTERNAL RESPIRATION - Refers to the exchange of gases between the body tissues and the capillaries. The CO_2 goes to the capillaries and the O_2 to the body cells. This is also accomplished through diffusion.

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Department of Medicine
School of Health Care Sciences
Sheppard Air Force Base, Texas

SW 3ALR91630-II-1C(4)

August 1973

PULMONARY MEDICINE

Gas Exchange and Transportation

1. Explain uniform and non-uniform alveolar ventilation. (See p. 60-65 of The Lung by Comroe, et al).

   a. Uniform ventilation.

   b. Non-uniform ventilation.

2. List four causes of uneven ventilation.

   a. Regional changes in elasticity.

   b. Regional obstruction (partial).

   c. Regional check valves.

d. Regional disturbances in expansion.

3. Delineate the effects of hypoventilation of the whole lung and uneven ventilation of parts of the lung.

a. Hypoventilation of whole lung.

b. Uneven ventilation to parts of it.

c. Prolongs induction period for inhalation anesthesia.

4. Explain what ventilation blood flows are and the five different categories of ratios.

$$\frac{V_a}{Q_c} \quad \begin{aligned} &= \text{alvelor ventilation (L/Min)} \\ &= \text{pulmonary capillary blood flow (L/Min)} \end{aligned}$$

a. General.

b. Types of categories.

(1) Uniform ventilation - uniform blood flow.

(2) Uniform ventilation - non-uniform blood flow.

(3) Non-uniform ventilation - uniform blood flow.

(4) Non-uniform ventilation - non-uniform blood flow, uncompensated.

(3) Non-uniform ventilation - non-uniform blood flow, compensated.

5. Define diffusion and list the factors determining diffusion of O_2 and CO_2 in the lung.

a. Definition.

b. Factors.

(1)

(2)

(3)

(4)

(5)

(6)

(7)

6. Describe the mechanism by which O_2 and CO_2 are exchanged between the lungs and the blood.

7. Describe how O_2 and CO_2 transported by the blood.

a. Oxyhemoglobin dissociation curve.

b. Blood oxygen saturation factors.

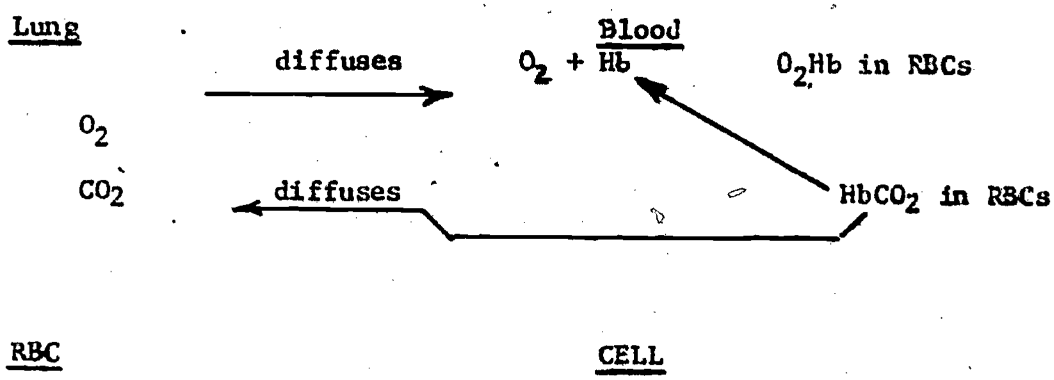
(1) pO_2

(2) pH

(3) Temperature

(4) Type of Hemoglobin (Hb)

c. Diffusion of CO_2



8. Describe the mechanism by which O_2 and CO_2 are exchanged by the blood and tissues. (Student will study drawing above copied from blackboard).

9. State the normal values for blood hemoglobin.

14-17 gm% - males
12-15 gm% - females

10. List the physiologic values for major respiratory gases in alveolar air, venous blood and arterial blood.

a. Symbols.

b. Venous blood.

c. Alveolar air.

SUMMARY: Uniform ventilation in the lungs insures complete and thorough resupply of oxygen plus adequate removal of carbon dioxide. Non-uniform or uneven ventilation can lead to hypoxemia and respiratory acidosis.

In addition to good lung ventilation, proper blood flow is required to insure the blood is oxygenated and CO_2 is removed. A foul up in blood flow can also cause hypoxia and acidosis.

Diffusion is important because it is the primary mechanism allowing exchange and transport of CO_2 and O_2. Proper diffusion is dependent on pressure gradients, solubility, area, distance traveled, molecular weight of the diffusing gas, temperature of the fluid through which the gas diffuses and the nature of the membrane through which the gas diffuses.

Oxygen is primarily transported in combination with hemoglobin in the red blood cell. The amount of oxygen in the blood can be altered by pO_2, temperature, the pH and type of hemoglobin. CO_2 is primarily transported as H_2CO_3 in the RBCs and the plasma. The major factor allowing diffusion of both O_2 or CO_2 is the pressure gradient.

10-6

47

Department of Medicine
School of Health Care Sciences, USAF (ATC)
Sheppard Air Force Base, Texas

Handout 3ALR91630-II-1c
June 1973

PULMONARY MEDICINE
CONTROL OF RESPIRATION

1. Define respiration and explain the function of the human respiratory system.

2. Delineate the parts of the human body involved in the control of respiration.

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478

3. List and explain the functions of the pneumotaxic center, the apneustic center, main respiratory center, and peripheral chemoreceptors.

527

4. Differentiate the responses of the peripheral versus the central chemoreceptors in response to changes inpH, CO_2, and O_2.

5. Explain how the Hering-Breuer reflexes work to effect breathing.

480

6. Define and explain the following types of breathing: eupnea, hypopnea, hyperpnea, bradypnea, tachypnea, Biots, Cheyne-Stokes, apnea, and apneustic.

523

481

Department of Medicine
School of Health Care Sciences
Sheppard AFB, Texas

STUDY GUIDE/WORKBOOK 3ALR91630-II-1c (3)
July 1973

Pulmonary Medicine
HYPERBARIC AND HYPOBARIC PHYSIOLOGY

1. Explain the significance of barometric pressure to the human body in a hypobaric and hyperbaric condition.

ALT (M')	PRESS (mmHg)	DEPTH (FT)	ATA	mmHg
100	8	Surface	1	760
63	47	33	2	1520
50	87	66	3	2280
18	380	99	4	3040
10	523	132	5	3800
SL	760	165	6	4560

1 ft. of sea water = 0.445 psig or 23 mmHg

1 psig = 51.7 mmHg

Supersedes SHO 3ALR91630-II-1, June 1973

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2. Explain why supplementary oxygen is needed above 10,000 feet altitude.

3. Specify the principles of how oxygen is supplied to aviators at altitude.

531

4. Delineate the principles of Oxygen High Pressure Therapy (OHP).

5. Explain how the Goodman Treatment Tables are used to treat specific disease entities.

533

SUMMARY

Our bodies are the result of years of development in evolution under a pressure of 14 PSI. As a result, it doesn't take much of a barometric pressure change to reach the limits of our adaptive powers. When pressure is decreased on our bodies, this is called the hypobaric condition; when pressure is increased above normal, this is called the hyperbaric condition.

As man ascends to altitude breathing air, the atmospheric pressure decreases and so does the partial pressure of oxygen. At 10,000 feet a safe minimum is reached in which the alveolar partial pressure of oxygen is 60 mmHg giving 87% blood oxygen saturation. To keep this blood oxygen saturation, oxygen regulators supply increasing concentrations of oxygen as altitude increases. Above 40,000 feet, 100% oxygen is supplied with positive pressure. Above 50,000 feet, pressure suits are used.

The majority of the oxygen our body tissues is transported by the hemoglobin of the red blood cells. Very little oxygen is carried in the plasma; however, under hyperbaric conditions 2.3 volumes percent of oxygen can be carried per atmosphere of increased pressure. Besides increasing the total amount of oxygen in the blood, hyperbaric therapy (OHP) can increase the diffusion distance of oxygen around capillaries if there is good blood perfusion of tissues.

The Goodman Treatment Tables are used to treat patients in hyperbaric chambers for such conditions as decompression sickness, gas gangrene, carbon monoxide poisoning, air embolisms, emphysema, open heart surgery, and cancer (enhances radiation therapy).

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Sheppard Air Force Base, Texas

SG 3ALR91630-II-1c(1)
August 1973

RESPIRATORY PHYSIOLOGY - PART I

1. List the muscles important in ventilation

    a. Quiet inspiration

        (1) Scaleni

        (2) Posterior serrati

        (3) Diaphragm

    b. Deep inspiration

        (1) Sternomastoid

        (2) All of above

    c. Deep expiration - muscles of abdominal wall

    d. Intercostal muscles

2. Function of ventilation muscles

    a. Diaphragm - contracts, increasing depth of pleural cavity.

    b. Scaleni and posterior serrati - contract and elevate ribs, increasing diameter of pleural cavity.

    c. Sternomastoid - contracts, elevates sternum, and increases diameter of pleural cavity.

    d. Abdominal muscles - pull ribs down, decreasing diameter, and force diaphragm up.

    e. Intercostal muscles - maintain rib spacing and transmit forces.

This SG supersedes SHO 3ALR91730 XII, dated May 1972

3. Pleural cavity function

   a. Volume increases and pressure falls.

   b. Subatmospheric at all times.

   c. Pleural cavity abosrbs fluid or gas.

4. Inspiration

   a. Muscles contract.

   b. Volume increases.

   c. Pressure falls.

   d. Lungs expand in response to falling pressure.

   e. Alveolar volume increases.

   f. Pressure falls below atmospheric, and air rushes in.

5. Expiration reverses this.

6. Parameters of pulmonary function.

   a. Tidal volume, volume of a normal breath. (500cc.)

      (1) 350cc goes to alveoli.

      (2) 150cc ventilates regions where no gas exchange occurs, thus this 150cc is called dead space.

   b. Inspiratory reserve volume (3000cc). Additional volume inhaled after a normal breath.

   c. Expiratory reserve volume (1100cc). Additional volume exhaled after a normal breath.

   d. Residual volume (1200cc). Amount which can't be forced out of lungs.

   e. Vital capacity (4600cc). Total gas exchanged in one maximal breath.

f. Functional residual capacity. Sum of residual volume and expiratory reserve volume.

g. Compliance = $\frac{\text{Volume increase}}{\text{Pressure change}}$

(1) Measure "stiffness" of lungs. (How difficult it is to inflate lungs)

(2) Two components - lungs and chest wall.

h. Airway resistance

$$\text{Resistance} = \frac{\text{Atmospheric Pressure} - \text{Alveolar Pressure}}{\text{Flow Rate}}$$

(1) FEV_1 = Forced Expiratory Volume

$$\frac{\text{Amount of vital capacity exhaled in one second}}{\text{Vital capacity}} \times 100 = FEV_1$$

(2) Percent of the vital capacity exhaled in one second.

(3) Measures resistance: 70% or greater is normal.

i. Maximum breathing capacity - maximum amount of air a patient can exchange per minute.

150-170 L/minute = normal

7. Energy cost of breathing

a. Work = pressure change X volume change.

b. Work a measure of energy expenditure:

(1) Expanding chest wall.

(2) Expanding lungs.

(3) Moving air against frictional resistance.

c. Any disease effecting above factors may increase work of breathing.

(1) Stiff chest wall in arthritis.

(2) Pulmonary edema/fibrosis.

(3) Bronchitis or other factors obstructing airways by narrowing airways.

8. List the components of the CNS respiratory system.

a. Medullary respiratory center.

(1) Floor of 4th ventricle.

(2) Mixture of inspiratory and expiratory neurons.

(a) Inspiratory tonically active.

(b) Expiratory - excited by peripheral nervous system.

(3) Alternate activity of expiratory and inspiratory neurons sets basic rhythmicity of breathing.

(4) Vagal sensory afferents inhibit the inspiratory neurons.

(a) When lungs are stretched, stretch receptors fire and inhibit inspiratory neurons.

(b) Termed Herring-Breuer reflex.

(5) Pneumotaxic center inhibits inspiratory neurons.

9. Describe humoral regulation

a. Chemosensitive regions in brainstem respond to increased hydrogen ion by increasing the rate and depth of ventilation.

b. Carotid, aortic bodies respond to falls in pO_2, increases in pCO_2 or falls in pH by stimulating the medullary respiratory center to increase the rate and depth of ventilation.

c. Medulla mechanism of response to CO_2.

(1) CO_2 crosses blood brain barrier.

(2) Hydrogen,and bicarbonate <u>DO NOT</u>.

(3) Carbonic anhydrase in brain converts CO_2 to hydrogen ion and bicarbonate ion.

(4) This increased hydrogen ion concentration then stimulates the medullary chemoreceptors to increase the rate and depth of ventilation.

Department of Medicine
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas

STUDY GUIDE 3ALR91630-II-1a(2)
February 1975

RESPIRATORY PHYSIOLOGY - PART II

OBJECTIVES

Using a segmental lung, student will identify the physiology of the lungs and respiratory system.

INTRODUCTION

An understanding of respiratory physiology is essential in the diagnosis and treatment of lung disorders.

INFORMATION

1. Describe the anatomy of the pleural cavity

a. Definition - the pleural cavities are the cavities in which the lungs rest.

(1) Right pleural cavity contains the right lung.

(2) Left pleural cavity contains the left lung.

b. Effectively "airtight," the pressure inside is subatmospheric.

(1) Isolated from outside air.

(2) Separated from air inside the lungs.

c. Line by parietal pleura.

(1) Thin membrane composed of one layer of flattened mesothelial cells, and connective tissue.

(2) Pair sensitive nerve endings are present.

d. Boundaries

(1) Floor is formed by the dome-shaped diaphragm.

(2) Roof is formed by skin and connective tissue.

(3) Posterior is formed by ribs and vertebrae.

(4) Anterior is formed by sternum and ribs.

(a) Sternum composed of manubrium and sternum proper.

(b) Hinge joint between manubrium and sternum which moves inducing breathing.

(5) Medial borders formed by the mediastinum.

(6) Lateral borders formed by ribs.

This supersedes SG 3ALR91630-II-1b, August 1973

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2. Describe the construction of the lungs.

a. Composed of alveoli mainly.

(1) Plastic, stretch, and shrink

(2) Thin, a single cell layer thick.

(3) Surrounded by capillaries.

(4) Lined by a thin fluid layer, otherwise they are dry.

b. Alveoli are in contact with the atmosphere, through a system of tubes.

(1) Through a network of bronchioles, bronchi, trachea, larynx, nose, and mouth.

(2) NOT in continuity with the pleural cavity.

c. Gas exchange between the lungs and the blood occurs in the functional unit called the respiratory lobule. It is composed of the following:

(1) Respiratory bronchioles - walls contain a few alveoli.

(2) Alveolar ducts - walls lined by alveoli.

(3) Alveolar sacs - regions into which many alveoli empty.

(4) Terminal bronchiole - note that no gas exchange occurs in this structure.

d. Nerves

(1) Elements of the sympathetic nervous system reach the lungs.

(2) No pain fibers innervate lung parenchyma or visceral pleura.

e. Divided into lobes - three right, two left.

f. Covered by visceral pleura.

(1) Identical to pariental pleura except it has no pain fibers.

(2) Visceral and parietal pleura are continuous with one another at the hilum of the lungs. The space between the visceral and parietal pleura is termed the pleural or intrapleural space.

DEPARTMENT OF MEDICINE

CARDIOPULMONARY LABORATORY SPECIALIST

GAS LAWS

April 1975

SCHOOL OF HEALTH CARE SCIENCES, USAF
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494

Department of Medicine
School of Health Care Sciences, USAF
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SW 3ALR91630-II-5
April 1975

GAS LAWS

OBJECTIVES

a. Using slide rule and calculator, student will solve problems in the lungs by using gas laws.

b. Student will use pertinent laws for particular lung problems.

INTRODUCTION

A basic understanding of Gas Laws is essential to the operation of a pulmonary lab. The solving of these problems is most often the difference in good and poor treatment of patients with lung problems.

INFORMATION

1. Define barometric pressure and explain how it is produced and measured.

2. Explain what is meant by partial pressure.

3. Define the term temperature and be able to express it in degrees absolute, degrees fahrenheit, and degrees centigrade (Celsius).

This supersedes SW 3ALR91630-II-4, July 73

543

4. Without reference, convert the temperature from one scale to another using the fahrenheit, centigrade, and Kelvin scales.

5. Without reference, explain what Avagadro's Law and Number are and how they apply to gases.

Element or Compound	Symbol	At.Wt.	Formula	Molec Wt.
Oxygen				
Carbon				
Carbon Dioxide				
Nitrogen				
Helium				

6. Without reference, define Dalton's Law and apply it to problems dealing with respiration.

7. Without reference, define Boyle's Law and apply it to problems in respiration.

8. Without reference, define Henry's Law and Graham's Law then apply these laws to respiratory diffusion.

a. Definitions

b. Solubility coefficient.

SCs for major gases (solubility in water at 37° C. and 760 mmHg.)

Nitrogen (N_2) - 0.012

Oxygen (O_2) - 0.024

Hydrogen (H_2) - 0.016

Carbon Dioxide (CO_2) - 0.592

Carbon Monoxide (CO) - 0.018

c. Comparing the diffusing capacity of one gas to another.

d. Clinical relevancy.

9. Without reference, define Charles' Law and apply it to problems in respiration.

10. Without reference, define Gay-Lussac's Law and apply it in solving a problem.

11. Without reference, solve a problem using a combination of Charles' Law, Gay-Lussac's Law, and Boyle's Law.

12. Without reference, define ATPS, BTPS, and STPD; then solve a problem requiring conversion of a given volume under specified conditions to ATPS, BTPS, and STPD.

a. ATPS - ambient temperature and pressure saturated with water vapor.

b. BTPS - body temperature and pressure saturated with water vapor.

c. STPD - standard temperature and pressure dry (0 C, 760 mmHg.)

$$V_{STPD} = V_1 \times \frac{273}{T+273} \times \frac{P_B - P_{H_2O}}{760}$$

13. Gas Laws Problems

a. Convert 98.6° F. to centigrade.

b. Convert your answer in question 1 to A°.

c. Convert 70° F. into A°.

d. Convert 10° C. to F°.

e. Given the following information in the table, fill in the missing information.

Element or Compound	Symbols	Atomic Wt.	Formula	Molecular Wt.
Water				
Carbon Monoxide				
Methane				
Nitrous Oxide				

f. Calculate the densities of 1 mole of the following mexture of gases at STP:

95% O_2 + 5% H_2O = ______________________ gms/L

100% O_2 = ______________________ gms/L

95% O_2 + 5% CO_2 = ______________________ gms/L

g. In a gas cylinder, the pressure reads 2200psig. This cylinder contains a 95% O and 5% CO_2 mixture. What is the PO_2 and the PCO_2?

h. A patient has just exhaled into a spirometer. After exhalation, the change of volume in the spirometer is 4.0 liters. The temperature of the gas under the bell is 25° C. and is saturated with water vapor. The temperature of the body is 37° C. and saturated with water vapor. Barometric pressure is 750 mmHg. (pH_2O at 25° C. is 24 mmHg; pH_2O at 37° C. is 47 mmHg). Correct the volume in the bell to BTPS.

i. Three (3) liters of exhalation was collected in a spirometer at 30° C. (pH_2O = 30 mmHg) and 755 mmHg. Correct the volume to ATPS, BTPS, and STPD.

14. **Gas Law Formulas**

a. Dalton's Law = $P_T = P_1 + P_2 + P_3 \ldots\ldots$

b. Boyle's Law = $\frac{V1}{V2} = \frac{P_2}{P_1}$ $V_1P_1 = V_2P_2$

$$V_2 = V_1 \frac{P_1}{P_2}$$

°F = (C° X 1.8) + 32

°C = (F° − 32) X 0.556

°K or °A = C° + 273

Henry's Law $= \frac{V_1}{V_2} = \frac{P_1}{P_2}$ $V_1P_2 = V_2P_1$

$V_2 = \frac{V_1}{V_2} P_1$

c. Diffusing Capacity $D_C = \frac{1}{\sqrt{\text{molec Wt}}}$

d. Graham's Law

e. Diffusing through a liquid $D_C = \frac{\text{sol. coef.}}{\sqrt{\text{molec wt.}}}$

f. Comparing Diffusion Capacities $\frac{D_x}{D_y} = \frac{(\text{Sol Co } x)\ (\sqrt{\text{mol wt y}})}{(\text{Sol Co y})\ (\sqrt{\text{mol wt x}})}$

g. Charles" Law $= \frac{V_1}{V_2} = \frac{T_1}{T_2}$ $V_1T_2 = V_2T_1$ $V_2 = \frac{T_2}{T_1} V_1$

h. Gay-Lussac's Law $= \frac{P_1}{P_2} = \frac{T_1}{T_2}$ $P_1T_2 = P_2 T_1$ $P_2 = P_1 \times \frac{T_2}{T_1}$

i. Combination $= V_2 = V_1 \times \frac{T}{T} \times \frac{P}{P}$

j. STPD $= V_{STPD} = V_1 \times \frac{273}{T+273} \times \frac{P_B - P_{H2}O}{760}$

k. ATPS $= V_{ATPS} = V_1 \times \frac{P_B - pH_2O}{P_B}$

l. BTPS $= V_{BTPS} = V_1 \times \frac{P_B - pH_2O}{P_B - pH_2O} \times \frac{T}{T} \frac{T_{AMD}}{T_{BODY}}$

54?

DEPARTMENT OF MEDICINE

CARDIOPULMONARY LABORATORY SPECIALIST

BASIC MATHEMATICS - FRACTIONS

April 1975

10-6

SCHOOL OF HEALTH CARE SCIENCES, USAF
SHEPPARD AIR FORCE BASE, TEXAS

Department of Medicine
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas

PT 3ALR91630-II-5c-(1)
April 1975

BASIC MATHEMATICS - FRACTIONS

OBJECTIVES

1. Define a fraction.

2. Identify the two parts of a given fraction and explain what each part shows.

3. Identify proper fractions, improper fractions, and mixed numbers from a given list.

4. Change a given list of improper fractions to mixed numbers and mixed numbers to improper fractions.

5. Reduce a list of fractions to their lowest terms.

6. Solve problems in addition and subtraction of fractions. Answers must be in lowest terms.

7. Solve problems in multiplication of fractions, cancelling where applicable. Answers must be in lowest terms.

8. Solve problems in division of fractions, cancelling where applicable. Answers must be in lowest terms.

NAME ______________________________

CLASS ______________________________

INTRODUCTION

In Pulmonary Medicine the solving of Gas Laws is often quite complex. By learning fractions, the complex problems are made easier.

INSTRUCTIONS

1. This is not a test. This is a learning situation. In this Programmed Lesson on fractions, you will be learning at your own speed.

2. Two types of programming are used in this lesson:

   a. LINEAR - In this portion, you will go from frame to frame using a provided cardboard to cover upcoming frames and answers. In each frame, you are given information and then a question to answer or a problem to solve. Your answer can be checked at the bottom of each question. "Peeking" is <u>not</u> an advantage. If you make an error, strike out your incorrect answer, reread the frame, and write the correct answer.

   b. SCRAMBLED - In this portion, you will be given problems to solve and asked to select the answer from a list of answers. Circle the answer you choose and go to the page as your answer directs. Follow directions closely. If you select an incorrect answer, do not erase, but put an "X" through the circle. Rework the problem again and circle another answer.

3. READ ALL INFORMATION CAREFULLY. BE SURE YOU UNDERSTAND WHAT IS SAID BEFORE YOU TRY TO ANSWER THE QUESTION. If you wish, you may turn back in the program for review at any time.

This supersedes PT 3ALR91630-I-5u(1), July 1973

INFORMATION

1. A fraction is a part of a whole. 3/4 is a fraction and therefore is a part of a ______.

//

whole

---

2. Part of a whole is the definition of a ______________________.

//

fraction

---

3. The definition of a fraction is stated as: ____________ of a ____________.

//

part whole

---

4. Define a fraction.

//

part of a whole

---

5. Fractions have two parts - a numerator (above the line) and a denominator (below the line).

Example: $\frac{3}{8}$ 3 - numerator, 8 - denominator

In the fraction $\frac{2}{3}$, the number 3 below the line is the ____________ and the number 2 above the line is the ________________.

//

denominator
numerator

---

6. All fractions have denominators and numerators. In the fractions $\frac{2}{3}$ and $\frac{11}{12}$, the 3 and 12 are ______________ and the 2 and 11 are ______________.

//

denominators

numerators

3A

Wrong! 12 x 3 = 36, but you must now do step 2. Add this product (36) to the numerator; retain the denominator to get the improper fraction. Go back to page , Frame , and select an select another answer.

3B

Nope! You will still have to go to lower terms. You reduced by dividing two into the numerator and denominator but you must now find a number to further reduce 21/27 and then you'll have it. Return to page 7F, select the other answer, and continue.

3C

2/5 is the correct answer.

Now try another problem. 3/8 - 2/3 = ____________

If your answer is:	Go to page:
1/4	9E
4 or 4/1	13C
9/16	13F

3D

Wrong! Multiplication and addition are correct but you msut place this sum over the denominator of the fraction. Return to page 12, Frame 29, and select another answer.

3E

Right! Now try this. Reduce 14/56 to its lowest term.

If your answer is:	Go to page:
1/4	5B
7/28	5D

3F

No! You forgot to obtain the reciprocal of the divisor (invert the divisor), before you multiplied. Go back to page 12, frame 29; review the procedure again, then rework the problem from frame again and select the correct answer.

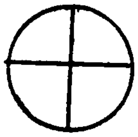
505

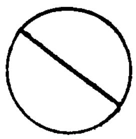
7. The denominator tells how many equal parts the whole has been divided into. In the fraction $\frac{9}{10}$, the denominator indicates the whole has been divided into _________ equal parts.

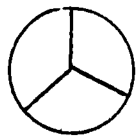
/ /

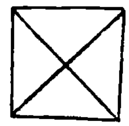
10

8. Under the figures below, write the number that would be used as the denominator of a fraction:


a. __________


b. __________


c. __________


d. __________

/ /

a. 4

b. 2

c. 3

d. 4

9. In the fraction below, circle the denominator and explain what it indicates.

$\frac{15}{16}$ ____

/ /

16 denominator Tells (indicates) how many parts the whole has been divided into.

10. The numerator (number above the line) of a fraction shows "how many parts of the whole are being considered." In the fraction $\frac{2}{3}$, the numerator indicates that ____ parts of the whole are being considered and the denominator indicates that the whole has divided into ________ equal parts.

/ /

2

3

11. In the fraction $\frac{13}{14}$, the number of parts being considered is __________ and the part of the fraction that tells us this is called the ______________.

/ /

13

numerator

506

5A

Correct. Now change 15 1/5 to an improper fraction.

If your answer is:	Go to page:
76/5	5C
75/5	5E

5B

Good! You might have started with dividing by two (2) and doing several steps, but 14 divides into 14 and 56 evenly. To reduce an improper fraction such as 8/4 or 9/5, you simply divide the denominator into the numerator. Reduce 9/5 into its lowest terms.

If your answer is:	Go to page:
9/5	5F
1 4/5	7B

5C

Right! 76/5 is correct. You can check your answers by changing the improper fraction back to the mixed number. Change 7 1/4 to an improper fraction and check your answer.

7 1/4 = ______________ = ______________
(improper fraction) (mixed number)

Go to page 14, frame 30, check your answer and continue from there.

5D

You reduced - but not to the lowest terms. Return to page 3E and find the number that will reduce the 7/28 and then you'll have the correct answer that will allow you to continue.

5E

Wrong! You forgot to add the numerator to the product of the whole number times the denominator. If you now see your error, go back to page 5A and select the other answer and follow directions. If you need the rule again, return to page 12, Frame 28, and start again from there.

5F

No. . . To reduce an improper fraction, you simply change it to a whole number or to a whole number and a fraction (mixed number) by dividing the numerator by the denominator. Now go back to page 5B and reduce properly.

5G

Negative. You have simply added numerators, retained highest denominator, and reduced. You must change to equivalent fractions. Reread rule on page 16, Frame 39, and rework problem from page 18, Frame 43, again.

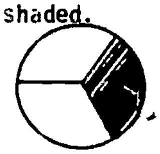
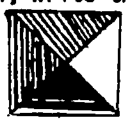
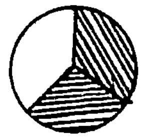
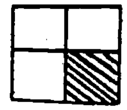
12. The number of parts being considered is indicated by the __________ of a fraction.

/ /

numerator

---

13. Under the figures below, write the fractions. The number of parts being considered are shaded.

a. ______________ b. ______________ c. ______________ d. ______________

/ /

a. $\frac{1}{3}$ b. $\frac{3}{4}$ c. $\frac{2}{3}$ d. $\frac{1}{4}$

---

14. In the fraction below, write what each number is called and what it indicates: $\frac{6}{7}$.

6 - ____

7 - ____

/ /

6 numerator, indicates how many parts of the whole are being considered.

7 denominator, indicates how many equal parts the whole has been divided into.

---

15. There are three types of common fractions - proper, improper, and mixed numbers. The three types of common fractions are mixed numbers, ______________ and ______________ fractions.

/ /

proper

improper

(either order)

---

16. The difference between proper and improper fractions is the size of the numerator. The numerator of an improper fraction is always the same as or larger than the denominator; therefore, in a proper fraction, the numerator is ______________ than the denominator.

/ /

smaller

(less than)

7A

No! 2/4 can be reduced to 1/2 by dividing two (2) into both the numerator and denominator. Remember the rule, a fraction is in its lowest terms only when the number one (1) is the only number that divides evenly into both the numerator and denominator. Return to page 14, Frame 31, and select the correct answer.

7B

1 4/5 is correct. If we ask you to reduce the fraction 8/4, would you answer 2? You would have been correct there,too. Now turn to top of page 14, Frame 32, and continue the program.

7C

No. You've added numerators but have not changed fractions to equivalent fractions. Read rule again on page 17, Frame 40, then rework problem on page 17, Frame 43. Select another answer.

7D

Wrong! 6/9 can be further reduced. Three (3) is the largest number that divides evenly into both the numerator (6) and the denominator (9). 6/9, then, reduced to lowest possible terms, is 2/3. Now return to page 14, Frame 32, and select the correct answer.

7E

Right! 1 1/4 is the correct answer. Try another, reduce to lowest terms.

Add 1/2 + 1/2 + 4/5 + 3/20 = ______________

If your answer is:	Go to page:
1 9/10	90
1 19/20	9G

7F

3/7 is correct. One (1) is the only number that divides evenly into both 3 and 7. Let's try a larger fraction. Reduce 42/54 to its lowest terms.

If your answer is:	Go to page:
21/27	3B
7/9	3E

---

17. $\frac{7}{8}$ is a proper fraction because the __________ is __________ than the denominator.

/ /

numerator

smaller (less)

---

18. $\frac{8}{7}$ and $\frac{8}{8}$ are improper fractions because the __________ are __________ than the denominators.

/ /

numerators

are same as or greater (are the same as or larger)

---

19. In the list below, place a "P" by the proper fractions and "I" by the improper fractions.

a. $\frac{12}{17}$ b. $\frac{9}{7}$ c. $\frac{4}{5}$ d. $\frac{12}{12}$

/ /

20. A mixed number is a whole number combined with a proper fraction. 3 5/6 is a whole number (3) and a proper fraction (5)/(6); therefore, 3 5/6 is a __________.

/ /

a. P b. I c. P d. I

---

21. To review definitions, match the following types of fractions with the correct statement or statements by writing the letter of the statement by the number of the fraction. All letters are to be used.

1. Proper fraction
2. Mixed number
3. Improper fraction

A. Numerator greater than the denominator
B. Numerator less than the denominator
C. Whole number and a proper fraction
D. Numerator equal to denominator

/ /

B. 1.

C. 2.

D,A 3.

510

9A

No. Not quite. Your addition is correct but you must have overlooked the "reduce answers to lowest terms." Go back to page 18, Frame 43, reduce, and pick the correct answer.

9B

6/15 is wrong. You borrowed one (1) from 16, which gave you the fraction 15/15, but now you must add 15/15 + 8/15, then do your subtraction. Return to page 9F, rework the problem, and select another answer.

9C

You have the correct fraction but made a mistake in the addition of whole numbers. Now return to page 11C and work the problem again. Do not just pick the other answer without first reworking the problem to find your error.

9D

Incorrect. You've made a mistake someplace in changing fractions to equivalent fractions of the same denominator. Return to page 16, Frame 39, reread the rule, then go back to page 7E and choose the other answer.

9E

1/4 is wrong. You did not obtain the reciprocal of the divisor. 2/3 inverted is 3/2 and the reciprocal of 2/3 is also 3/2. Go back to page 3C, rework the problem, and select the correct answer.

9F

Very good. Work the following problem by subtracting mixed numbers. Reduce to lowest term. 16 8/15 - 15 3/5 = ________________.

If your answer is:	Go to page:
1 14/15	11B
14/15	11D
6/15	9B
can't be solved	13D

9G

Good. 1 19/20 is correct. Now try one on subtraction and reduce answer to lowest terms.

4/13 - 3/39 = ____________________.

If your answer is:	Go to page:
3/13	11C
3/39	15E

22. In the list below, place a "P" by the proper fractions, an "I" by the improper fractions, and an "M" by the mixed numbers.

a. 3 1/2 e. 22/29

b. 9/5 f. 7/7

c. 12 2/3 g. 79/75

d. 3/4

/ /

a. M b. I c. M d. P e. P f. I g. I

---

23. An improper fraction can be changed to a mixed number by dividing the denominator into the numerator. The fraction 21/10 can be changed to a mixed number by dividing the numerator ______ by ______ the denominator.
(number) (number)

/ /

21

10

---

24. To change the improper fraction 21/10 to a mixed number, follow two steps: (1) Divide the numerator by the denominator to get the whole number:

$$\begin{array}{r l} 2 & \text{the whole number} \\ 10\overline{)21} & \\ \underline{20} & \\ 1 & \text{the remainder} \end{array}$$

(2) Place the remainder over the denominator to get the proper fraction: 1/10 the proper fraction.

Then 21/10 = ______________
(mixed number)

/ /

2 1/10

---

25. Now change the improper fraction 26/5 to a mixed number. Show your work.

$\overline{)\quad\quad}$ ______________
(mixed number)

/ /

$$\begin{array}{r} 5 \\ \overline{)26} \\ \underline{25} \\ 1 \end{array}$$

5 1/5
(mixed number)

11A

No. 6 29/36 is incorrect. Again you forgot to invert the divisor. The divisor 1 1/6 is changed to 7/6 and inverted is 6/7. Now go back to page 13F and select another answer.

11B

You've forgotten the rule on borrowing.

16 8/15	=	16 8/15	=	15 23/15
- 15 3/5	=	15 9/15	=	15 9/15

You cannot subtract 9/15 from 8/15, so you have to borrow a whole number (1). 1 = 15/15, which you now add to the 8/15. Don't forget now that you borrowed a whole number from 16. Go back to page 9F. Rework the problem and select the correct answer.

11C

Good. Now for the rule for adding and subtracting mixed numbers:

1. Change fractions to <u>like</u> fractions (LCD). 2. Add/subtract the fractions. 3. Add/subtract the whole numbers. 4. Reduce answers to lowest terms. Example: 1 1/3 + 3 11/12 and 7 1/2 - 4 1/5.

1 1/3	=	1 4/12		7 1/2	=	7 5/10
+ 3 11/12	=	3 11/12		- 4 1/5	=	4 2/10
		4 15/12 = 4 + 1 3/12 = 5 1/4				3 3/10

Now add these fractions: 7 1/9 + 6 5/8 + 1/6 = __________.

If your answer is:	Go to page:
14 5/9	9C
13 5/9	9F

11D

Very good. The idea here was to see if you remember how to borrow. Solve the addition and subtraction problems below. Answers must be in lowest terms.

a. 1/21 + 4/7 + 2/3 =

b. 3 3/8 - 2 1/4 =

c. 11 1/8 + 1 3/16 + 1/2 + 3/4 =

d. 14 1/6 - 12 5/12 =

Go to page 19, Frame 44, to check answers and continue from there.

---

26. Try another. Change 54/11 to a mixed number.

/______ = ____________.

//

4 10/11 -- If you missed this one, reread and rework Frames 22 through 26, then continue.

---

27. An improper fraction can be changed to a mixed number. So can a <u>mixed number be changed to an improper fraction</u>. Therefore, an improper fraction is <u>interchangeable</u> with a ____________ number.

//

mixed

---

28. Changing mixed numbers to improper fractions requires three steps: Example: Change 4 3/5 to an improper fraction.

<u>Step</u>

(1) Multiply the whole number by the denominator of the fraction. 4 x 5 = 20

(2) Add the product to the numerator. 20 + 3 = 23.

(3) Place the sum over the denominator of the fraction.

Then 4 3/5 = ____________
(improper fraction)

//

23/5

---

29. Change 12 2/3 to an improper fraction.

If your answer is:	Go to page:
36/3	3A
38/2	3D
38/3	5A

If you came to this frame directly from the previous frame, you have not followed the directions given in the previous frame. From this point (unless otherwise directed) in the lesson, you will proceed by the scrambled method. <u>Do Not</u> read the frames in sequence, but after selecting an answer, refer to the proper page <u>or</u> frame as directed. Return to page , Frame , check your answer, and refer to the page as directed.

13A

5 is the correct answer. Try one more. 5 4/7 ÷ 3 =

If your answer is:	Go to page:
1 6/7	15B
16 5/7	15C
13/7	13E

13B

Not quite. 35/7 is an improper fraction and for the answer to be completely correct (lowest terms), you must now change your answer to a mixed number. Return to page 13F recheck your work, and reduce answer to lowest terms.

13C

4 or 4/1 is incorrect. You obtained the reciprocal of the dividend. You're to obtain the reciprocal of the divisor and then proceed as in multiplication. Now go to page 3C, rework the problem, and select the correct answer.

13D

You've forgotten the rule on borrowing. True, you can't subtract 15 from 16 8/15 unless you borrow. Why not take one (1) from 16 and add the fraction 15/15 to 8/15? Now you can subtract, but don't forget the one (1) you borrowed. Go back to page 20A, rework the problem, and select another answer.

13E

13/7 is unacceptable, because answers will always be reduced to their lowest terms. Return to page 13A and select the correct answer that is in its lowest terms.

13F

9/16 is correct. Dividing with mixed numbers requires three steps: (1) Change the mixed number or mixed numbers to improper fractions. (2) Obtain the reciprocal of the divisor (invert divisor). (3) Multiply the dividend by the reciprocal of the divisor. Try this problem:

5 5/6 ÷ 1 1/6 =

If your answer is:	Go to page:
5	13A
6 29/36	11A
35/37	13B

515

30. You came from page 5C.

7 1/4 = 29/4

29/4 = 7 1/4

- -

Change each of the following improper fractions to mixed numbers and the mixed numbers to improper fractions:

a. 1 4/9 b. 21/8 c. 10 11/12 d. 49/3

/ /

a. 13/9 b. 2 5/8 c. 131/12 d. 16 1/3

---

31. A fraction is in its lowest terms when the number one (1) is the only number that divides evenly into both the numerator and the denominator. (NOTE: Dividing both the numerator and denominator by the same number does not change the value of the fraction.) Select the fraction below that is in its lowest terms.

If your answer is:	Go to page:
2/4	7A
6/9	7D
3/7	7F

---

32. You came from page 7B.

- -

Reduce each of the following fractions to lowest terms:

a. 12/4 = b. 21/49 = c. 64/72 = d. 17/51 =

/ /

a. 3 or 3/1 b. 3/7 c. 8/9 d. 1/3

---

33. To add or subtract fractions, they must be like fractions. Like fractions have the same number for a denominator. 7/12 + 5/12 or 7/12 - 5/12 are like fractions because they have the same number for a ________________.

/ /

denominator

---

34. Fractions must have like (common) denominators before you can ____________ or ____________ them.

/ /

add subtract (any order)

15A

Not quite right. You must not have cancelled the 3s after obtaining the reciprocal of the divisor and you haven't reduced to the lowest terms. Go back to page 21, frame 59, and correct your mistake. Then select the correct answer.

15B

1 6/7 is correct. Divide the following fractions and reduce answers to lowest terms:

a. 5/8 ÷ 3/4 =

b. 22 ÷ 6 7/8 =

c. 2 1/6 ÷ 4 1/2 =

d. 8/21 ÷ 3 3/7 =

Check answers on page 15D

15C

No! Does it sound reasonable that 3 is contained in 5 4/7 - - - 16 and 5/7 times? You forgot to obtain the reciprocal of the divisor before you multiplied. Go back to page 13A, invert the divisor, multiply, and then select the correct answer.

15D

Answers from page 15B: a. 5/6 b. 3 1/5 c. 13/27 d. 1/9

If you had any answers other than those above, you must rework the problems on page 15B. When you've gotten all correct, solve these problems:

a. 5 2/3 ÷ 9 5/9 =

b. 5 2/5 x 2 1/4 x 4 2/3 =

c. 21 1/16 + 9 3/8 + 8 1/2 + 3/4 =

d. 3 3/16 - 1 3/4 =

Check answers on page 15F

15E

Never! The only way you could have arrived at this answer was to have reduced the numerator and not the denominator. Return to page 9G, work the problem again, and select the correct answer.

15F

Answers from page 15D : a. 51/86 b. 56 7/10 c. 39 11/16 d. 1 7/16

If you missed any problem, you must rework and recheck. After all problems are correct, read the rules again that are on the pages listed below and then go to page 17A.

Problem:	Go to page:
a. Division	13F
b. Multiplication	20, Frame 55
c. Addition	11C
d. Subtraction and Borrowing	11B

After you've read the rules again, go to page 21, frame 60.

35. When fractions have common denominators, you add or subtract numerators and retain the common denominator.

Example: 7/12 + 5/12 = 12/12 reduced = 1

Then 7/12 - 5/12 = ______________ reduced = ______________.

/ /

2/12 1/6

---

36. Before fractions with unlike denominators can be added or subtracted, they must be changed to their lowest common denominator (LCD). LCD is the lowest number that is divisable by each denominator. Example: 2/5 + 1/20 or 2/5 - 1/20.

The lowest number divisible by each denominator is 20; therefore, 20 is the __________.

/ /

least or lowest common denominator or (LCD)

---

37. Again, the lowest number divisible by each denominator of fractions to be added or subtracted is called the ______________.

/ /

LCD

---

38. Determine the lowest common denominator (LCD) for these fractions:

1/2 + 1/4, the LCD is ______________.

2/7 - 1/42, the LCD is ______________.

/ /

4

42

---

39. After the LCD has been determined, change all fractions to equivalent fractions of the same denominator; then add or subtract. Example: 2/7 + 1/42, the LCD is 42. To change 2/7 to LCD 42: Divide 7 into 42; the quotient is 6. Multiply 6 by the numerator 2 and place the product (12) over the LCD. 2/7 = 12/42. Now we can add. 12/42 + 1/42 = 13/42 reduced is 13/42. Change the fractions below so they have the same LCD.

a. 1/3 + 5/6 + 1/12 = ______________ + ______________ + ______________

b. 4/5 - 1/3 = ______________ - ______________

/ /

a. 4/12 + 10/12 + 1/12

b. 12/15 - 5/15

---

40. Find the LCD for the fractions below:

a. 5/8 + 1/16 + 1/4, the LCD is ______________.

b. 4/7 - 1/49, the LCD is ______________.

/ /

a. 16

b. 49

---

41. Find the LCD and change the fractions below to equivalent fractions.

a. 1/9 + 1/81 + 2/3 = ____________ + ____________ + ____________

b. 4/5 - 5/8 = ______________ - ______________

/ /

a. 9/81 + 1/81 + 54/81

b. 32/40 - 25/40

---

42. The rule again for adding and subtracting fractions. (1) Change fractions to common denominators. (2) Add or subtract numerators. (3) Keep common denominator. (4) Reduce answers to lowest terms. Above and below are the LCD problems from the last frame. Complete the problems.

a. 9/81 + 1/81 + 54/81 = ______________ reduced ______________

b. 32/40 - 25/40 = ______________ reduced ______________

/ /

64/81 reduced is 64/81

7/40 reduced is 7/40

---

43. Does it all come back to you now? Solve this problem and reduce answer to lowest terms.

1/28 + 6/7 + 5/14 = ______________________

If your answer is:	Go to page:
1 1/4	7E
1 7/28	9A
12/28	7C
3/7	5G

---

44. You came from 11D.

a. 1 2/7 b. 1 1/8 c. 13 9/16 d. 1 3/4

- -

When multiplying two or more fractions, multiply numerators of the fractions to obtain numerator of the product. To obtain the numerator of the product in the problem 2/3 x 2/3, multiply ________ (number) times ________ (number).

/ /

2

2

---

45. Like the numerator, the denominator of the product is obtained by multiplying the denominators of the fractions. In the problem 2/3 x 4/5, the numerator of the product is obtained by multiplying ________ times ________ and the denominator is obtained by multiplying ________ times ________.

/ /

2 x 4

3 x 5

---

46. The rule, then, for multiplying fractions is: "Multiply numerators of the fractions to obtain the ________ of the product and multiply the denominators to obtain the ________ of the product." Solve this problem:

2/3 x 2/5 =

/ /

numerator

denominator

4/15

---

47. The word "of" is sometimes used in place of the multiplication sign"x". 2/3 of 15 = 10 can be written as 2/3 x 15/1 = 30/3 = 10. Solve this problem and reduce:

5/8 of 40 = ________ reduced ________

/ /

$\frac{200}{8}$

reduced = 25

520

48. If the problem contains more than two fractions, multiply all the numerators and multiply all the denominators. Example: 2/5 x 1/3 x 2/3 x 1/4 = 4/180 reduced 1/45.

Solve this problem: 3/5 x 4/7 x 1/2 = ______________ reduced = ______________

/ /

12/70 reduced = 6/35

---

49. Cancellation is a short cut used in multiplying fractions. The short cut in multiplying fractions is called ______________.

/ /

cancellation

---

50. Cancellation is much the same as reducing. The first step is to select a numerator and denominator that can be divided evenly by the same number. The problem 5/10 x 2/5 x 4/10 can be reduced to 1 ~~5~~/~~10~~ 5 x 1 ~~2~~/~~5~~ 1 x 2 ~~4~~/~~10~~ 5. The next step is to multiply the numerators and the denominators 1/5 x 1/1 x 2/5 = 2/25 reduced is 2/25. Solve the problem below by cancellation. Show work.

5/8 x 4/7 x 1/5 = ______________

/ /

1 ~~5~~/~~8~~ 2 x 1 ~~4~~/~~7~~ x 1/~~5~~ 1 = 1/14

---

51. When you use the cancellation method, the basic principle is: Dividing both the numerator and the denominator by the same number does not change the value of a fraction. The value of a fraction is not changed when the ______________ and the ______________ are ______________ by the same number.

/ /

numerator

denominator
(either order)

divided

---

52. In the problem 2/15 x 3/8, the 2 and 8 can be cancelled by dividing each by ______ and the 3 and 15 cancelled by dividing each by ______________. The answer to the problem, then, is ______________.

/ /

2

3

1/20

563

53. In the problem 10/13 x 26/50 x 7/21, the 10 and 50 are cancelled by dividing each by ________; the 13 and 26 are cancelled by dividing each by ________; and 7/21 can be reduced to ________. Now solve the problem, showing your cancellation.

10/13 x 26/50 x 7/21 = ____________

/ /

10; 13; 1/3

1 ~~10~~/~~13~~ 1 x 2 ~~26~~/~~50~~ 5 x 1 ~~7~~/~~21~~ 3 = 2/15

---

54. Solve the following problems, using cancellation where applicable. Reduce answers to lowest terms.

a. 2/5 x 3/10 x 7/9 =

b. 12/16 x 8/24 x 8/10 =

/ /

a. 7/75

b. 1/5

---

55. In order to multiply fractions and mixed numbers, the mixed numbers must be changed to improper fractions. Example: 2 1/2 x 3/8 x 1 1/3 will be changed to

5/2 1 x 1 3/8 2 x 1 4/3 1 = 5/4 reduced is 1 1/4

Solve the following problems, using cancellation where applicable, and reduce answers to lowest terms:

a. 3 1/3 x 5 1/2 x 9/10 =

b. 4 1/2 x 3 1/3 x 2 2/8 =

c. 3/4 of 80 =

/ /

a. 16 1/2 b. 33 3/4 c. 60

---

56. Solve the problems below, cancelling where applicable, and reduce answers to lowest terms.

a. 3/5 of 2 5/8 = c. 3 1/2 x 2 1/4 x 2/3 =

b. 1/6 of 24 = d. 2 1/8 x 3 3/4 x 1 1/3 =

/ /

a. 1 23/40 c. 5 1/4

b. 4 d. 10 5/8

---

57. Dividing common fractions requires two steps:

Example: 2/7 ÷ 1/3 =
Dividend Divisor

(1) Obtain reciprocal of divisor - - 3/1.
(invert divisor)

(2) Multiply the dividend by the reciprocal of the divisor - - 2/7 x 3/1 = 6/7.

Then 2/7 ÷ 1/3 = ________________.

/ /

6/7

---

58. Fill in the steps to find 5/9 ÷ 3/4.

(1) Obtain reciprocal of divisor ________
(invert the divisor)

(2) Multiply the dividend by the reciprocal of the divisor. ________

Then 5/9 - 3/4 = ________________.

/ /

4/3 5/9 x 4/3 20/27

---

59. Solve this problem : 3/10 ÷ 3/4 =

If your answer is:	Go to page:
2/5	3C
9/40	3F
12/30	15A

---

60. You have completed the Programmed Lesson on fractions. For some, the program was just a review; for others, it has been a process of learning.

A SELF-TEST ON FRACTIONS COMMENCES ON PAGE 22.

571

SELF-TEST ON FRACTIONS

1. Write the definition of a fraction.

____

2. Identify the two parts of the fraction 7/8 and explain what each part shows.

7 - ____

8 - ____

3. Identify the proper fractions, the improper fractions, and the mixed numbers in the following list by placing a "P" by the proper fractions, an "I" by the improper fractions, and an "M" by the mixed number.

a. 15/16
b. 19/17
c. 2 4/5
d. 9/7
e. 77 2/3
f. 300/299
g. 10/11
h. 7/12
i. 6 3/7
j. 5/6

4. Change the mixed numbers to improper fractions and the improper fractions to mixed numbers.

a. 3 2/3
b. 11/10
c. 12 4/5
d. 19/15
e. 7 7/8

5. Reduce the following fractions to their lowest terms:

a. 18/81
b. 9/12
c. 21/63
d. 3/7
e. 14/21
f. 16/64

6. Solve the following ADDITION and SUBTRACTION problems. Reduce answers to lowest terms.

a. 1/2 + 1/2 =
b. 5/7 - 2/3 =
c. 3/8 + 3/4 =
d. 2 3/8 - 1 5/8 =
e. 6 7/10 - 4 4/5 =
f. 11 3/4 + 19 5/8 + 9 1/2 + 3/16 =

7. Multiply the following fractions, cancelling where applicable. Reduce answers to lowest terms.

a. 1/2 x 3/4 x 2/3 =
b. 4 2/3 x 5 1/4 x 2 2/3 =
c. 3/4 x 5 1/2 =
d. 1/8 of 16 =

8. Divide the following fractions, cancelling where applicable. Reduce answers to lowest terms.

a. 7/8 - 7/16 =
b. 15 - 4 1/5 =
c. 4 2/3 - 12 4/9 =
d. 4/5 - 2 7/15 =

Answers on next page.

524

ANSWERS TO SELF-TEST

1. A fraction is part of a whole.
2. 7 - Numerator. Indicates how many parts of the whole are being considered.

   8 - Denominator. Indicates how many equal parts the whole has been divided into.
3. a. P b. I c. M d. I e. M f. I g. P h. P i. M j. P
4. a. 11/3 b. 1 1/10 c. 64/5 d. 1 4/15 e. 63/8
5. a. 2/9 b. 3/4 c. 1/3 d. 3/7 e. 2/3 f. 1/4
6. a. 1 b. 1/21 c. 1 1/8 d. 3/4 e. 1 9/10 f. 41 1/16
7. a. 1/4 b. 65 1/3 c. 4 1/8 d. 2
8. a. 2 b. 3 4/7 c. 3/8 d. 12/37

57

5225

PREPARE THE MAN

PROGRAMMED TEXT 3ALR91630-II-(2)

Department of Medicine

Technical Training

CARDIOPULMONARY LABORATORY SPECIALIST

ALGEBRAIC EXPRESSIONS

July 1973

10-6

AIR TRAINING COMMAND

SHEPPARD AIR FORCE BASE

Original Material Prepared
by
Naval Air Technical Training Command
(2TPT-5111-07)

Designed For ATC Course Use

DO NOT USE ON THE JOB

ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more readihg periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by page and/or frame)	REVIEW QUESTIONS (by No)

ALGEBRAIC EXPRESSIONS

OBJECTIVES:

1. Select, from a list of statements, the statement that defines an algebraic expression.
2. Complete a statement describing definite numbers.
3. Complete a statement describing general numbers.
4. Select, from a list, the words that complete the definition of a factor.
5. Select, from a list of statements, the statement that defines a coefficient (numerical only).
6. Select, from a list of statements, the statement that defines an exponent.
7. Select, from a list of statements, the statement that defines subscripts.
8. Match a list of algebraic expressions to a description of each expression.
9. Select, from a list of statements, the statement describing a monomial.
10. Select, from a list of statements, the statement describing a polynomial.
11. Match signs of grouping to the name each sign of grouping represents.

Suggested study time 70 minutes.

	1. In the language of algebra, an algebraic expression is defined as any expression that represents a number by means of the signs and symbols of algebra. These symbols include the letters of the alphabet, numbers, and signs of operation. Just as in arithmetic the sum of 4 and 2 is one quantity, that is, 6, in algebra the sum of c and d is one quantity, that is, c+d. Likewise, $\frac{a}{b}$, $\sqrt{b}$, a, ab, a-b, a + b + c, and so forth, are algebraic expressions representing one quantity. Longer expressions may be formed by combinations of the various signs and symbols, but no matter how complex such expressions are, they still represent a number. When an expression represents a number by using the signs and symbols of algebra, it is an ________ ________.
algebraic expression	2. The signs and symbols of algebra form an algebraic expression and represent a number, as in the expression 3abc. In the algebraic expression $\frac{-8a}{4}$, the signs and symbols represent a ________.
number	3. The signs and symbols of algebra represent numbers, as in the algebraic expression 2a - 4. Algebraic expressions are formed by using the ________ and ________ of algebra.
signs symbols	4. Select, from the statements below, the statement that defines an algebraic expression. Circle the letter beside your choice. a. A statement that expressions are equal in value. b. An expression that represents a number by means of the signs and symbols of algebra.

b. is correct.	5. Numbers in algebra are used to represent some definite quantity and are called DEFINITE NUMBERS. Definite numbers are used in algebra to represent some definite quantity and are (letters/numbers). Select one answer.
numbers	6. The numerals 0,1,2,3,4, etc., have definite meanings and do not change when used in algebra. In algebra, when definite numbers are used, they (do/do not) change. Select one answer.
do not	7. Definite numbers are those numbers that are used in arithmetic and do not change when used in algebra. When the numeral 7 is used in algebra, it is a __________ number.
definite	8. Complete the statement below by circling the letter in front of your choice. Definite numbers are those numbers used in arithmetic that a. change when used in algebra. b. are represented by letters of the alphabet. c. do not change when used in algebra.
c. is correct.	9. There is another type of number used in algebra and referred to as GENERAL NUMBERS or literal numbers. Algebra uses two types of numbers; they are __________ and __________ numbers.

definite general (literal)	10. General numbers are represented by letters of the English or Greek alphabets and can be upper or lower case. Upper and lower case letters are used in algebra to represent ______________ numbers.
general or literal	11. The letters A,B,C,Ω,Δ, etc., (upper case) and a,b,c,μ,π, etc., (lower case) do not have definite values, but when used in any particular algebra problem will have the same value throughout the problem. A letter used in any particular algebra problem will have the same value throughout the problem and is called a ______________ number.
general or literal	12. Complete the statement below by circling the letter in front of your choice. General numbers or literal numbers are those numbers a. not represented by letters of the alphabet. b. represented by letters of the alphabet. c. represented by upper case letters only.
b. is correct.	13. In the make-up of an algebraic expression, there are many parts; first parts to be considered are FACTORS, the multiplication parts that furnish a product. Factors are the parts of an expression that, when ______________, furnish a product.

multiplied	14. To indicate multiplication of factors, sometimes a dot is placed between them, as in the examples below. $I \cdot R$, $\pi \cdot r^2$, $2 \cdot h - 2 \cdot w$, $1 \cdot w$ In the expression $2 \cdot \pi \cdot r$, the 2, π, and r are called __________ and the dot indicates __________.
factors multiplication	15. More commonly, multiplication of factors will be indicated without a dot between them, as in the examples below. $a(b)$, $2\pi r$, πr^2, $(A)(h)$, $2\pi fC$ In the expression, lwh, the factors are ____, ____, and ____.
1,w,h.	16. There are two types of factors in algebraic expressions, numerical and literal, as shown in the examples below. numerical factors $2\pi fX_c$, $2KE$, $4\pi r^2$, $\frac{1}{2}ab$ literal factors In the expression, 4ab, the 4 is a numerical __________, the a and b are __________ factors.
factor literal	17. Numerical and literal factors indicate that the parts of an algebraic expression are to be multiplied. In the expression, 4abc, the 4, a, b, and c are factors indicating __________ of the parts.

multiplication	18. Complete the statement below, by circling the letter in front of your choice. Factors are the parts of an expression that, when _____________, furnish the _____________. a. multiplied, sum. b. added, product. c. multiplied, product.
c. multiplied, product.	19. The numerical factor is said to be the COEFFICIENT of an algebraic expression. In an algebraic expression, the numerical factor is the _____________.
coefficient	20. The numerical coefficient of an algebraic expression in all cases will be a number, as shown in the examples below. $3xy$, $4abc$, $2\Pi R$, $\frac{1}{2}ab$ In the expression, $\frac{1}{4}adf$, the numerical coefficient would be ____.
$\frac{1}{4}$	21. In an algebraic expression, when no numerical factor is indicated, the number one (1) is understood to be the coefficient. The coefficient 1 is always understood, never written. When no numerical factor is indicated in an expression, the coefficient will always be the number ____.
one (1)	22. All algebraic expressions have a numerical coefficient to the left of the literal factors. In the expression, abc, there is a numerical coefficient which is not indicated and is the number _____________, which is never written.

one (1)	23. Examples of algebraic expressions are shown below. a. $\frac{1}{2}ab$ b. abc c. 3IR d. I^2R What are the numerical coefficients of the expressions shown above? a. ____ b. ____ c. ____ d. ____
a. $\frac{1}{2}$ b. 1 c. 3 d. 1	24. Select, from the statements below, the definition of a numerical coefficient. Circle the letter in front of your choice. a. The literal factors that are added or subtracted from an algebraic expression. b. The numerical factor is the coefficient of an algebraic expression.
b. is correct.	25. EXPONENTS are the small numbers written to the right and a little above the base, as shown in the examples below. x^2, y^3, a^2, b^3, x^2y^3 The name of the small numbers written above and to the right of the base is (coefficient /exponent).
exponent	26. The base may be either a number or a letter, as shown in the examples below. a^2, B^2, C^2, 4^2, 8^2, 2^3 The number or letter written below and to the left of the exponent is the ____________.

base	27. The exponent indicates the number of times the base is to be used as a factor. Example - - - - - x^3 In the example above, how many times is the base used as a factor? Answer _____.
3 times	28. The base is used as a factor the number of times the exponent indicates, as shown in the example below. Example - - - - - x^2 The exponent of "x" is 2; therefore, the base, which is "x", is multiplied 2 times or $x \cdot x$. In the expression y^3, the exponent indicates the base is to be used 3 times as a ____________.
factor	29. Exponents indicate how many times the base is to be used as a factor. a. y^3 b. 3^3 c. a^2 d. 2^4 In the examples above, how many times is the base used as a factor? a.____ b. ____ c. ____ d. ____
a. 3 b. 3 c. 2 d. 4	30. Select, from the statements below, the statement that defines an exponent. Circle the letter in front of your choice. a. Numbers written above and to the right of the base, indicating how many times the base is used as a factor. b. Numbers written below and to the right of the base, indicating how many times the base is used as a factor.

a. is correct.	31. SUBSCRIPTS are small numbers or letters written below and to the right of a base letter, to distinguish it from other letters of the same classification. A small number or letter written to the right and below a base letter is a ____________.
subscript	32. When a base letter has a small number or letter written below and to the right, it is a subscript, as shown in the example below. $R_t - R_1 - R_2$ subscripts When a subscript is written near a letter, it will appear to the ____________ and ____________ the letter.
right, below	33. In the expression $R_1 + R_2 + R_3$, the letters are the base. The small numbers written to the right and below the base are called ____________.
subscripts	34. Subscripts have no numerical value and are used only to distinguish base letters from other letters of the same classification, as shown in the example below. $E_1 + E_2 + E_3$ The base letter, which is "E", can be distinguished from each other by using the numerals 1, 2, and 3. In the expression $I_p + I_s$, the ____________ distinguish the letter "I" from the other letters of the same classification.

subscripts	35. To distinguish base letters from each other when they are used more than once in an expression, subscripts are used. In the expression $P_1 + P_2$, the P's are of the same classification, the 1 and 2 are the subscripts. You would read the expression as: P sub 1 plus P sub 2. In the expression $E_b - iR_L$, how would you write the expression in words? Answer __________________________.
E sub b minus iR sub L.	36. Numbers or letters written to the right and a little below the base letter distinguish the base letter from other letters of the same classification. a. $R^2 + X^2$ e. $P_t - P_1 - P_2$ b. $E_p + E_s$ f. $E_{B1} + E_{B2}$ c. $C^2 - A^2$ g. $8ab^2$ d. $T_1 + T_2$ h. I^2R In the examples above, select the expressions having subscripts indicated. Circle the letters in front of your choice.
b. d. e. f. are correct.	37. Select, from the statements below, the statement that defines a subscript. Circle the letter in front of your choice. a. Small numbers or letters written below and to the right of a base letter, to distinguish it from other letters of the same classification. b. Small numbers or letters written above and to the right of the base letter, to distinguish it from other letters of the same classification.
a. is correct.	38. The parts of a TERM in an algebraic expression are not separated by plus (+) or minus (-) signs. $-4ax$, $3ab$, ad^2, $-2ax^2$, $6a^2b^2$ In each expression above, the parts of each term (are/are not) separated by a plus or minus sign.

are not	39. The plus or minus sign preceding the term is a part of that term. $P_1 - P_2$ In the algebraic expression above, the negative sign is a part of the term ____ and the understood sign for the term P_1 is __________.
P_2 positive	40. The TERMS of an algebraic expression are separated by plus (+) or minus (-) signs. In the expression 4x - 5y + 2z, how many terms are there? Answer __________.
three (3)	41. In algebraic expressions, you can have different numbers of terms, but there are only two types, like terms or unlike terms. The two different types of terms in algebraic expressions are the ________ terms and ________ ________.
like unlike terms	42. LIKE TERMS are the type of terms that contain the same <u>literal</u> <u>factors</u> and exponents, as shown below. $4a^2,\ 7a^2,\ 3a^2,\ 10a^2.$ In the examples above, since each term contains the same literal factors, they are __________ terms.
like	43. Terms that are exactly the same or that differ only in their coefficients are called like terms, as shown below. 12xyz , -4xyz , -7xyz The expression 3ab + 2ab contains unlike ________ and ________ literal factors.

coefficients like	44. In the expression $a^2b + 4a^2b$, each term has the same ____________ factors.
~~literal~~	45. The second type of terms is UNLIKE terms, those terms that have <u>different literal factors</u>, as shown below. $3ab + 4bc$, $-15cd + 3de$ When an expression contains terms having different literal factors, they are ____________ terms.
unlike	46. Terms that differ in their literal factors are called unlike terms, as shown below. $A^2 + B^2$ The expression $4a - b - 2c$ contains three ____________ literal factors.
unlike	47. Match each expression below to a description of each expression. Place the letter beside each description in the space provided in front of each expression. EXPRESSION — DESCRIPTION ( ) $7x^2 - 5x^2$ — a. An expression containing three unlike terms. ( ) $2ay^2 - ay^2 + 3ay^2$ — b. An expression containing two like terms. ( ) $5b^2x - 3bx^2$ — c. An expression containing three like terms. ( ) $-5x^2 + 3xy - 8y^2$ — d. An expresson containing two unlike terms.

b. c. d. a.	48. An expression consisting of <u>one term</u> is a MONOMIAL(mono means one). Monomials are expressions of ________ term only.
one	49. A monomial is an algebraic expression of one term only. The expression -6axy is a ________ algebraic expression.
monomial	50. When an expression contains one term only, it is a monomial. Is the expression 3xy a monomial? Answer ________.
yes	51. Select, from the statements below, the statement that describes a monomial. Circle the letter in front of your choice. a. An algebraic expression consisting of two or more terms. b. An algebraic expression consisting of like terms. c. An algebraic expression consisting of one term.
c. is correct.	52. An expression consisting of <u>two terms</u> is a BINOMIAL(bi means two). A binomial is an algebraic expression of ________ terms.
two	53. A binomial is an algebraic expression consisting of two terms. The expression 2b-y is a ________ algebraic expression.

binomial	54. When an expression contains two terms, it is a binomial. Is the expression $xy + xy^2$ a binomial? Answer __________.
yes	55. An expression consisting of <u>three terms</u> is a TRINOMIAL(tri means three). A trinomial algebraic expression contains __________ terms only.
three	56. A trinomial algebraic expression in general can be called a polynomial containing three terms. The expression $a^2+b^2-c^2$ is a __________ or __________ expression containing three terms.
trinomial polynomial (any order)	57. An expression consisting of <u>two or more</u> terms is a POLYNOMIAL(poly means many). Polynomial algebraic expressions are expressions containing __________ or __________ terms.
two or more	58. A polynomial is an algebraic expression of two or more terms. The expression $a+b-3y$ is a (monomial/polynomial). Select one answer.
polynomial	59. When an expression contains two or more terms, it is a polynomial. Is the expression x^2-3x^2 a polynomial? Answer __________.

yes	60. All expressions with four or more terms are just called polynomials or multinomials. No response is required. Continue.
	61. Select, from the statements below, the statement describing a polynomial. Circle the letter in front of your choice. a. An algebraic expression consisting of part of a term. b. An algebraic expression consisting of two or more terms. c. An algebraic expression consisting of one term.
b. is correct.	62. Terms can be grouped together and treated as one quantity by using signs of grouping. When terms are grouped together by means of signs of grouping, they are treated as ________ ________.
one quantity	63. There are four signs of grouping used in algebra: parentheses ( ), brackets [ ], braces { }, and the vinculum ——. Parentheses, brackets, braces, and the vinculum are the ________ of ________ used in algebra.
signs grouping	64. To group terms together that are to be affected by the same operation, you will use one or more of the signs of grouping. $3a[\,-2(a+b)]$ In the expression above, the terms are grouped together by using one or more of the ________ of ________.

signs grouping	65. PARENTHESES ( ) are usually the innermost sign of grouping. $2x[-8(x-4)]$ In the expression above, the innermost sign of grouping is ______________.
parentheses( )	66. The second innermost sign of grouping in algebra is BRACKETS [ ]. $2x\ [-8(x-4)]$ In the expression above, the quantity $-8(x-4)$ is inside which sign of grouping? Answer ______________.
brackets	67. In the expression $2x[x(5+x)-2]$, what is the innermost sign of grouping? Answer ______________.
parentheses	68. Usually the outermost sign of grouping is BRACES { }. $2x-\{3y-[8-5y-(x-4)]\}$ In the expression above, what is the outermost sign of grouping? Answer ______________.
braces	69. The VINCULUM ——, when used in algebra, is used mostly in connection with a radical sign, as in square root, or in fractions. Examples $\sqrt{4}$, $\frac{15}{16}$, $\frac{A}{B}$, $\frac{R_1 \times R_2}{R_1 + R_2}$ The sign of grouping that is used with fractions and the radical sign is the ______________.

vinculum	70. The vinculum is used in algebra as a sign of grouping. $\sqrt{4c^2}$ $\qquad$ $\frac{2x^2}{x}$ In the expressions above, what sign of grouping is used? Answer ______________.
vinculum	71. The vinculum is usually placed over the term or terms to be grouped. In the expression $2a\ \overline{a-c}$, the vinculum is placed ______________ the terms a-c.
over	72. If a sign of grouping is preceded by a plus sign, the enclosed terms are to be added to what precedes. $2+(4+I-E)$ In the expression above, the quantity $+(4+I-E)$ is to be ______________ to the quantity 2.
added	73. When a minus sign precedes a sign of grouping, it indicates that the terms enclosed by the sign of grouping are to be subtracted from the term that precedes the minus sign. $4 + R - (2R - E)$ In the expression above, the expression $(2R - E)$ is to be ______________ from the quantity ____.
subtracted R	74. Signs of grouping are preceded by numbers, letters, positive or negative signs, or any combination of them. When this occurs, the enclosed terms are to be multiplied by the coefficient (term preceding) of the sign of grouping. $2(a-b)$, $a(a+b)$, $a+(a+b)$, $a-(a-b)$ Terms enclosed within a sign of grouping are ______________ by the ______________ of the sign of grouping.

multiplied coefficient	75. In the expression $2(4+x)$, the quantity $(4+x)$ is multiplied by the quantity plus 2. To remove the sign of grouping, each term within the sign of grouping is multiplied by the coefficient of the sign of grouping, which is 2. Therefore, 2 times 4 is 8 and 2 times x is 2x, and you have the expression 8+2x. When removing a sign of grouping, each term within the sign of grouping must be ______________ by the ______________ of the sign of grouping.
multiplied, coefficient	76. If a sign of grouping is followed by an exponent, then the enclosed terms are to be used as factors that number of times. $(4+b)^2$ In the expression above, the quantity (4+b) is used as factors ______________ times.
two (2)	77. Signs of grouping can be considered to have a coefficient and exponent. When no number is expressed, the number one (1) is understood. a. $-(a+b)^2$ b. $(4-b)$ c. $(6-E)^2$ d. $-(4+I-E)$ In the expressions above, what sign of grouping is used? Answer ______________. What are the coefficient and exponent of each sign of grouping? a. ____ , ____ c. ____ , ____ b. ____ , ____ d. ____ , ____

parentheses a. -1 , 2 b. 1 , 1 c. 1 , 2 d. -1 , 1	You have completed a program on algebraic expressions; now lets have a review on the information you have learned.
	1. An algebraic expression is any expression that represents a number by means of the __________ and __________ of algebra.
signs symbols	2. Numbers used in algebra to represent a definite quantity are called __________ numbers.
definite	3. General numbers are represented by __________, and are sometimes called __________ numbers.
letters literal	4. Terms are the parts of an expression that are separated from each other by __________ and __________ signs.
plus (+) minus (-) (any order)	5. A term in an algebraic expression is a part of the expression __________ separated by plus or minus signs.
NOT	6. Factors are the parts of an expression that when __________ produce a product.
multiplied	7. The two types of factors used in algebra are __________ and __________.

546

numerical literal (any order)	8. An algebraic expression consisting of one term is a ________.
monomial	9. An algebraic expression consisting of two or more terms is a ________.
polynomial	10. An algebraic expression consisting of two terms is a ________ or ________.
binomial polynomial (any order)	11. The ________ factors are said to be the coefficient of an expression.
numerical	12. A small number, written above and to the right of another number, that indicates the number of times the base is used as a factor is an ________.
exponent	13. Small numbers or letters written to the right and below the base are called ________.
subscripts	14. When signs of grouping are used in algebra, the enclosed terms are treated as ________ ________.
one quantity	15. The signs of grouping used in algebra are parentheses, ________, ________, and the ________.
brackets braces vinculum	16. To remove signs of grouping, you ________ each term enclosed within the sign of grouping by the ________ of the group.
multiply coefficient	**END OF PROGRAM** Self-test starts on the next page.

SELF-TEST FOR ALGEBRAIC EXPRESSIONS

1. Select, from the statements below, the statement that defines an algebraic expression. Circle the letter beside your choice.

   a. An expression that represents a number by means of the signs and symbols of algebra.

   b. A statement that expressions are equal in value.

2. Definite numbers are those numbers used in arithmetic that (Circle the letter that completes the statement.)

   a. are represented by letters of the alphabet.

   b. do not change when used in algebra.

   c. change when used in algebra.

3. General numbers are those numbers, referred to as literal numbers, (Circle the letter in front of your choice.)

   a. represented by letters of the alphabet.

   b. not represented by letters of the alphabet

   c. represented by upper case letters only.

4. Factors are the parts of an expression that when ______________ furnish the ______________.

   a. added, sum.

   b. divided, quotient.

   c. multiplied, product.

5. Select, from the statements below, the statement that defines a coefficient. Circle the letter in front of your choice.

   a. The numerical factor is the coefficient of an algebraic expression.

   b. The factor that is added to or subtracted from an algebraic expression.

6. In the algebraic expression XYZ, what is the numerical coefficient?

   a. 0.
   b. 1.
   c. 2.
   d. 3.

7. Select, from the statements below, the statement that defines an exponent. Circle the letter in front of your choice.

   a. Small numbers, written to the right and a little below the base, indicating the number of times the base is to be used as a factor.

   b. Small numbers, written to the right and a little above the base, indicating the number of times the base is to be used as a factor.

8. Select, from the statements below, the statement that defines subscripts. Circle the letter in front of your choice.

   a. Small numbers or letters, written below and to the right of a base letter, to distinguish it from other letters of the same classification.

   b. Small numbers or letters, written above and to the right of a base letter, to distinguish it from other letters of the same classification.

9. Match each algebraic expression to the description of each expression. Place the letter that is beside each description in the space beside the expression.

EXPRESSION	DESCRIPTION
( ) $4ab - a^2 + 2ab^2$	a. An expression containing two like terms.
( ) $4ab + 2ab$	b. An expression containing three unlike terms.
( ) $abc + 3abc - 3abc$	c. An expression containing two unlike terms.
( ) $4az - 2az^2$	d. An expression containing three like terms.

10. Select, from the statements below, the statement that describes a monomial. Circle the letter in front of your choice.

    a. An expression consisting of like terms.

    b. An expression consisting of one term.

    c. An expression consisting of two or more terms.

11. Select, from the statements below, the statement that describes a polynomial. Circle the letter in front of your choice.

    a. An expression consisting of part of a term.

    b. An expression consisting of one term.

    c. An expression consisting of two or more terms.

12. Match each sign of grouping to the name of each sign of grouping. Place the letter that is beside each name in the space beside each sign of grouping.

SIGNS OF GROUPING		NAME	
( )	( )	a.	vinculum
( )	[ ]	b.	braces
( )	{ }	c.	parentheses
( )	——	d.	brackets

PREPARE THE MAN — PROGRAMMED TEXT 3ALR91630-II-5C (3) 550

Department of Medicine
School of Health Care Sciences

CARDIOPULMONARY LABORATORY SPECIALIST

BASIC MATHEMATICS - ALGEBRAIC EQUATIONS

July 1973

Sheppard Air Force Base, Texas

Original Material Prepared
by
Naval Air Technical Training Command
(2TPT-3111-03)

Designed For ATC Course Use

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The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

The STUDY GUIDE AND WORKBOOK (SW) contains both SG and WB material under one cover. The two training publications are combined when the WB is not designed for you to write in, or when both SG and WB are issued for you to keep.

The PROGRAMMED TEXT (PT) presents information in planned steps with provisions for you to actively respond to each step. You are given immediate knowledge of the correctness of each response. PTs may either replace or augment SGs and WBs.

The HANDOUT (HO) contains supplementary training materials in the form of flow charts, block diagrams, printouts, case problems, tables, forms, charts, and similar materials.

Training publications are designed for ATC course use only. They are updated as necessary for training purposes, but are NOT to be used on the job as authoritative references in preference to Regulations, Manuals or other official publications.

552

ANSWERS TO SELF-TEST

1.
   a. Unknown
   b. Equal Sign
   c. First Member
   d. Second Member

2. c.

3. b.

4. b.

5. b. and c.

6. b.,c.,f., and g.

7.
   a. $a = 5$ b. $2.3 = w$
   c. $r = 13$ d. $z = 4$

8.
   a. $x = 5$ b. $x = 10$
   c. $e = 4$ d. $x = 1$

9.
   a. $5 = t$ b. $x = 9$
   c. $x = 2$ d. $x = 1$

10.
   a. $y = 8$ b. $z = 1$
   c. $b = 10$ d. $t = 12$

11.
   a. $R_T - R_1 - R_3 = R_2$ b. $\frac{E}{I} = R$
   c. $\sqrt{\frac{P}{R}} = I$ d. $\frac{2A}{h} = b$

ALGEBRAIC EQUATIONS

OBJECTIVES:

1. Label the first member, second member, equal sign, and unknown of an algebraic equation.
2. Select, from a list of statements, the statement that defines an algebraic equation.
3. Select, from a list of statements, the statement that describes the Golden Rule of algebra.
4. Select, from a list of statements, the statement that describes transposition.
5. Select, from a list of statements, the statements that describe how factors are moved from one side of an equation to the other side.
6. Select, from a list of statements, the conditions that must be met when solving algebraic equations.
7. Solve algebraic equations containing an unknown on one side of the equal sign.
8. Solve algebraic equations containing an unknown on both sides of the equal sign.
9. Solve algebraic equations containing signs of grouping.
10. Solve algebraic equations containing fractional quantities.
11. Solve algebraic equations containing definite variables.

SUGGESTED STUDY TIME 150 MINUTES.

INSTRUCTIONS FOR TAKING THIS PROGRAM

This is a programmed lesson. It is self-teaching, but an instructor will always be on hand to answer any questions that you may have.

The program is set up in the following manner:

a. It contains numbered blocks that are frames.

b. Each frame contains the following:

   1. Information to teach you.

   2. A way for you to see if you learned the information. This may be writing, filling in blanks, labeling parts, or solving equations.

c. As soon as you finish a frame, you can see if you made the correct answer by looking to the left of the next frame. If you do not make the correct answer, you should re-study that frame. If your answer is correct, then continue working the lesson.

d. You should keep the correct answers covered until you have made your answer. The correct answers can be kept covered with a piece of paper or cardboard.

e. The example below shows how this program is set up.

	1. A monomial is an algebraic expression of one term. An algebraic expression that contains one term is a ____________.
monomial	2. A binomial is . . . . etc.

The program is written with instructions all the way through it. Follow these instructions very carefully.

Take your time. Read and study each frame very carefully.

GO TO THE NEXT PAGE AND START THE LESSON.

	1. The equal sign separates the members of an algebraic equation. The equal sign is labeled in the equation below. $y + 3 \overset{\text{equal sign}}{=} 5$ Label the equal sign in the equation below. $2x = 10$
equal sign $2x = 10$	2. The first member of an algebraic equation is all the letters and numbers to the left of the equal sign. The first member is labeled in the equation below. $\underbrace{y + 3}_{\text{first member}} = 5$ Label the first member in the equation below. $x + 3 = 3x - 1$
$\underbrace{x + 3}_{\text{first member}}$	3. The second member of an algebraic equation is all the letters and numbers to the right of the equal sign. The second member is labeled in the equation below. $y + 3 = \underbrace{5}_{\text{second member}}$ Label the second member in the equation below. $x + 3 = 3x - 1$

$\underbrace{3x + 1}_{\text{second member}}$	4. The first member of an equation is to the left of the equal sign. The second member of an equation is to the right of the equal sign. Label the first and second members of the equation below. $x - 1 = y + z$
$\underbrace{x - 1}_{\text{first member}}$ $\underbrace{y + z}_{\text{second member}}$	5. The unknowns of an algebraic equation are letters. The unknown is labeled in the equation below. $\overset{\text{unknown}}{\overset{\swarrow}{w}} + 6 = 9$ The letters in an equation are the ________________. In the equation below, there are ________________ unknowns. Label the unknowns in the equation below. $6x - 4 = 3y + 24$
unknowns two The x in the first member and y in the second member are unknowns. If you labeled x and y unknowns, you are correct.	6. Label the equation below with its first member, second member, equal sign, and unknown. A. ________________ B. ________________ $\underbrace{4 + y} = \underbrace{9 - 4}$ C. ________________ D. ________________

<table>
<tr>
<td>A. unknown

B. equal sign

C. first member

D. second member</td>
<td>7. Now we will develop a definition of an algebraic equation. The equal sign means that both members of an equation are equal in value; in other words, there is equality between the first and second members.

Which of the statements below is correct? Circle the letter beside your choice.

a. There is equality between the first and second members of an equation.

b. The first and second members of an equation are not equal in value.</td>
</tr>
<tr>
<td>a. is correct.

If you selected b., you should re-study frame 7.</td>
<td>8. There must be an unknown in at least one member of an algebraic equation. There can be more than one of the same unknown or two or more different unknowns in an equation.

Examples:

$4y + 1 = 9$ (y is the unknown)

$4y + 2 = 9 + y$ (two of same unknown)

$2y - 4z = 7w + 10$ (different unknowns)

Which of the statements below is correct? Circle the letter beside your choice.

a. There must be unknowns in both members of an algebraic equation.

b. There must be an unknown in at least one member of an algebraic equation.</td>
</tr>
</table>

b. is correct. If you selected a., you should re-study frame 8.	9. The definition we have developed for an algebraic equation is: Equality between members when at least one member has an unknown. An algebraic equation must have ____________ between its members. At least one member of an algebraic equation must have an ____________.
equality unknown	10. Select, from the statements below, the statement that defines an algebraic equation. Circle the letter beside your choice. a. An algebraic expression containing two or more terms. b. Equality between members when at least one member has an unknown. c. Some unknown quantity, represented by a symbol, that is multiplied by itself.
b. is correct. If you selected a. or c., re-study frame 9.	11. The <u>Golden Rule</u> of algebra <u>is</u> that you can <u>do anything to one member</u> of an equation <u>if you do</u> the <u>same thing to</u> the <u>other member</u>. In other words, if you performed any one of the four operations: addition, subtraction, multiplication, or division, to one member, then you must perform the ____________ operation to the ____________ member.

same

other

12. Doing the same thing to both members of an algebraic equation is the Golden Rule of algebra. The equations below are examples how the Golden Rule is used to solve equations.

a. By addition

$$\begin{array}{r} y - 4 = 10 \\ 4 = 4 \\ \hline y = 14 \end{array}$$

b. By subtraction

$$\begin{array}{r} x + 6 = 10 \\ (-)6 = (-)6 \\ \hline x = 4 \end{array}$$

Which of the statements below is correct? Circle the letter beside your choice.

a. The same thing was done to both members of equation a.

b. A different thing was done to both members of equation a.

---

a. is correct.

If you selected b., re-study frames 11 and 12.

13. You can also do the same thing to both members of an algebraic equation as shown below.

a. By multiplication

$$\frac{a}{4} = 10$$

$$\frac{a}{4} \times \frac{4}{1} = \frac{10}{1} \times \frac{4}{1}$$

$$a = 40$$

b. By division

$$2z = 10$$

$$\frac{2z}{2} = \frac{10}{2}$$

$$z = 5$$

Which of the statements below is correct? Circle the letter beside your choice.

a. A different thing was done to both members of equation b.

b. The same thing was done to both members of equation b.

b. is correct. If you selected a., re-study frames 11, 12, and 13.	14. Select, from the statements below, the statement that describes the Golden Rule of algebra. Circle the letter beside your choice. a. Factors of an equation are multiplied together and give the original equation. b. Take a term from one member of an equation, across the equal sign, and change its operation. c. You can do anything to one member of an equation if you will do the same thing to the other member.
c. is the correct statement and should have been your choice.	15. Transposition is a process where positive (+) or negative (-) terms are moved from one member of an equation to the other member. The process of moving terms from one member to the other member of an equation is ____________.
transposition	16. When a term, preceded by a plus sign, is transposed, the sign of the term must be changed to minus. Example: $2z + 2 = 10$ Becomes $2z = 10 - 2$ after the term $+2$ is transposed. The sign of the term was changed from plus to ____________.
minus	17. When a term, preceded by a minus sign, is transposed, the sign of the term must be changed to plus. Example: $4y - 8 = 4$ Becomes $4y = 4 + 8$ after the term -8 is transposed. The sign of the term was changed from minus to ____________.

 561

plus	18. Would the equation $5x + 4 = 20$, look like this, $5x = 20 - 4$, after the +4 has been transposed? Answer ____
Yes, because a transposed +4 must become a -4.	19. Would the equation $3y = 5y + 10$, look like this, $3y + 5y = 10$, after the +5y has been transposed? Answer ____
No, it would look like this, $3y - 5y = 10$. When the 5y is transposed, it must be changed to -5y.	20. Select, from the statements below, the statement that describes transposition. Circle the letter beside your choice. a. Any term preceded by a plus or minus sign may be moved from one member of an equation to the other member if the sign of the term is changed. b. Any term preceded by a plus or minus sign may be moved from one member of an equation to the other member if the sign is kept the same. c. Any term preceded by a plus or minus sign may be moved from one member of an equation to the other member if all unlike terms are changed.
a. is the best statement and should have been your choice.	21. Factors can be moved from one side of the equal sign of an equation to the other side if the indicated operation for the factor is changed. When a factor is moved across the equal sign of an equation, you must change the ____________ ____________ for the factor.

indicated operation	22. When a factor indicates the operation of multiplication on one side of the equal sign and you move it across the equal sign, the indicated operation must be changed to division. Example: $2z = 14$ Becomes $z = \frac{14}{2}$ after the factor 2 is moved across the equal sign; the indicated operation for the factor was changed from multiplication to ______________.
division	23. When a factor indicates the operation of division on one side of the equal sign and you move it across the equal sign, the indicated operation must be changed to multiplication. Example: $\frac{a}{4} = 10$ Becomes $a = 10(4)$ after the factor 4 is moved across the equal sign; the indicated operation for the factor was changed from division to ______________.
multiplication	24. Would the equation $2x = 16$ look like this: $x = \frac{16}{2}$, after the factor 2 has been moved across the equal sign? Answer ______
Yes, because the 2x indicates x multiplied by 2 before it is moved. After the factor 2 is moved across the equal sign, it must indicate 16 divided by 2.	25. Would the equation $\frac{z}{4} = 2$, look like this: $z = 2(4)$, after the factor 4 has been moved across the equal sign? Answer ____

Yes.	26. Select, from the statements below, the statements that best describe how factors are moved from one side of an equation to the other. Circle the letter beside your choices. a. A factor that indicates multiplication on one side of the equal sign may be moved across the equal sign if you change the indicated operation to division. b. A factor that indicates multiplication on one side of the equal sign may be moved across the equal sign if you change the indicated operation to addition. c. A factor that indicates division on one side of the equal sign may be moved across the equal sign if you change the indicated operation to subtraction. d. A factor that indicates division on one side of the equal sign may be moved across the equal sign if you change the indicated operation to multiplication.
a. and d. are correct and should be your choices.	27. There are four (4) conditions that must be met when solving algebraic equations. One of the conditions is: All terms <u>that contain the unknown must be on one side of the equal sign.</u> All other terms must be on the other side of the equal sign. Example: $2x - 10 = 12 - 9x$ Becomes $9x + 2x = 12 + 10$ when all terms containing the unknown are on __________ side of the equal sign.

one	28. Another condition that must be met is: All like terms must be collected or combined. Example: $9x + 2x = 12 + 10$ Becomes $11x = 22$ when all like terms have been ____________ or ____________.
collected combined (any order)	29. Still another condition that must be met is: The coefficient of the unknown must be one (1). Example: $11x = 22$ Becomes $x = \frac{22}{11}$, and the unknown now has a ____________ of one.
coefficient	30. Still another condition that must be met is: The exponent of the unknown must be one (1). Example: $x^2 = 100$ Becomes $\sqrt{x^2} = \sqrt{100}$, when you indicate that the root of both members is to be extracted. Thus, $x = 10$ and the unknown now has an exponent of ____________.
one	31. Now let's solve the equation: $8y^2 - 6 = 4y^2 + 10$. First, we must move all terms containing the unknown to one side of the equation and all other terms to the other side. The equation now looks like this: $8y^2 - 4y^2 = 10 + 6.$ Thus, we have all terms containing the unknown on ____________ side of the equation.

one	32. The next condition to be met in solving the equation $8y^2 - 4y^2 = 10 + 6$, would be to collect or combine all like terms. The equation would become: $4y^2 = 16$, after we have collected or combined all __________ terms.
like	33. The next condition to be met in solving the equation $4y^2 = 16$, would be to reduce the coefficient of the unknown to one. The equation would become $y^2 = \frac{16}{4}$, or $y^2 = 4$, and the __________ of the unknown has been reduced to __________.
coefficient one	34. There is still one more condition to be met, because the equation $y^2 = 4$ has an unknown with an exponent of more than one. Let's reduce the exponent to one by taking the root of both members of the equation. Thus, $\sqrt{y^2} = \sqrt{4}$ becomes $y = 2$ after taking the root of both members and the __________ of the unknown is now __________.

exponent one	35. Select, from the statements below, the statements that describe the conditions to be met when solving algebraic equations. Circle the letter beside your choices. a. The unlike terms must be collected or combined. b. The coefficient of the unknown must be reduced to one. c. The unknown must be on both sides of the equation. d. The like terms must be collected or combined. e. The exponent of the unknown must be reduced to one. f. The coefficient of the unknown can be more than one. g. The exponent of the unknown can be more than one. h. The unknown must be on one side of the equation.
b.,d.,e., and h. are the correct statements.	If you missed any of the conditions to be met when solving equations, you should go back and re-study all frames from number 27 to 35. If you got all the conditions, then you can go to the next page and start solving equations.

567

36. Solve the equations below.

A. $4x + 1 = 5$

D. $2z + 2 = 10$

B. $4y - 8 = 10$

E. $7r + 4 = 81$

C. $3z + 4 = 16$

F. $z^2 - 4 = 12$

The answers for the equations in frame 36 are shown below. The transposition method of solving is shown but, if you used the Golden Rule and got the correct answer, it is all right.

A.
$$4x + 1 = 5$$
$$4x = 5 - 1$$
$$4x = 4$$
$$x = \cancel{\frac{4}{4}}\ 1$$
$$x = 1$$

B.
$$4y - 8 = 10$$
$$4y = 10 + 8$$
$$4y = 18$$
$$y = \cancel{\frac{18}{4}}\ 4\tfrac{1}{2}$$
$$y = 4\tfrac{1}{2} \text{ or } y = 4.5$$

C.
$$3z + 4 = 16$$
$$3z = 16 - 4$$
$$3z = 12$$
$$z = \cancel{\frac{12}{3}}\ 4$$
$$z = 4$$

D.
$$2z + 2 = 10$$
$$2z = 10 - 2$$
$$2z = 8$$
$$z = \cancel{\frac{8}{2}}\ 4$$
$$z = 4$$

E.
$$7r + 4 = 81$$
$$7r = 81 - 4$$
$$7r = 77$$
$$r = \cancel{\frac{77}{7}}\ 11$$
$$r = 11$$

F.
$$z^2 - 4 = 12$$
$$z^2 = 12 + 4$$
$$z^2 = 16$$
$$\sqrt{z^2} = \sqrt{16}$$
$$z = 4$$

37. Solve the equations below.

A. $16r + 4 = 10r + 6$

B. $4x - 5 = 0 + x$

C. $14w + 6 - 4 = 2w + 28 - 2$

D. $2z + 4 = z + 12$

E. $8z^2 - 6 = 4z^2 + 10$

F. $9y + 4 = y - 30 + 10$

The answers for the equations in frame 37 are shown below. The Golden Rule method of solving is shown but, if you used transposition and got the correct answer, it is all right.

A.

$$16r + 4 = 10r + 6$$
$$\underline{-10r - 4} \quad \underline{-10r - 4}$$
$$6r = 2$$
$$\frac{6r}{6} = \frac{2}{6}$$
$$\frac{\cancel{6}r}{\cancel{6}} = \frac{\cancel{2}}{\cancel{6}}\,1/3$$
$$r = 1/3$$

B.

$$4x - 5 = 0 + x$$
$$\underline{-x + 5} \quad \underline{+5 - x}$$
$$3x = 5$$
$$\frac{3x}{3} = \frac{5}{3}$$
$$\frac{\cancel{3}x}{\cancel{3}} = \frac{\cancel{5}}{\cancel{3}}\,1\frac{2}{3}$$
$$x = 1\frac{2}{3}$$

C.

$$14w + 6 - 4 = 2w + 28 - 2$$
$$14w + 2 = 2w + 26$$
$$\underline{-2w - 2} \quad \underline{-2w - 2}$$
$$12w = 24$$
$$\frac{12w}{12} = \frac{24}{12}$$
$$\frac{\cancel{12}w}{\cancel{12}} = \frac{\cancel{24}}{\cancel{12}}\,2$$
$$w = 2$$

D.

$$2z + 4 = z + 12$$
$$\underline{-z - 4} \quad \underline{-z - 4}$$
$$z = 8$$

E.

$$8z^2 - 6 = 4z^2 + 10$$
$$\underline{-4z^2 + 6} \quad \underline{-4z^2 + 6}$$
$$4z^2 = 16$$
$$\frac{4z^2}{4} = \frac{16}{4}$$
$$\frac{\cancel{4}z^2}{\cancel{4}} = \frac{\cancel{16}}{\cancel{4}}\,4$$
$$z^2 = 4$$
$$\sqrt{z^2} = \sqrt{4}$$
$$z = 2$$

F.

$$9y + 4 = y - 30 + 10$$
$$9y + 4 = y - 20$$
$$\underline{-y - 4} \quad \underline{-y - 4}$$
$$8y = -24$$
$$\frac{8y}{8} = \frac{-24}{8}$$
$$\frac{\cancel{8}y}{\cancel{8}} = \frac{\cancel{-24}}{\cancel{8}}\,-3$$
$$y = -3$$

NOTE

If you had trouble with frames 36 and 37, go back to frame 31 and re-study all frames to this one before going ahead with this lesson.

	38. In order to solve algebraic equations that contain signs of grouping, you must remove the signs of grouping in the first steps. When solving algebraic equations that contain signs of grouping, you must first remove the ______________ ______________.
signs of grouping	39. When removing the signs of grouping, you must remove the innermost sign of grouping first. As you remove the signs of grouping, remember to apply the laws of signed numbers. The first sign of grouping to be removed when solving algebraic equations, is the ______________ one. Draw a circle around the innermost sign of grouping in the equation below. $5 = 24 - [w - 18(w - 2)]$
innermost (w - 2) should have a circle drawn around it.	40. In the equation below, the innermost sign of grouping is the <u>parentheses</u> ( ). Therefore, the parentheses are the first sign of grouping to be removed. Remove the ( ) in the equation below and apply the laws of signed numbers. $-\{y - 5[2y + 2(y - 5)] + 4\} = -16$

$-\{y-5[2y+2y-10]+4\} = -16$ As you can see, the quantity $(y-5)$ was multiplied by $+2$ and the result is $+2y - 10$.	41. Now the innermost sign of grouping is the <u>brackets</u> [ ]. Therefore, the brackets are the next sign of grouping to be removed and you must apply the laws of signed numbers as you do so. Remove the [ ] in the equation below. $-\{y - 5[2y + 2y - 10] + 4\} = -16$
$-\{y-10y-10y+50+4\} = -16$ The quantity $[2y+2y-10]$ was multiplied by -5 and the result is $-10y-10y+50$.	42. This leaves you with one more sign of grouping to be removed. It is the <u>braces</u> { }. Remove the { } in the equation below. $-\{y - 10y - 10y + 50 + 4\} = -16$
$-y+10y+10y-50-4 = -16$ In this step, everything inside the braces was multiplied by the understood -1 that precedes the braces.	43. Now that you have removed all the signs of grouping, finish solving the equation below. $-y + 10y + 10y - 50 - 4 = -16$
$19y = -16+50+4$ $19y = 38$ $y = \cancel{\frac{38}{19}}\ 2$ $y = 2$	<u>REVIEW</u> WHEN SOLVING EQUATIONS THAT CONTAIN SIGNS OF GROUPING, ALWAYS REMOVE THE INNERMOST SIGN OF GROUPING FIRST AND WORK OUTBOARD IN EACH SUCCEEDING STEP UNTIL ALL SIGNS OF GROUPING ARE REMOVED FROM THE EQUATION. REMEMBER TO APPLY THE LAWS OF SIGNED NUMBERS AS YOU REMOVE THE SIGNS OF GROUPING.

44. Solve the equations below.

A. $3(y - 2) = 9$

B. $4(a + 3) = 2(24 - a)$

C. $5 = 24 - [w - 18(w - 2)]$

D. $-3[m - 8(m + 2) - 4] = 34$

574

The answers for the equations in frame 44 are shown below. The transposition method was used to solve the equations.

A.
$$3(y - 2) = 9$$
$$3y - 6 = 9$$
$$3y = 9 + 6$$
$$3y = 15$$
$$y = \frac{\cancel{15}\,5}{\cancel{3}}$$
$$y = 5$$

B.
$$4(a + 3) = 2(24 - a)$$
$$4a + 12 = 48 - 2a$$
$$4a + 2a = 48 - 12$$
$$6a = 36$$
$$a = \frac{\cancel{36}\,6}{\cancel{6}}$$
$$a = 6$$

C.
$$5 = 24 - [w - 18(w - 2)]$$
$$5 = 24 - [w - 18w + 36]$$
$$5 = 24 - w + 18w - 36$$
$$5 - 24 + 36 = 18w - w$$
$$17 = 17w$$
$$1\,\frac{\cancel{17}}{\cancel{17}} = w$$
$$1 = w$$

NOTE

If you had trouble with any of the equations in frame 44, you should go back to frame 38 and re-study all frames to this one before you go ahead with this lesson.

D.
$$-3[m - 8(m + 2) - 4] = 34$$
$$-3[m - 8m - 16 - 4] = 34$$
$$-3m + 24m + 48 + 12 = 34$$
$$-3m + 24m = 34 - 48 - 12$$
$$21m = -26$$
$$m = \frac{-26}{21}$$
$$m = -1\frac{5}{21}$$

	45. Some equations are of a fractional type. Example: $\frac{z}{6} = 4$ This could be written $\frac{1z}{6} = 4$ or stated one-sixth of z equals ________.
four (4)	46. To solve the equation, $\frac{z}{6} = 4$, you must first change the fraction $\frac{z}{6}$ to a whole number. To do this, you indicate multiplication of both sides of the equation by the denominator of the fraction. $(6)\ \frac{z}{6} = 4\ (6)$ In order to solve a fractional-type equation you must first change the ________ to a whole ________
fraction number	47. After you indicate that you multiply both sides of the equation by the denominator of the fraction, you must cancel or perform the indicated operation as shown below. $(\cancel{6})\ \frac{z}{\cancel{6}} = 4\ (6)$ thus, $z = 24$ The fraction, in a fractional-type equation, is changed to a whole number by multiplying both sides of the equation by the ________ of the fraction.

denominator	48. To solve the fractional equation, $\frac{c}{5} = 1$, you must first multiply both sides of the equation by the denominator of the fraction. The indicated multiplication is shown below. $(5)\ \frac{c}{5} = 1\ (5)$ The first step to perform when solving the equation above is to __________ both sides of the equation by the __________ of the fraction.
multiply denominator	49. After you have indicated that both sides of the equation, $\frac{c}{5} = 1$, must be multiplied by the denominator of the fraction, you can cancel the fives to the left of the equal sign and multiply the one (1) times five to the right of the equal sign as shown below. $(\cancel{5})\ \frac{c}{\cancel{5}} = 1 \times 5$ thus, $c = 5$ The indicated multiplication to the left of the equal sign in the equation above can be __________.

cancelled	50. Solve the equation below. $\frac{t}{6} = 4$
$(\cancel{6})\frac{t}{\cancel{6}} = 4(6)$ $t = 24$	51. Now you will study the steps to perform when solving more complex fractional type equations. For example, let's solve the equation $\frac{3x}{4} - 12 = 9$. In the first step, you can transpose the term -12 and the equation becomes: $\frac{3x}{4} = 9+12$. The term -12 became a +12 after it was ____________.
transposed	52. After you have transposed the term -12, you can combine like terms and the equation will be $\frac{3x}{4} = 21$. The next step is to multiply both sides of the equation by the denominator as shown below. $(4)\ \frac{3x}{4} = 21\ (4)$ The equation above indicates multiplication, by the denominator, on ____________ sides of the equation.

both	53. The indicated multiplication to the left of the equal sign in the equation $(4)\ \frac{3x}{4} = 21\ (4)$ can be cancelled and the equation is $3x = 21 \times 4$, or $3x = 84$. The next step is to reduce the coefficient of the unknown to one, as shown below. $x = \frac{84}{3}$, thus, $x = 28$. The unknown, in the equation, $x = 28$, now has a ____________ of one and the equation $\frac{3x}{4} - 12 = 9$, is solved.
coefficient	54. Solve the equation below. $\frac{6p}{3} + 8 = 12$

$\frac{6p}{3} = 12 - 8$ $\frac{6p}{3} = 4$ $(\cancel{3})\frac{6p}{\cancel{3}} = 4(3)$ $6p = 12$ $p = \frac{\cancel{12}\,2}{\cancel{6}}$ $p = 2$	55. A more complex fractional-type equation to solve is one in which you must find the LOWEST COMMON DENOMINATOR as the first step. Example $\frac{1}{2} + 2 = \frac{1}{x}$ The lowest common denominator in the example above is 2x. When solving fractional-type equations that contain two or more different denominators, the first step is to determine the __________ __________ denominator.
lowest common	56. Once you have determined the lowest common denominator, you must then multiply all the terms in the equation by that value. Example: $(2x)\frac{1}{2} + (2x)2 = (2x)\frac{1}{x}$ All terms in the above equation must be multiplied by the __________ common __________.
lowest denominator	57. After you have the multiplication of all the terms by the lowest common denominator indicated, you can cancel like values in each of the fractional terms. Example: $(\cancel{2}x)\frac{1}{\cancel{2}} + (2x)2 = (2\cancel{x})\frac{1}{\cancel{x}}$ Thus, $x + 4x = 2$. Like values of the fractional terms can be __________.

cancelled	58. What is the lowest common denominator in the equation below? $\frac{2}{x} + \frac{4}{x} = \frac{1}{4}$ Answer ____________
4x	59. After you have determined the lowest common denominator, you must multiply all the terms by that value. All the terms of a complex, fractional-type equation are multiplied by the ____________ ____________ ____________.
lowest common denominator	**REVIEW** THE EQUATION BELOW SHOWS THE STEPS TO PERFORM WHEN SOLVING FRACTIONAL-TYPE EQUATIONS. $\frac{2}{x} + \frac{4}{x} = \frac{1}{4}$ 4x is the lowest common denominator. $(4x)\frac{2}{x} + (4x)\frac{4}{x} = (4x)\frac{1}{4}$ $(4\cancel{x})\frac{2}{\cancel{x}} + (4\cancel{x})\frac{4}{\cancel{x}} = (\cancel{4}x)\frac{1}{\cancel{4}}$ $(4)2 + (4)4 = (x)1$ $8 + 16 = x$ $24 = x$

60. Solve the equations below.

A. $\frac{2R}{5} = 10$	C. $\frac{x}{2} - \frac{1}{3} = \frac{x}{4} + 2$
B. $a + \frac{1}{2} = \frac{3a}{4}$	D. $4 = \frac{1}{y} + 1$

The answers to the equations in frame 60 are shown below.

A. $\frac{2R}{5} = 10$

$(5)\frac{2R}{5} = 10(5)$

$\cancel{(5)}\frac{2R}{\cancel{5}} = 10(5)$

$2R = 50$

$\frac{\cancel{2}R}{\cancel{2}} = \frac{\cancel{50}}{\cancel{2}}\ 25$

$R = 25$

C.

$\frac{x}{2} - \frac{1}{3} = \frac{x}{4} + 2$

$(12)\frac{x}{2} - (12)\frac{1}{3} = (12)\frac{x}{4} + (12)2$

$\overset{6}{(\cancel{12})}\frac{x}{\cancel{2}} - \overset{4}{(\cancel{12})}\frac{1}{\cancel{3}} = \overset{3}{(\cancel{12})}\frac{x}{\cancel{4}} + (12)2$

$6x - 4 = 3x + 24$

$6x - 3x = 24 + 4$

$3x = 28$

$\frac{\cancel{3}x}{\cancel{3}} = \frac{\cancel{28}}{\cancel{3}}\ 9\frac{1}{3}$

$x = 9\frac{1}{3}$

B. $a + \frac{1}{2} = \frac{3a}{4}$

$(4)a + (4)\frac{1}{2} = (4)\frac{3a}{4}$

$(4)a + \overset{2}{(\cancel{4})}\frac{1}{\cancel{2}} = (\cancel{4})\frac{3a}{\cancel{4}}$

$4a + 2 = 3a$

$4a - 3a = -2$

$a = -2$

D. $4 = \frac{1}{y} + 1$

$4 - 1 = \frac{1}{y}$

$3 = \frac{1}{y}$

$(y)3 = \frac{1}{\cancel{y}}\ (\cancel{y})$

$3y = 1$

$\frac{\cancel{3}y}{\cancel{3}} = \frac{1}{3}$

$y = \frac{1}{3}$

61. A formula varies from the general form of algebraic equations in that symbols are used to represent definite variables.

An equation that has symbols to represent definite variables is a ____________.

formula

62. Symbols, usually letters, are used in formulas to represent definite variables or words.

Definite variables or words are represented in formulas by ____________.

symbols

63. The area (A) of a rectangle is equal to the product of its base (b) times the altitude (h). This statement, written as a formula, is A = bh. You can solve for (b) by using either method shown below.

$$A = bh \qquad\qquad A = bh$$

$$\frac{A}{h} = b \qquad\qquad \frac{A}{h} = \frac{bh}{h}$$

$$\text{or} \qquad\qquad \frac{A}{h} = \frac{b\cancel{h}}{\cancel{h}}$$

$$b = \frac{A}{h} \qquad\qquad \frac{A}{h} = b \text{ or } b = \frac{A}{h}$$

Solve for (h) in the formula A = bh. Use either method you prefer.

$A = bh$ $\frac{A}{b} = h$ $A = bh$ $\frac{A}{b} = \frac{bh}{b}$ $\frac{A}{b} = \frac{\cancel{b}h}{\cancel{b}}$ $\frac{A}{b} = h$ The methods of solving for h are shown above.	64. The commonest formula in electricity is Ohm's Law. A variation of Ohm's law is $E = I \times R$. This means that to find the value of E, you must multiply I times R. Solve for I in the formula $E = I \times R$.
$E = I \times R$ $\frac{E}{R} = \frac{I \times R}{R}$ $\frac{E}{R} = \frac{I \times \cancel{R}}{\cancel{R}}$ $\frac{E}{R} = I$	65. Solve for R in the formula $E = I \times R$.
$E = I \times R$ $\frac{E}{I} = \frac{I \times R}{I}$ $\frac{E}{I} = \frac{\cancel{I} \times R}{\cancel{I}}$ $\frac{E}{I} = R$	66. In the formula, $R_t = R_1 + R_2 + R_3$, if you solved for R_1, the formula would look like this, $R_1 = R_t - R_2 - R_3$. Use the same formula and solve for R_3.

$R_3 = R_t - R_1 - R_2$ or $R_t - R_1 - R_2 = R_3$	67. The formula for finding the area of a triangle is $A = 1/2\ bh$. To solve for h, would the formula look like this? $h = \frac{2A}{b}$ Answer ____
Yes. $(2)A = \frac{1}{\cancel{2}}bh(\cancel{2})$ $2A = bh$ $\frac{2A}{b} = \frac{\cancel{b}h}{\cancel{b}}$ $\frac{2A}{b} = h$	68. In formulas, the exponent of the unknown must be reduced to one (1) before the equation is solved. You <u>reduce the exponent to one by taking the root of each member as</u> shown below. $E^2 = PR$ $\sqrt{E^2} = \sqrt{PR}$ $E = \sqrt{PR}$ When solving formulas that contain terms with exponents of more than one, you must reduce the __________ to one by taking the __________ of both members.
exponent root	69. A power formula of electricity looks like this, $P = I^2R$. If you solved for I, would the formula look like this? $\sqrt{I^2} = \sqrt{\frac{P}{R}}$ Answer ____

No, it would look like this:

$I = \sqrt{\frac{P}{R}}$

because the root of I^2 can be extracted, but the root of $\sqrt{\frac{P}{R}}$ cannot.

70. The formula for finding the volume of a a cone is $V = \frac{\pi r^2 h}{3}$. When solved for h, does the formula look like this?

$h = \frac{3V}{\pi r^2}$

Answer ____

Yes,

$(3)V = \frac{\pi r^2 h(\cancel{3})}{\cancel{3}}$

$3V = \pi r^2 h$

$\frac{3V}{\pi r^2} = \frac{\cancel{\pi r^2} h}{\cancel{\pi r^2}}$

$\frac{3V}{\pi r^2} = h$

REVIEW

TWO METHODS OF SOLVING FOR R IN THE FORMULA $L = \frac{Rm}{K}$ ARE SHOWN IN THE EXAMPLES BELOW.

$L = \frac{Rm}{K}$

$KL = Rm$

$\frac{KL}{m} = R$

or

$R = \frac{KL}{m}$

$L = \frac{Rm}{K}$

$(K)L = \frac{Rm(\cancel{K})}{\cancel{K}}$

$KL = Rm$

$\frac{KL}{m} = \frac{R\cancel{m}}{\cancel{m}}$

$\frac{KL}{m} = R$

or

$R = \frac{KL}{m}$

71. Solve the equations below.

A. Solve for B.

$$V = \frac{Bh}{3}$$

D. Solve for B.

$$C^2 = A^2 + B^2$$

B. Solve for P_2.

$$V_1P_1 = V_2P_2$$

E. Solve for t.

$$s = \frac{At^2}{2}$$

C. Solve for s.

$$hp = \frac{Fs}{550t}$$

The answers to the equations in frame 71 are shown below.

A. $V = \frac{Bh}{3}$

$3V = Bh$

$\frac{3V}{h} = B$

B. $V_1P_1 = V_2P_2$

$\frac{V_1P_1}{V_2} = P_2$

C. $hp = \frac{Fs}{550t}$

$hp550t = Fs$

$\frac{hp550t}{F} = s$

D. $C^2 = A^2 + B^2$

$C^2 - A^2 = B^2$

$\sqrt{C^2 - A^2} = \sqrt{B^2}$

$\sqrt{C^2 - A^2} = B$

E. $s = \frac{At^2}{2}$

$2s = At^2$

$\frac{2s}{A} = t^2$

$\sqrt{\frac{2s}{A}} = \sqrt{t^2}$

$\sqrt{\frac{2s}{A}} = t$

SELF-TEST FOR ALGEBRAIC EQUATIONS

1. Label the equation below with its first member, second member, equal sign, and unknown.

   a. ______________________ b. ______________________

   $$\underbrace{x + 10}\ = \ 5$$

   c. ______________________ d. ______________________

2. Select, from the statements below, the statement that defines an algebraic equation. Circle the letter beside your choice.

   a. Some unknown quantity represented by a symbol that is multiplied by itself.

   b. An algebraic expression containing two or more terms.

   c. Equality between members when at least one member has an unknown.

3. Select, from the statements below, the statement that describes the Golden Rule of algebra. Circle the letter beside your choice.

   a. Take a term from one member of an equation, across the equal sign, and change its operation.

   b. You can do anything to one member of an equation if you do the same thing to the other member.

   c. Factors of an equation are multiplied together and give the original equation.

4. Select, from the statements below, the statement that describes transposition. Circle the letter beside your choice.

   a. Any term preceded by a plus or minus sign may be moved from one member of an equation to the other member if the sign is kept the same

   b. Any term preceded by a plus or minus sign may be moved from, one member of an equation to the other member if the sign of the term is changed.

   c. Any term preceded by a plus or minus sign may be moved from one member of an equation to the other member if all unlike terms are changed.

5. Select, from the statements below, the statements that describe how factors are moved from one side of an equation to the other. Circle the letter beside your choices.

   a. A factor that indicates division on one side of the equal sign may be moved across the equal sign if you change the indicated operation to subtraction.

   b. A factor that indicates multiplication on one side of the equal sign may be moved across the equal sign if you change the indicated operation to division.

   c. A factor that indicates division on one side of the equal sign may be moved across the equal sign if you change the indicated operation to multiplication.

   d. A factor that indicates multiplication on one side of the equal sign may be moved across the equal sign if you change the indicated operation to addition.

6. Select, from the statements below, the statements that describe the conditions to be met when solving algebraic equations. Circle the letter beside your choices.

   a. The unlike terms must be collected or combined.

   b. The coefficient of the unknown must be reduced to one.

   c. The unknown must be on one side of the equation.

   d. The exponent of the unknown can be more than one.

   e. The coefficient of the unknown can be more than one.

   f. The exponent of the unknown must be reduced to one.

   g. The like terms must be collected or combined.

   h. The unknown must be on both sides of the equation.

7. Solve the equations below.

   a. $8a = 40$ b. $23 = 10w$

   c. $2r - 10 = 16$ d. $2z + 2 = 10$

592

8. Solve the equations below.

a. $5x = 3x + 10$

b. $2x^2 - 10 = 190$

c. $4e = 2e + 8$

d. $6x + 4 = 5 + x + 4$

9. Solve the equations below.

a. $16 = 2(t + 3)$

b. $2 + 3(x - 6) = 11$

c. $6(2x - 1) = 3(x + 4)$

d. $[-x + 18(x + 2)] = 53$

10. Solve the equations below.

a. $\frac{3y}{4} = 6$

b. $4 = \frac{2}{z} + 2$

c. $4 + \frac{3b}{10} = 7$

d. $\frac{t}{4} = 3$

11. Solve the equations below.

a. Solve for R_2.

$R_T = R_1 + R_2 + R_3$

b. Solve for R.

$E = I \times R$

c. Solve for I.

$\frac{P}{R} = I^2$

d. Solve for b.

$A = \frac{hb}{2}$

ANSWERS TO SELF-TEST ARE INSIDE COVER PAGE

594

STUDY GUIDE

3ALR91630-II-6b

Technical Training

Cardiopulmonary Laboratory Specialist

NOMOGRAMS

November 1975

10-6

SCHOOL OF HEALTH CARE SCIENCES, USAF
Department of Medicine
Sheppard Air Force Base, Texas 76311

Designed For ATC Course Use

DO NOT USE ON THE JOB

595

Department of Medicine
School of Health Care Sciences, USAF
Sheppard Air Force Base, Texas 76311

SG 3ALR91630-II-6b
November 1975

NOMOGRAMS

OBJECTIVE

Explain the use of Nomograms.

INTRODUCTION

This study guide was prepared to assist in the calculations of complex problems. As Cardiopulmonary Laboratory Technicians you will be required to calculate complex problems. This task is made easier by the use of nomograms. A basic knowledge of the types and uses of nomograms is essential to you as C.P. Techs.

64

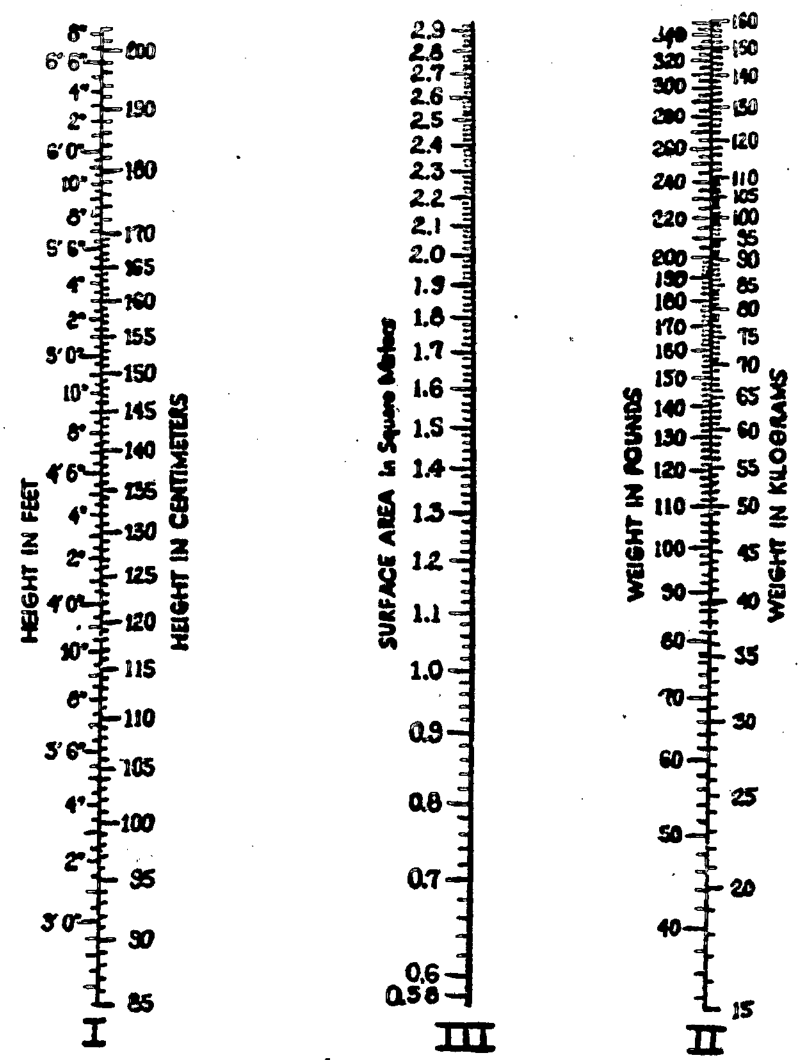
INFORMATION

1. Body Surface Area Nomogram

   a. The following nomogram is used to calculate the body surface area of your patient.

DUBOIS BODY SURFACE CHART

(As prepared by Boothby and Sandiford of the Mayo Clinic)



DIRECTIONS

To find body surface of a patient, locate the height in inches (or centimeters) on scale I and the weight in pounds (or kilograms) on Scale II and place a straight edge (ruler) between these two points which will intersect Scale III at the patient's surface area.

2. Temperature Conversion Nomogram

a. The following nomogram is used to convert the centrigrade temperature from the spirometer to a corrected BTPS factor.

Factors to Convert Gas Volumes from Room Temperature, Saturated, to 37°C, Saturated (9)

Factor to Convert Vol. to 37°C Sat.	When Gas Temperature (C) Is	With Water Vapor Pressure (Mm Hg)* of
1,102	20	17.5
1,096	21	18.7
1,091	22	19.8
1,085	23	21.1
1,080	24	22.4
1,075	25	23.8
1,068	26	25.2
1,063	27	26.7
1,057	28	28.3
1,051	29	30.0
1,045	30	31.8
1,039	31	33.7
1,032	32	35.7
1,026	33	37.7
1,020	34	39.9
1,014	35	42.2
1,007	36	44.6
1,000	37	47.0

*H_2O vapor pressures from Handbook of Chemistry and Physics (28th ed.; Cleveland: Chemical Rubber Publishing Co., 1944), p. 1802.

Note:--These factors have been calculated for barometric pressure of 760 mm Hg. Since factors at 22°C, for example, are 1.0904, 1.0910 and 1.0915, respectively, at barometric pressures 770, 760 and 750 mm Hg, it is unnecessary to correct for small deviations from standard barometric pressure.

TABLE I (BTPS)

Comroe, J. H., Jr.: Methods in Medical Research. Vol. 2. 361 pp. Chicago: Yearbook Publishers, 1950. Pp. 74-244.

3. MEFR & MMF

a. The following nomogram is used to calculate the MEFR & MMF

The $FEF_{200-1200}$ (MEFR) and the $FEF_{25-75\%}$ (MMF)
IN NORMAL ADULTS BY 10 year AGE GROUPS

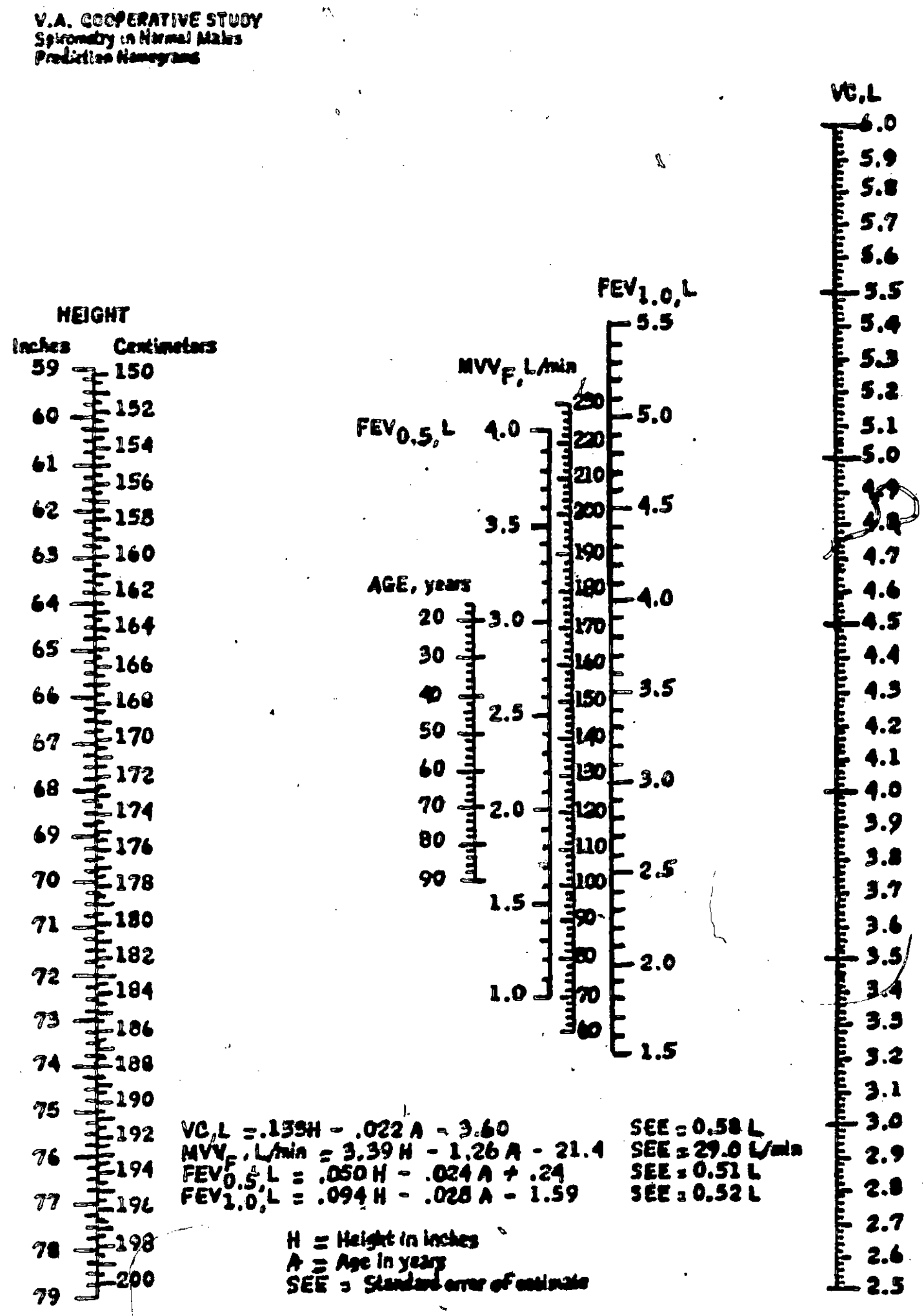
Age Range (yrs.)	Number of Subjects	Mean Values ± Standard Deviations			
		$FEF_{200-1200}$ (MEFR)		$FEF_{25-75\%}$ (MMF)	
		L./sec.	L./min.	L./sec.	L./min.
		MALES			
20 - 29	103	9.1±2.1	546±126	5.4±1.3	324±78
30 - 39	105	9.0±2.0	540±126	4.6±1.2	276±72
40 - 49	150	8.3±2.4	498±144	4.3±1.3	258±78
50 - 59	113	7.2±1.8	432±108	3.6±1.1	216±66
60 - 69	43	6.4±1.9	384±114	3.0±1.0	180±60
		FEMALES			
20 - 29	109	5.9±1.2	354± 72	4.1±0.8	246±48
30 - 39	124	6.0±1.9	360±114	3.9±1.0	234±60
40 - 49	117	5.6±1.2	336± 72	3.4±0.7	204±42
50 - 59	92	5.4±1.2	324± 72	3.1±0.9	186±54
60 - 69	87	4.9±0.8	294± 48	2.8±0.6	168±36

Kory, R. C., Callahan, R., Smith, J. R. and Hamilton, L. H.
To be published.

4. Clinical Spirometry (MEN)

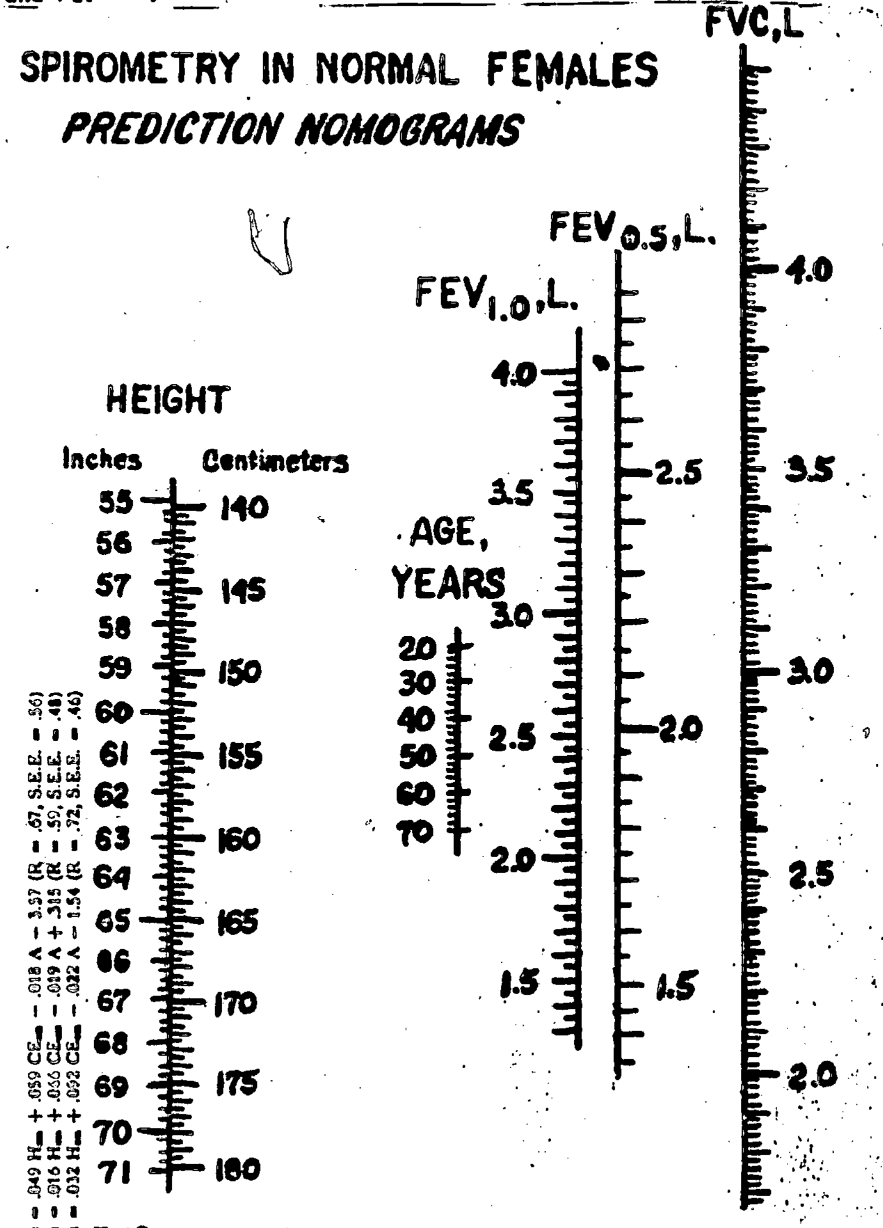
a. The following nomogram is used to calculate the forced vital capacity, $Fev^{0.5}$, $Fev^{1.0}$, and MVV.

Clinical Spirometry in Normal Men—*Kory et al.* AMERICAN JOUR



5. Clinical Spirometry (WOMEN)

a. The following nomogram is used to calculate the following: Forced Vital Capacity Fev 0.5, and Fev 1.0.



VC, liters = .049 H + .059 CE – .018 A – 3.57 (R = .67, S.E.E. = .56)
FEV0.5 liters = .016 H + .036 CE – .019 A + .315 (R = .59, S.E.E. = .48)
FEV1.0 liters = .032 H + .092 CE – .022 A – 1.54 (R = .72, S.E.E. = .46)

$FVC = 0.041\,H - 0.018\,A - 2.689$ (SEE = 0.371)

$FEV_{0.5} = 0.018\,H - 0.011\,A - 0.297$ (SEE = 0.306)

$FEV_{1.0} = 0.028\,H - 0.021\,A - 0.867$ (SEE = 0.330)

H = Height in cm. A = AGE in years. N = 450

SEE = Std. Error of Estimate

600

649

6. Maximum Breathing Capacity of Male Children and Adolescents

   a. This nomogram is used to calculate the MBC in MALE Children & Adolescents.

MAXIMUM BREATHING CAPACITY OF MALE CHILDREN AND ADOLESCENTS

By B. G. Ferris, Jr., M.D., J. L. Whittenberger, M.D., and
J. R. Gallagher, M.D.
Boston

TABLE 2

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO AGE IN YEARS

Age (yrs.)	5.0 to 5.9	6.0 to 6.9	7.0 to 7.9	8.0 to 8.9	9.0 to 9.9	10.0 to 10.9	11.0 to 11.9	12.0 to 12.9	13.0 to 13.9	14.0 to 14.9	15.0 to 15.9	16.0 to 16.9	17.0 to 17.9
No.	4	8	6	7	7	10	6	3	20	72	9	5	4
Mean LPM	42	45	65	69	75	79	75	109	117	117	129	134	155
Std. Dev. LPM	6	10	6	10	19	18	7	17	25	25	34	18	11

TABLE 4

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO WEIGHT IN KILOGRAMS

Wt. (kg.)	20.0 to 24.0	25.0 to 29.9	30.0 to 34.9	35.0 to 39.9	40.0 to 44.9	45.0 to 49.9	50.0 to 54.9	55.0 to 59.9	60.0 to 64.9	65.0 to 69.9	70.0 to 74.9	75.0 to 79.9	80.0 to 84.9
No.	9	7	12	11	10	15	8	22	20	12	18	11	3
Mean LPM	46	53	74	71	83	93	110	121	120	119	126	122	136
Std. Dev. LPM	9	16	17	16	11	10	20	18	27	27	32	24	16

TABLE 6

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO BODY SURFACE AREA IN METERS,

B.S.A. M^2	0.70 to 0.89	0.90 to 0.99	1.00 to 1.09	1.10 to 1.19	1.20 to 1.29	1.30 to 1.39	1.40 to 1.49	1.50 to 1.59	1.60 to 1.69	1.70 to 1.79	1.80 to 1.89	1.90 to 1.99	2.00 to 2.09
No.	8	5	9	9	10	10	11	12	22	36	12	14	3
Mean LPM	46	48	65	70	79	84	93	108	110	130	130	125	148
Std. Dev. LPM	9	16	15	19	12	11	7	28	20	23	50	26	12

TABLE 8

MAXIMUM BREATHING CAPACITY IN LITERS/MINUTE IN RELATION TO HEIGHT IN CENTIMETERS

Ht. (cm.)	115.0 to 119.9	120.0 to 124.9	125.0 to 129.9	130.0 to 134.9	135.0 to 139.9	140.0 to 144.9	145.0 to 149.9	150.0 to 154.9	155.0 to 159.9	160.0 to 164.9	165.0 to 169.9	170.0 to 174.9	175.0 to 179.9	180.0 to 180.9
No.	7	5	4	5	9	9	9	5	12	17	30	19	16	8
Mean LPM	44	45	68	[illegible]	68	79	82	86	[illegible]	115	[illegible]	[illegible]	[illegible]	[illegible]

65

7. Maximum Breathing Capacity in Female Children and Adolescents.

   a. This nomogram is used to calculate the MBC in children and adolescents.

MAXIMUM BREATHING CAPACITY IN FEMALE CHILDREN AND ADOLESCENTS

By B. G. FERRIS, JR., M.D., AND C. W. SMITH, M.D.*
Boston

TABLE 2

MAXIMUM BREATHING CAPACITY IN L./MINUTE IN RELATION TO AGE IN YEARS FOR FEMALE CHILDREN AND ADOLESCENTS

Age, yr.	5.0–5.9	6.0–6.9	7.0–7.9	8.0–8.9	9.0–9.9	10.0–10.9	11.0–11.9	12.0–12.9	13.0–13.9	14.0–14.9	15.0–15.9	16.0–16.9	17.0–17.9	18.0–18.9
No.	12	8	13	10	20	22	23	[illegible]	14	10	12	10	12	2
Mean, LPM	41.2	52.6	52.8	60.3	67.0	71.9	79.3	96.8	[illegible]	[illegible]	105	98.0	[illegible]	[illegible]
Std. Dev., LPM	10.9	5.2	10.1	12.1	10.5	11.2	14.9	21.3	18.7	20.3	22.2	18.2	24.0	20.1

TABLE 4

MAXIMUM BREATHING CAPACITY IN L./MINUTE IN RELATION TO WEIGHT IN KG. FOR FEMALE CHILDREN AND ADOLESCENTS

Wt., kg.	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	45.0–49.9	50.0–54.9	55.0–59.9	60.0–64.9	65.0–69.9	70.0–74.9	75.0–79.9
No.	6	[illegible]	17	19	26	28	[illegible]	[illegible]	[illegible]	15	4	3	1
Mean, LPM	[illegible]	[illegible]	60.7	65.0	77.6	77.3	[illegible]	91.6	[illegible]	105.9	97.9	[illegible]	131.7
Std. Dev., LPM	5.3	10.0	10.0	13.5	13.4	15.2	19.9	[illegible]	[illegible]	23.3	23.6	17.5	

TABLE 6

MAXIMUM BREATHING CAPACITY IN L./MINUTE IN RELATION TO BODY SURFACE AREA IN METERS² FOR FEMALE CHILDREN AND ADOLESCENTS

B.S.A., M²	0.60–0.79	0.80–0.89	0.90–0.99	1.00–1.09	1.10–1.19	1.20–1.29	1.30–1.39	1.40–1.49	1.50–1.59	1.60–1.69	1.70–1.79	1.80–1.89
No.	5	18	14	25	30	22	32	30	[illegible]	34	9	3
Mean, LPM	41.9	53.0	59.6	63.3	69.3	75.7	81.2	90.8	[illegible]	[illegible]	120.6	[illegible]
Std. Dev., LPM	10.4	11.3	17.9	13.4	11.8	13.1	13.9	[illegible]	[illegible]	24.5	17.9	19.1

TABLE 8

MAXIMUM BREATHING CAPACITY IN L./MINUTE IN RELATION TO HEIGHT IN CM. FOR FEMALE CHILDREN AND ADOLESCENTS

Ht., cm.	100.0–109.9	110.0–114.9	115.0–119.9	120.0–124.9	125.0–129.9	130.0–134.9	135.0–139.9	140.0–144.9	145.0–149.9	150.0–154.9	155.0–159.9	160.0–164.9	165.0–169.9	170.0–174.9
No.	4	7	13	10	15	19	30	19	16	23	[illegible]	13	17	6
Mean, LPM	41.5	45.2	49.8	64.7	57.9	66.1	72.0	73.7	77.9	80.3	90.9	[illegible]	101.5	[illegible]
Std. Dev., LPM	13.6	8.6	11.0	16.3	9.3	10.6	11.3	13.2	13.4	[illegible]	21.8	24.4	23.4	16.6

PREPARE THE MAN

PROGRAMMED TEXT 3ALR91630-II-10a (1)

602

Department of Medicine
School of Health Care Sciences

CARDIOPULMONARY LABORATORY SPECIALIST

BASIC MATHEMATICS.PERCENTAGE

July 1973

10-6

Sheppard Air Force Base, Texas

Original Material Prepared
by
Naval Air Technical Training Command
(2TPT-5111-05)

Designed For ATC Course Use

DO NOT USE ON THE JOB

652

PURPOSE OF STUDY GUIDES, WORKBOOKS, PROGRAMMED TEXTS AND HANDOUTS

Study Guides, Workbooks, Programmed Texts and Handouts are training publications authorized by Air Training Command (ATC) for student use in ATC courses.

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The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

The STUDY GUIDE AND WORKBOOK (SW) contains both SG and WB material under one cover. The two training publications are combined when WB is not designed for you to write in, or when both SG and WB are issued for you to keep.

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ANSWERS TO SELF-TEST

1. PARTS PER HUNDRED

2. a. 12%
   b. 23%
   c. .5% or ½%

3. a. .28
   b. .635
   c. .0075

4. a. 73/100

   b. 1/5

   c. 43/100

5. a. 75%
   b. 66 2/3%
   c. 81.25%

6. a. $\frac{X}{50} = \frac{3\%}{100\%}$

   b. $\frac{12}{75} = \frac{X}{100\%}$

   c. $\frac{9}{X} = \frac{12\%}{100\%}$

7. a. 43.2
   b. 32

8. a. 23.3
   b. 12.5

9. a. 40
   b. 1600

10. a. 675
    b. 121

606

ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by page and/or frame)	REVIEW QUESTIONS (by No)

653

407

OBJECTIVES

1. Write the definition of percent.

2. Change given decimals to percents.

3. Change given percents to decimals.

4. Change given percents to fractions.

5. Change given fractions to percents.

6. Substitute numbers taken from given problems into the "percentage problem formula". The formula will be given.

7. Solve problems by finding percentages.

8. Solve problems by finding what percent one number is of another.

9. Solve problems by finding a number when the percent of a number is known.

10. Solve problems where the percents are greater than 100%.

When working with percents, you will also have to use decimals and fractions at times. Therefore, a knowledge of each will be required. The denominator of a decimal fraction will be determined as follows: The number immediately to the right of the decimal point indicates tenths value. For example, .5 equals 5/10. The second number to the right of the decimal point indicates hundredths, .75 equals 75/100. The third indicates thousandths, .250 equals 250/1000. Each fraction can then be reduced to its lowest terms.

SUGGESTED READING TIME 55 MINUTES

	1. Percent (%) is defined as parts per hundred. Therefore, in the fraction $\frac{6}{100}$, which is the same as the decimal .06, the 6 indicates we are concerned with six parts per __________.
hundred	2. 33%, written as a fraction $\frac{33}{100}$ or the decimal .33, indicates we are concerned with __________ parts per __________.
33 hundred	3. 5% of a number means $\frac{5}{100}$ of it; 15% of a number means $\frac{15}{100}$ of it. Therefore, 23% of a number means __________ (Fraction) of it and indicates we are concerned with _____ parts per hundred.
23/100 23	4. Percent is defined as __________ per __________.
parts hundred	5. In your own words, write the definition of percent. ______________________________
parts per hundred	6. To change a decimal to a percent, the first step is to move the decimal point two places to the right, e.g., .28 or 28. Therefore, the decimal .28 becomes 28. To change a decimal to a percent, the first step is to move the decimal point two places to the __________.

Continue to page 3

2A

5 is correct. 5 is the smallest number of sailors, because 25 is the total number of sailors in the office. Proceed to page 4B.

2B

10% is wrong. 10% <u>is</u> the smaller of the two percents. However, we are looking for the number of people. (This is on the left side of the equal sign.) Return to page 4B and select another answer.

2C

$\frac{63}{X} = \frac{100\%}{720}$ is incorrect. Remember to keep all the percents on one side of the equal sign and all other information on the other side. In this case, 100% should be on the bottom right. "X" is the percent we are looking for and 720 is the larger number and is placed on the bottom left. Return to page 8A and select another answer.

right	7. After moving the decimal point two places to the right, add the percent sign (%); e.g., .35 or 35. or 35%. To change a decimal to a percent, move the decimal point ________ places to the ________ and add the ________ sign.
two right percent (%)	8. The decimal .83 is changed to a percent by moving the decimal point ________ places to the ________. The result is ________.
two right 83%	9. Change the following decimals to percents: a. .15 equals ____% b. .23 equals ____% c. .75 equals ____% d. .31 equals ____% e. .005 equals ____%
a. 15% b. 23% c. 75% d. 31% e. $\frac{1}{2}$ or .5%	10. A decimal point is not shown with whole percents. For example, 63% does not have a decimal point shown. Mentally, however, a decimal point is placed to the right of the number three (63.%). In the percent below, place an "X" where you would mentally place a decimal point. 47 %
47x%	11. Fractional percents do have decimal points. For example, 56½% can be written as 56.5%. The fractional percent 23¼% can be written as ________.

Continue to page 5

4A

$\frac{63}{720} = \frac{X}{100\%}$ is correct. You have set the problem up in the correct form for solving percents. Try one more for a double check. "John purchased 24 oranges and later found 6 were spoiled. What percent were spoiled?" Select the correct formula.

If your answer is:	Go to page:
$\frac{6}{24} = \frac{X}{100\%}$	10B
$\frac{6}{X} = \frac{100\%}{24}$	6B

4B

Using the problem below, substitute into the formula. "10% of the people in town are farmers. There are 90 people in town. How many are farmers?" What number should go on the bottom left to complete the formula?

$$\frac{\text{small}}{\quad} = \frac{10\%}{100\%}$$

If your answer is:	Go to page:
90	6A
10%	2B
100%	8B

4C

25 is not correct. 25 is the total number of airmen in the office. Therefore, the number of airmen that are overweight must be a smaller number. Return to page 10A and select another answer.

23.25%	12. Change a percent to a decimal by dropping the percent sign and moving the decimal point two places to the left. For example, 12.5% becomes 12.5 after dropping the percent sign. Move the decimal point two places to the left and 12.5 then becomes .125. Therefore, the percent 12.5% equals the decimal .125. In changing a percent to a decimal, move the decimal point two places to the __________.
left	13. The first step in changing 46% to a decimal is to drop the __________.
percent sign	14. The second step is to move the decimal point __________ places to the __________.
two left	15. Change the following percents to decimals: a. 34% equals __________ b. ¼% equals __________ c. 24.5% equals __________ d. .5% equals __________

Continue to page 7.

6A

90 is correct. It is the total number of people in town. The number of farmers would be a smaller number, since there are only 10% farmers. Proceed to page 8A.

6B

$\frac{6}{X} = \frac{100\%}{24}$ is incorrect. All percents are placed on one side of the equal sign and all other information on the opposite side. Return to page 4A and select another answer.

6C

$\frac{63}{720} = \frac{100\%}{X}$ is incorrect. You are looking for the smaller percentage. 100% should be on the bottom of the formula. Return to page 8A and select another answer.

a. .34 b. .0025 c. .245 d. .005 (Read the question carefully. ¼% is less than 1%. Therefore, ¼% equals the decimal .0025 and not .25)	16. To change a percent to a common fraction, first change the percent to a decimal. For example, 75% = .75. 45% would be changed to the decimal .45. The second step after changing the percent to a decimal is to change the decimal to a fraction and reduce to its lowest terms. Refer to footnote on instruction page 1. For example, 80% = .80 = $\frac{80}{100}$ or $\frac{4}{5}$. In changing a percent to a fraction, first change the percent to a __________ and then to a __________ and reduce to its lowest terms.
decimal fraction	17. 60% is equal to the decimal __________ and the fraction __________.
.60 60/100 or 3/5	18. Change the following percents, first to decimals and then to fractions. Reduce to lowest terms. a. 40% = __________ = __________ b. 22.5% = __________ = __________ c. 20% = __________ = __________ d. 12.5% = __________ = __________.
a. .40 2/5 b. .225 9/40 c. .20 1/5 d. .125 1/8	19. To change a fraction to a percent, first change the fraction to a decimal and then the decimal to a percent. For example, $\frac{3}{8}$ = .375 = 37.5%. To change the fraction $\frac{2}{3}$ to a percent, you must first change it to a __________.

Continue to page 9

8A

Select the correct formula for the following problem. "X" indicates the unknown number (number to be found). "Out of 720 weather observations taken last month, there were 63 errors. What was the percent of error? You are looking for a percent that represents 63 errors.

If your answer is:	Go to page:
$\frac{63}{X} = \frac{100\%}{720}$	2C
$\frac{63}{720} = \frac{100\%}{X}$	6C
$\frac{63}{720} = \frac{X}{100\%}$	4A
$\frac{X}{720} = \frac{63}{100\%}$	10C

8B

100% is incorrect. We are looking for the large number. True, 100% is a large number but we are looking for a large number representing people. Return to page 4B and select another answer.

8C

100% is not correct. You are looking for the smallest number. 100% would be the total percent of sailors in the office or the largest number percentage-wise. Return to page 10A and select another answer.

decimal	20. After changing the fraction to a decimal, change the decimal to a percent. $\frac{3}{4}$ is changed to the decimal .75 and then changed to a ____________.
percent	21. To change a fraction to a percent, first change the fraction to a ____________ and <u>then</u> to a ____________.
decimal percent	22. $\frac{4}{5}$ is first changed to the decimal .80 and then to the percent ____________.
80% ($\frac{4}{5}$ is changed to a decimal by dividing the 4 by 5 and then to a percent by moving the decimal point two places to the right and adding the percent sign %)	23. Change the following fractions to percents. Be careful with your division. a. $\frac{3}{4}$ = ____________ b. $\frac{3}{8}$ = ____________ c. $\frac{7}{8}$ = ____________ d. $\frac{3}{9}$ = ____________

Continue to page 10A

ANSWERS FROM PAGE 9: a. 75% b. 37.5% c. 87.5% d. 33.3%

10A

All percentage problems can be solved by substituting given information into the formula $\frac{\text{small number}}{\text{large number}} = \frac{\%}{100\%}$.

For the problem, "There are 25 airmen in the office. Of the 25, there are 5, overweight. What percent of the airmen are overweight?

The formula would look like this: $\frac{\text{(small)}}{\text{(large)}} = \frac{X\text{(unknown)}\%}{100\%}$.

Substituting from the information in the problem, what number should you place on the top left in the formula? Select an answer below and turn to the page indicated after your answer.

If your answer is:	Go to page:
5	2A
25	4C
100%	8C

10B

$\frac{6}{24} = \frac{X}{100\%}$ is correct. Now for the final test. Go to page 11, Frame 24 and continue.

10C

$\frac{X}{720} = \frac{63}{100\%}$ is incorrect. Remember that all percents are on one side of the equal sign. The unknown (X) is a percent and should be on the other side. Return to page 8A and select another answer.

	24. A company had 100 employees and 15 were women. Write the formula using the given information. Proceed to the next frame to check your answer. ____________ (Your answer)
$\frac{15}{100} = \frac{X}{100\%}$	25. It rained 10 days out of 30. Write the formula using the given information. ____________
$\frac{10}{30} = \frac{X}{100\%}$	26. 20 men work in the weather office. 4% can go on leave. You would be looking for the number of men on leave as the unknown value. ____________
$\frac{X}{20} = \frac{4\%}{100\%}$	<u>REVIEW</u> Percentage numbers all go on one side of the formula and all other information on the other side. For example, $\frac{\text{small}}{\text{large}} = \frac{\text{small }\%}{100\%}$

Continue to page 12

	27. You are now going to learn how to <u>solve</u> percentage problems. For example, 20 students are in the class. 20% are failing. How many students are failing? Substitute into the formula by changing percents to decimals and cross-multiply. (Do not reduce before multiplying.) Step #1 $\frac{\text{small}}{\text{large}} = \frac{\%}{100\%}$ #2 $\frac{\text{X (unknown)}}{\text{20 students}} = \frac{20\%}{100\%}$ #3 $\frac{X}{20} = \frac{.20}{1.00}$ (Change percents to decimals and cross-multiply.) #4 $1X = 4.00$ #5 X = ________ students failing. (Your answer) #6 <u>Read the problems carefully.</u>
4	28. Solve the following problems. You are solving for the <u>percent of a number</u>. During the month of April (30 days), it rained 23% of the time. How many days did it rain? ________________ (Place answer here)
6.9	29. During the year (365 days), it was cloudy 48% of the time. How many days was it cloudy? ________________ (Place answer here)

Continue to page 13

620

175.2	30.	Solve the following problems by finding what percent one number is of another. It rained 12 days during the months of September and November (60 days). What percent of the total days did it rain? ______
20%	31.	Of the 1400 personnel assigned to an Air Force Base, 65% own automobiles. How many personnel own automobiles? ______
910	32.	Solve the following problems by finding a number when the percent of a number is known: The Smith family spends $52 weekly for food, shelter, and clothing. That is 65% of their weekly income. What is their weekly income? ______
$80	33.	Bill said that the $10.50 he intended to spend for a football was just 35% of what he had saved. How much did he save? ______

Continue to page 14

$30	34. At times, you will be using percents greater than 100%. For example, current enrollment is 250% of last year's; last year's enrollment was 160. In this case, the larger percent (250%) goes on the bottom and 100% goes on top. For example, $\frac{160}{X} = \frac{100\%}{250\%}$. Solve the following problems where percents are greater than 100%. Last year's donations amounted to $154. This year's donations were 120% of last year's. What was the amount donated this year? ________________
$184.80	35. Find 122% of 65. ________________
79.3	You have just completed a programmed course in percentage. END

SELF-TEST

1. Write the definition of percent.

2. Change each of the following decimals to a percent:

   a. .12 =

   b. .23 =

   c. .005 =

3. Change each of the following percents to a decimal:

   a. 28% =

   b. $63\frac{1}{2}$% =

   c. $\frac{3}{4}$% =

4. Change each of the following percents to a fraction and reduce to lowest terms:

   a. 73% =

   b. 20% =

   c. 43% =

5. Change each of the following fractions to a percent:

   a. $\frac{3}{4}$ =

   b. $\frac{2}{3}$ =

   c. $\frac{13}{16}$ =

Continue to page 16

6. Using the "percentage problem formula", $\frac{\text{small number}}{\text{large number}} = \frac{\%}{100\%}$,
substitute numbers into the formula from the following problems.

Do not try to solve the problems. Set up the formula only.

a. The trainee fired 50 shots at the target, missing only 3%.

b. During the next firing, the trainee missed 12 out of 75 shots.

c. 9 non-rated personnel work in an office. The non-rated personnel make up 12% of the office staff.

a. ____________ b. ____________ c. ____________

7. Solve the following problems by finding the percentage. Use the formula.

a. Last month the Weather Office took 720 weather observations and made 6% error. How many errors were made?

b. Out of 40 personnel in the Weather Office, 80% are qualified weather observers. How many personnel are qualified weather observers?

8. Solve the following problems by finding what percent one number is of another:

a. The duty section made 14 errors out of 60 observations. What was their percent of error?

b. The weather office has 4 out of 32 personnel in the hospital. What percent of the total personnel are in the hospital?

Continue to page 17

624

9. Solve the following problems by finding a number when the percent of a number is known:

a. 10% of the weather office personnel are allowed on leave. If there are 4 men on leave, how many men are attached to the weather office?

b. $\frac{3}{4}$% of the observations are in error. There are 12 errors.

How many observations were taken?

10. Solve the following problems. The percents are greater than 100%.

a. Last year the enrollment at the school was 540 students. The enrollment this year is 125% of last year's. What was the enrollment this year?

b. Find 275% of 44.

Go to inside front cover (i) for answers.

ATC-SHEPPARD AFB TEX. 70-9250

625 (2)

PREPARE THE MAN

PROGRAMMED TEXT 3ALR91630-II-10 A

Department of Medicine
School of Health Care Sciences

Technical Training

CARDIOPULMONARY LABORATORY SPECIALIST

REVIEW OF ARITHMETIC AND WHOLE NUMBERS

July 1973

10-6

Sheppard Air Force Base, Texas

Original Material Prepared
by
Naval Air Technical Training Command
(2TPT-5111-04)

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ANSWERS TO SELF TEST

1. A whole number represents/a complete unit.

2. millions
   hundred thousands
   ten thousands
   thousands
   hundreds
   tens
   units

3. e
   f
   a
   c

4. a. 127,010
   b. 2,840,000
   c. 334,000,000
   d. 1,000
   e. 100,000
   f. 500

5. a. minuend
   subtrahend
   remainder

   b. divisor
   quotient
   dividend
   remainder
   factors

   c. addend
   addend
   sum

   d. multiplicand
   multiplier
   product
   factors

6. a.
```
  455
  x33
 1365
1365
15015
```
b.
```
 3,690
-2,460
 1,230
```
c.
```
 44
275
+ 9
328
```
d.
```
     8
50/400
   400
```

7. a.
```
     8            38
38/308   check   x 8
  304            304
    4            + 4
                 308
```
b.
```
 389           122
  27   check    27
+122          +389
 538           538
```
c.
```
                  47          22
 47   check  22/1034  or 47/1034
x22              88           94
 94             154           94
 94             154           94
1034
```
d.
```
 996   check   939
 -57           +57
 939           996
```

8. a. 25
   b. 82
   c. 0
   d. 28

	1. Whole numbers represent COMPLETE UNITS. For example, the whole number 2 would represent two complete units. A COMPLETE UNIT is represented by a ____________ number.
whole	2. All whole numbers show or represent some "complete" unit. The definition of a whole number is: A whole number represents a ____________ unit.
complete	3. A whole number represents a complete unit. This is the definition of a ____________ ____________.
whole number	4. Write, in your own words, the definition of a whole number. ______________________________ ______________________________ - - - - - - - - - - - - - - - - If you need review of some part of the Program after you have already covered that section, you may turn back.

Continue to page 3

2A

Your addition is fine, but remember that you must put like units under like units. It makes no difference where you put the large numbers in the sequence but units must be under units, tens under tens, etc. The addition problem, 25 + 3,920, would be set up like this:

$$\begin{array}{r} 3{,}920 \\ \underline{25} \end{array} \quad \text{or} \quad \begin{array}{r} 25 \\ \underline{+3{,}920} \end{array}$$

Set up and solve this problem:

27 + 598 + 20,047 =

If your answer is:	Go to page:
20,047 27 + 598 20,672	6B
598 20,047 + 27 20,572	4B

2B

The smaller number must go on the bottom. Subtraction that is accurate is not possible the way it was set up. Always put the smaller number below the larger. Go back to page 6A and select the correct answer.

630

A whole number represents a complete unit.

5. Each digit in a whole number has a place value. The position of the digit in the number indicates its place value. The whole number below gives the name of each place.

9,	6	8	7,	3	5	4,	8	2	4,	3	4	7
TRILLIONS	HUNDRED BILLIONS	TEN BILLIONS	BILLIONS	HUNDRED MILLIONS	TEN MILLIONS	MILLIONS	HUNDRED THOUSANDS	TEN THOUSANDS	THOUSANDS	HUNDREDS	TENS	UNITS

The place to the far right is the ____________ place

units

6. The whole number 3,200 is to the thousands place. The two in the number is to the ____________ place.

hundreds

7. A very large number such as 23,913,777 is out to the ten ____________ place and the 1 in the number is in the ____________ ____________ place.

Continue to page 5

4A

You're guessing! The problem is set up all right but there is an error in arithmetic. Take a little more time with your work. Go back to page 21, frame 34, and find the correct answer.

4B

Watch your addition. Make sure that you "carry," because that is just what you neglected in this problem. Go back to page 2A and check the other answer. Then go to the correct answer page.

4C

Right. Try another to make sure that you have the idea.

$555 - 396 =$

If your answer is:	Go to page:
$\begin{array}{r} 555 \\ -396 \\ \hline 259 \end{array}$	6C
$\begin{array}{r} 555 \\ -396 \\ \hline 159 \end{array}$	16B

millions ten thousands	8. Label the place of each digit in the whole number below. (805,732,567) 8 ________ 0 ________ 5, ________ 7 ________ 3 ________ 2, ________ 5 ________ 6 ________ 7 ________
hundred millions ten millions millions hundred thousands ten thousands thousands hundred tens units	9. A whole number is read from the left. For example, the whole number 524 is read five hundred twenty-four. One thousand twenty-six would be shown as a whole number as ________ (number).
1,026	10. The commas in a whole number separate the major groups. The whole number seventy-seven million six hundred sixty-six thousand five hundred fifty-five would appear as ________.

Continue to page 7

6A

Right. Now let's subtract whole numbers. Just as in addition, like units must go under like units, BUT the smaller of the numbers will go under the larger. For example:

366 - 25 = would be set up like this:

$$\begin{array}{r} 366 \\ \underline{-25} \\ 341 \end{array}$$

Set up and work this problem. 3006 - 375 =

If your answer is:	Go to page:
$\begin{array}{r} 375 \\ \underline{-3,006} \\ 2,369 \end{array}$	2B
$\begin{array}{r} 3,006 \\ \underline{-\ 375} \\ 2,631 \end{array}$	4C

6B

Now you have it. Remember that like units go under like units. You are now ready for subtraction. Look at frame 6A, read the information, and work the problem.

6C

You did not borrow correctly. $\begin{array}{r} 555 \\ \underline{-396} \\ 259 \end{array}$ This is the way your problem appeared. After you borrow 1 from the hundreds place, it should change from 5 to a 4. Return to page 4C and rework the problem.

77,666,555	11. Match the word form number in column A with the numerical form in column B by placing the letter of the word form next to the correct number. A a. Three hundred five. b. Four thousand three hundred forty-five. c. Seventy million. d. Three hundred forty-nine million six hundred four. B _____ 349,604 _____ 70,000 _____ 4,345 _____ 305 _____ 44,345 _____ 70,000,000 _____ 349,000,604
a. 305 b. 4,345 c. 70,000,000 d. 349,000,604	12. In ROUNDING OFF whole numbers, <u>first</u> determine the place you want to round off. Then look at the number DIRECTLY to the RIGHT of the place. If it is 5 or more, the place becomes 1 more. For example: Round 10,869 to TENS. First look at the number to the right of the tens place. It is a 9. So the tens place (6) becomes 1 more (7) and the whole number becomes __________. (number)

Continue to page 9

8A

Right! Another thing to remember is: ZERO times ANY number is ZERO.

Example: 3,889,497 x 0 = 0

Let's try division. The division problem 250 ÷ 25 = 10 says 250 divided by 25 equals 10. Set up in workable form, it would look like this:

$$\begin{array}{r} 10 \\ 25\overline{)250} \\ \underline{25} \\ 00 \end{array}$$

. Notice that the number to the right of the division sign (÷ 25) is the divisor and goes outside the division block.

Work this problem:

450 ÷ 5 =

If your answer is:	Go to page:
90	18A
.01	14A

8B

Solve and check the following problems:

a. $10\overline{)352}$ check—

b. $\begin{array}{r} 12 \\ 16 \\ +\underline{305} \end{array}$ check—

c. $\begin{array}{r} 15 \\ \times\underline{3} \end{array}$ check—

d. $\begin{array}{r} 127 \\ -\underline{39} \end{array}$ check—

Answers on page 20.

10,870	13. If the number to the right of the place is LESS THAN 5, the value of that place will not change. The whole number 349 rounded to hundreds is __________.
300	14. ONLY the number to the right of the place you are rounding off is considered. Do not consider any other number. Round off 21,250 to thousands. __________.
21,000	15. Rounding off to the nearest FIVE hundred is somewhat different. If the number (to the hundreds place) is closer to 500 than it is to 000, then round to 500. For instance, 251 is closer to 500 than it is to 000, so 251 rounded to the nearest five hundred is __________.
500	16. If the number is closer to 1,000 than it is to 500, it is rounded off to 1,000. 762 rounded to the nearest five hundred is __________.
1,000	17. Round off the following whole numbers: 415,001 to ten thousands __________ 152,299 to hundred thousands __________ 12,636 to five hundreds __________

Continue to page 11.

10A

ANSWERS TO PAGE 18A:

a.
$$\begin{array}{r} 447 \\ +886 \\ \hline 1333 \end{array}$$

b.
$$\begin{array}{r} 670 \\ \times 350 \\ \hline 33500 \\ 2010 \\ \hline 234{,}500 \end{array}$$

c.
$$\begin{array}{r} 125 \\ 3\overline{)375} \\ \underline{3} \\ 7 \\ \underline{6} \\ 15 \\ 15 \end{array}$$

d.
$$\begin{array}{r} 3{,}030 \\ -2{,}300 \\ \hline 730 \end{array}$$

All problems can be checked to see if they are correct. This is done by doing the opposite function to the one that you had completed. For example, when you subtract, the check is done by adding the remainder to the subtrahend. If your subtraction was correct, the result will be the MINUEND.

Look at this problem:
$$\begin{array}{r} 300 \\ -\ 30 \\ \hline 270 \end{array} \quad \text{check} \quad \begin{array}{rl} 270 & \text{remainder} \\ +\ 30 & \text{subtrahend} \\ \hline 300 & \text{minuend (sum)} \end{array}$$

Solve and check this problem:
$$\begin{array}{r} 455 \\ -\ 50 \\ \hline \end{array} \quad \text{check} \ \_\_\_$$

If your answer is:	Go to page:
$\begin{array}{r} 455 \\ -\ 50 \\ \hline 405 \end{array}$ check $\begin{array}{r} 405 \\ -\ 50 \\ \hline 355 \end{array}$	16A
$\begin{array}{r} 455 \\ -\ 50 \\ \hline 405 \end{array}$ $\begin{array}{r} 405 \\ +\ 50 \\ \hline 455 \end{array}$	12A

10B

Your check was not correct; you multiplied the remainder by the divisor when you should have multiplied the divisor by the quotient and then added the remainder. Your answer will be the dividend, if your original division was right. Go back to page 14B and try the problem again.

420,000 200,000 12,500	18. Round off each of the following whole numbers: 276 to five hundreds __________ 549 to hundreds __________ 11,637,520 to millions __________ 132,399 to ten thousands __________ 749,999 to hundred thousands __________ 3,274 to tens __________
500 500 12,000,000 130,000 700,000 3,270	19. The answer arrived at by the addition of numbers is called the SUM. The numbers that are being added are called ADDENDS. Label the parts of the problem below: 4,444 __________ +333 __________ 4,777 __________
addend addend sum	20. The parts in a subtraction problem are the minuend, subtrahend, and the remainder. Example: 908 minuend - 143 subtrahend 765 remainder The answer or result is called the __________.
remainder	21. The larger number or the number you are subtracting from is called the __________ and the smaller number that is being subtracted from the larger number is called the __________.

Continue to page 13

12A

Very good. To check addition problems, invert the column and add. It is that simple.

Multiplication is checked by dividing the product by either the multiplicand or the multiplier. For example: $2 \times 3 = 6$ can be checked by dividing $2\overline{)6}$ (quotient 3) or $3\overline{)6}$ (quotient 2). Notice that the dividend is the product of the multiplication problem. Remember that you may use either one of the factors in the divisor spot, but the quotient must be the other factor.

Solve and check this problem. $4 \times 8 =$ check —

If your answer is:	Go to page:
$4 \times 8 = 32$ check $8\overline{)32}$ (quotient 4) or $4\overline{)32}$ (quotient 8)	14B

If you did not arrive at the above answer, reread the information.

12B

Wrong. You have placed the numbers directly below each other in the body of the multiplication. This is wrong. When your multiplication reaches the tens, hundreds, etc., place in your factors, the results will fall directly below the place. It will look like the other answer on page 16B, so return to page 16B and work the problem correctly.

640

minuend subtrahend	22. Label the parts of the problem below. $\begin{array}{r} 3{,}002 \\ -3{,}001 \\ \hline 1 \end{array}$ __________
minuend subtrahend remainder	23. Label the parts of these problems. a. $\begin{array}{r} 678 \\ +28 \\ \hline 706 \end{array}$ __________ b. $\begin{array}{r} 67 \\ -7 \\ \hline 60 \end{array}$ __________
a. addend addend sum b. minuend subtrahend remainder	24. Multiplication problem parts are multiplicand, multiplier, and product. The multiplicand is a number that is to be multiplied by another. The multiplier is the number doing the multiplying. The product is the answer. $\begin{array}{r} 45 \\ \times 4 \\ \hline 180 \end{array}$ In this problem, what is the number 4 called? __________
multiplier	25. The numbers that are being multiplied are also called factors. Label the problem below. $\begin{array}{r} 25 \\ \times 3 \\ \hline 75 \end{array}$ __________ The 25 and 3 are called __________.

Continue to page 15

14A

The only way possible to get the answer you have is to set up the problem incorrectly. 450 ÷ 5 is set up like this: $5\overline{)450}$

It states 450 divided by 5. The number to the right of the division sign always goes outside the division block. Return to page 8A and work the problem correctly. Then select the correct answer and go to the indicated page.

14B

Right. All that is left to check is division. This is done by multiplying the divisor by the quotient and adding the remainder (if any).

For example:

$$\begin{array}{r} 5 \\ 3\overline{)17} \\ \underline{15} \\ 2 \end{array} \quad \text{check} \quad \begin{array}{rl} 5 & \text{quotient} \\ \underline{\times 3} & \text{divisor} \\ 15 & \\ \underline{+\ 2} & \text{remainder} \\ 17 & \text{dividend} \end{array}$$

Solve and check this problem:

$5\overline{)23}$ check—

If your answer is:	Go to page:
$\begin{array}{r} 4 \\ 5\overline{)23} \\ \underline{20} \\ 3 \end{array}$ check $\begin{array}{r} 5 \\ \underline{\times 3} \\ 15 \\ \underline{+4} \\ 19 \end{array}$	10B
$\begin{array}{r} 4 \\ 5\overline{)23} \\ \underline{20} \\ 3 \end{array}$ check $\begin{array}{r} 5 \\ \underline{\times 4} \\ 20 \\ \underline{+3} \\ 23 \end{array}$	18B

multiplicand multiplier product factors	**26. Label the parts of each problem below.** a. 387 __________ b. 300 __________ -20 __________ x 3 __________ 367 __________ 900 __________ c. The 300 and 3 in problem b. are called __________.
a. minuend subtrahend remainder b. multiplicand multiplier product c. factors	27. In division, the names of the parts are divisor, dividend, quotient, and remainder. The quotient is the answer. For example: $14\overline{)28}$ with 2 above. 2 in the problem is the __________.
quotient	28. The dividend is the number or quantity that is being divided and the divisor is the number that is divided into the dividend. The divisor and quotient are factors of the dividend. In the problem $14\overline{)28}$ with 2 above, the 14 is the divisor and the 28 is the __________. The 14 and 2 are __________ of the dividend.
dividend factors	29. If the division doesn't come out evenly and there is a quantity left, that quantity is called the remainder. Label the parts of the problem below. 19 $15\overline{)292}$ 15 142 135 7 15 __________ 19 __________ 292 __________ 7 __________ 15 and 19 __________

Continue to page 17

643

16A

No! You must add the <u>remainder</u> to the <u>subtrahend</u> in order to obtain the minuend. This is the only way we know our subtraction is correct. If the sum of the check is not the same as the minuend in the problem, then you have made an error somewhere. Remember to ADD the remainder to the subtrahend to obtain the minuend. Go back to page 10A and select the correct answer.

16B

Fine. You are now ready for multiplication. Multiplication is actually a shortcut for addition. For example: 4 x 9 = 36 or 9 + 9 + 9 + 9 = 36. The smaller number should go on the bottom. For example, 300 x 21 = is set up and solved like this:

```
  300
  x21
  300
 600
6,300
```

Set up and solve: 2,764 x 22 =

If your answer is:	Go to page:
2,764 × 22: 5528, 5528, 11,056	12B
2,764 × 22: 5528, 5528, 60,808	8A

divisor quotient dividend remainder factors	30. If you have NOT missed any labels up to this point, turn to page 19, frame 33, and work from there. If you missed ANY, CHECK those labels that gave you the trouble AND complete frames 31 and 32 before continuing.
	31. Label the parts of the problems below. a. $\begin{array}{r} 25 \\ \underline{\times 4} \\ 100 \end{array}$ 25— ________ 4— ________ 100— ________ 25 and 4 are ________ b. $\begin{array}{r} 311 \\ \underline{-27} \\ 284 \end{array}$ 311— ________ 27— ________ 284— ________
a. multiplicand multiplier product factors b. minuend subtrahend remainder	32. Label the parts of the problems below. a. $\begin{array}{r} 10 \\ \underline{+11} \\ 21 \end{array}$ 10— ________ 11— ________ 21— ________ b. $\begin{array}{r} 7 \\ 20\overline{)155} \\ \underline{140} \\ 15 \end{array}$ 20— ________ 7— ________ 155— ________ 15— ________ 20 and 7 are ________

Continue to page 19

18A

Right. You are now ready to set up and solve problems in each of the processes of addition, subtraction, multiplication, and division. Set up and solve the following problems. SHOW ALL WORK.

a. 447 + 886 =

c. 375 ÷ 3 =

b. 670 x 350 =

d. 3,030 - 2,300 =

Go to page 10A

18B

You have now completed the solving and checking of all functions. Remember, the only one you did not do the opposite function to check was ADDITION, and then all that you do is: Invert the column of numbers and add again.

If you need more review on solving and checking, return to the page that teaches what you need. Otherwise, go to 8B.

SUBTRACTION	Page 10A
MULTIPLICATION	Page 12A
DIVISION	Page 14B
ADDITION	Paragraph above or page 12A

After you complete this review, go to 8B.

a. addend
addend
sum

b. divisor
quotient
dividend
remainder
factors

33. Label each part of each of the following addition, subtraction, multiplication, and division problems:

a.
```
  289
  488
+ 111
  888
```
289— ____________

488— ____________

111— ____________

888— ____________

b.
```
  397
-  44
  353
```
397— ____________

44— ____________

353— ____________

c.
```
  28
 x 9
 252
```
28— ____________

9— ____________

252— ____________

9 and 28 are ____________

d.
```
     11
27/298
   27
    28
    27
     1
```
27— ____________

11— ____________

298— ____________

1— ____________

27 and 11 are ____________

Your answers to frame 33 are:

a. addend
addend
addend
sum

b. minuend
subtrahend
remainder

c. multiplicand
multiplier
product
factors

d. divisor
quotient
dividend
remainder
factors

Continue to page 2?

ANSWERS TO PAGE 8B:

a.
```
     35                  35
 10/352      check     x 10
    30                  350
    52                 +  2
    50                  352
     2
```

b.
```
   12                   305
   16        check       16
 +305                  + 12
  333                   333
```

c.
```
   15                  15               3
  x 3        check   3/45     or    15/45
   45                 3                45
                      15
                      15
```

d.
```
  127                   39
 - 39        check    + 88
   88                  127
```

CONTINUE ON PAGE 22

ANSWERS TO FRAME 44, PAGE 24.

a. 5

b. 15

c. 28

d. 15

END OF LESSON

34. Any problem in addition, subtraction, multiplication, or division must be set up correctly in order to solve it. In ADDITION, you must put like units under like units. For example:

Wrong	Right	
347	347	* Notice how units are under units, tens are under tens, etc. This is the only way an addition problem can be solved.
9	9	
83	83	
+ 204	+ 204	

Set up and work this problem.

$3 + 297 + 48 =$

If your answer is:	Go to page:
297 3 + 48 375	2A
297 48 + 3 448	4A
48 297 + 3 348	6A

If you are reading this paragraph, you are not following directions. The preceding frame has given you directions to follow. These directions MUST be followed and you must be more careful when reading. Return to the above frame and READ CAREFULLY.

	35. The signs of operation are: + for addition, − for subtraction, x for multiplication, and ÷ for division. The +, −, x, and ÷ are ________ of ________.
signs operation	36. Some problems involve two or more different signs of operation. Example: $2 + 8 \times 3 = 26$ The signs of operation in the problem above are _____ and _____.
+ x	37. A problem may contain all the different signs of operation. Example: $4 + 2 \times 3 - 15 \div 3 = 5$ The signs of operation in the problem above are _____, _____, _____, and _____.
+ − x ÷	38. Problems that contain two or more different signs of operation are solved by following a specified order of operation. The problem in frame 37 was solved by using a specified ________ of ________.

order operation	39. The specified order of operation to follow when solving problems with two or more different signs of operation is; First—MULTIPLY Second—DIVIDE Third—ADD Fourth—SUBTRACT Example: $4 + 2 \times 3 - 15 \div 3 =$ If you perform the correct first step, the problem becomes: $4 + 6 - 15 \div 3 =$ What operation was performed and what numbers were involved? Answer ______________________
multiplication 2×3	40. The next step is division and the problem becomes: $4 + 6 - 5 =$ In this step, the number ______ was divided by the number ______.
15 3	41. The next step is addition and the problem becomes: $10 - 5 =$ The numbers ______ and ______ were added in this step.

4 6	42. The last step is subtraction and the problem becomes: $10 - 5 = 5$ The answer, 5, was obtained by subtracting the number _____ from the number _____.
5 10	43. The order of operation once again is: multiply, divide, add, and then subtract. If your problem has any one or more of the signs of operation missing, you would simply omit that step or steps in following the specified order of operation. Example: $10 + 5 \times 2 - 5 =$ The first step is to multiply _____ times _____. Then you must add the result of the multiplication to the number _____. The next step is to __________ and the answer to the problem is _____. The step that was omitted was __________.
5 2 10 subtract 15 division	44. Solve the problems below. a. $5 \times 5 \div 5 + 5 - 5 =$ b. $10 + 20 \div 4 =$ c. $33 - 15 \div 3 =$ d. $4 \times 3 - 2 + 5 =$

Answers are on page 20

SELF - TEST

1. Write, in your own words, the definition of a whole number.

____

2. Label the place (position) of each digit in the whole number below.

(9,257,800)

9, ____________

2 ____________ ____________

5 ____________ ____________

7, ____________

8 ____________

0 ____________

0 ____________

3. Match the words in column A with the numbers in column B by placing the letter of the numerical form next to the word form it corresponds with.

A	B
____ Forty-nine thousand six hundred twenty-two	a. 312
____ Ninety-nine million two	b. 490,622
____ Three hundred twelve	c. 3,999
____ Three thousand nine hundred ninety-nine	d. 99,000,200
	e. 49,622
	f. 99,000,002

4. Round off each of the whole numbers below.

   a. 127,009 to tens ____________

   b. 2,836,999 to ten thousands ____________

   c. 333,501,000 to millions ____________

   d. 999 to hundreds ____________

   e. 149,999 to hundred thousands ____________

   f. 297 to five hundreds ____________

5. Label each part of each problem below.

   a. $\begin{array}{r} 450 \\ -\ \underline{25} \\ 425 \end{array}$

   450— ____________

   25— ____________

   425— ____________

   b. $\begin{array}{r} 11 \\ 40\overline{)442} \\ \underline{40} \\ 42 \\ \underline{40} \\ 2 \end{array}$

   40— ____________

   11— ____________

   442— ____________

   2— ____________

   The 40 and the 11 are both ____________.

   c. $\begin{array}{r} 399 \\ +\ \underline{27} \\ 426 \end{array}$

   399— ____________

   27— ____________

   426— ____________

   d. $\begin{array}{r} 300 \\ \underline{x\ \ 6} \\ 1{,}800 \end{array}$

   300— ____________

   6— ____________

   1,800 — ____________

   The 300 and the 6 are both ____________.

6. Solve the four problems below. SHOW ALL WORK.

a. $455 \times 33 =$

b. $3{,}690 - 2{,}460 =$

c. $44 + 275 + 9 =$

d. $400 \div 50 =$

7. Solve and check each of the problems below. SHOW ALL WORK.

a. $38\overline{)308}$ check—

b. check—

$$\begin{array}{r} 389 \\ 27 \\ +\ \underline{122} \end{array}$$

c. check—

$$\begin{array}{r} 47 \\ \times\ \underline{22} \end{array}$$

d. check—

$$\begin{array}{r} 996 \\ -\ \underline{57} \end{array}$$

8. Solve the problems below.

a. $39 + 11 - 5 \times 10 \div 2 =$

b. $42 \div 6 + 27 \times 3 - 6 =$

c. $2 \times 4 \div 8 + 3 - 4 =$

d. $32 \div 4 + 36 - 8 \times 2 =$

ANSWERS TO SELF TEST ARE ON BACK OF FRONT COVER

ATC-SHEPPARD AFB TEX. 71-916C

656

PREPARE THE MAN — PT 3ALR91630-II-(3)

Department of Medicine
School of Health Care Sciences

Cardiopulmonary Laboratory Specialist

Volume 1

MATHEMATICS REVIEW

August 1973

10-6

Sheppard Air Force Base, Texas

Designed For ATC Course Use

DO NOT USE ON THE JOB

657

INSTRUCTIONS

This programmed text was prepared under the technical supervision of the George Washington University Human Resources Research Office. The text provides a REVIEW of specific elementary mathematical skills. The text consists of two volumes. Volume II reviews simple equations and proportions. This volume consists of four units:

MATHEMATICS I, multiplication and division of decimals.

MATHEMATICS II, cancellation.

MATHEMATICS III, powers and roots.

MATHEMATICS IV, powers of ten.

To successfully complete the first two units, you must know how to multiply and divide whole numbers; to complete the other two, you must know the mathematic skills required in units I and II, and must know the meaning of the terms "raising numbers to powers" and "extracting roots of numbers."

The contents of this text are presented in numbered statements or problems called "frames." The answer to frame number 1 appears below frame number 2; number 2's answer follows frame number 3, etc. Read each frame carefully and fill in the word(s) or number(s) in the parentheses which will complete the statement CORRECTLY. For example: Eight divided by four equals (two).

Next, compare the correct answer (below the next frame) with yours.

If your answer is correct, go to the next frame.

If your answer is wrong, reread the frame, draw a line through your answer, and write the correct answer next to (or below) yours.

Complete each frame in sequence. Don't skip any of them. THIS IS NOT A TEST, so you may refer to previous frames any time you want to. You may work at your own best speed. You are NOT being timed.

YOU MAY BEGIN

658

MULTIPLICATION AND DIVISION

(Decimals)

(Part One)

1. A decimal is just a whole number and a fraction written in decimal form. Thus, 2-1/2 is a whole number and a fraction, while 2.5 is a(   ).

2. Decimals are multipled exactly like whole numbers and then the DECIMAL place is added. The only difference between multiplying whole numbers and decimals is that for decimals you must find the (   ) place.

decimal

3. Decimals are multiplied exactly like (a) (   ) (   ). After multiplying a decimal, you must find the (b) (   ) (   ).

decimal

4. The only difference between multiplying whole numbers and decimals is finding the (   )(   ).

(a) whole numbers
(b) decimal place

5. For example, you would multiply 25 x 25 in this way:

```
 25
x25
125
50
625
```

and 2.5 x 2.5 in this way:

```
 2.5
x2.5
 125
 50
6.25
```

The only difference is the (   ) place.

decimal place

6. The number of decimal places in a decimal is the number of digits (numbers) to the RIGHT of the decimal point. Therefore, there are 2 decimal places in 1.41 and (   ) decimal place(s) in 1.4.

decimal

7. The number of decimal places in a decimal is the number of digits to the (   ) of the decimal point.

1

8. The number of decimal places in a decimal is the number of digits (   ) (   ) (   ) (   ) (   ).

right

9. How many decimal places in 14.213? (   )

to right of decimal point

10. How many decimal places in 0.41? (   )

3

11. How many decimal places in 0.04? (   )

2

12. How many decimal places in 1.0001? ( )

2

13. The number of decimal places in the product (answer) of a multiplication is the SUM total of the decimal places in the numbers which were multiplied. There are 2 decimal places in 40.21 and 2 in 20.11; therefore, there will be 4 in their product. How many decimal places will there be in the product of 2.1 x 4.23? ( )

4

14. Thus, to find the number of decimal places in the product of 40.21 x 20.11, you must find the sum total of decimal places in both numbers. The sum of the decimal places is ( )

3

15. How many decimal places in the product of 4.02 x 20.8? ( )

4

16. How many decimal places in the product of 6.002 x 0.041? ( )

3

17. You sum the decimal places in the numbers multiplied to get the decimal place in the product no matter how many numbers are multiplied. Thus, there will be ( ) decimal places in the product of 4.2 x 6.19 x 9.02.

6

18. How many decimal places in the product of 4.101 x 6.12 x 0.001? ( )

5

19. Remember, aside from the decimal place, decimals are multiplied exactly like whole ( ).

8

20. What is the product of 4.2 x 6.1? ( )

numbers

21. 2.01 x 6.98 = ( ).

25.62

22. 21.2 x 1.42 = ( )

14.0298

23. Zeros written to the right of a decimal point with no number other than zero to their right may be DROPPED in most multiplication. Thus 4.20 can be written 4.2, and 5.50 can be written ( ).

30.104

24. In multiplying 4.20 x 5.50 you would multiply 4.2 x ( ).

5.5

660

25. Zeros to the right of the decimal point with NUMBERS OTHER THAN ZERO to their RIGHT cannot be dropped without changing the value of the number. ~~Thus,~~ you cannot drop the zero in the number 6.105. Can you drop the zero in 23.4206? (   )

~~5.5~~

26. Thus 21.0 = 21, but in 21.01 the zero cannot be (   ).

No

27. Can you drop the zeros in 16.001 without changing the value of the number? (   )

dropped

28. Can the zero in 14.101 be dropped without changing the value of the number? (   )

No

29. Can the zeros in 16.100 be dropped without changing the value of the number? (   )

No

30. Can the zero in 42.0 be dropped? (   )

Yes

31 Solve: 4.20 x 5.50 = (   ).

Yes

32. Solve: 1.010 x 4.002 = (   ).

23.10 or by dropping the zero in the answer 23.1.

33. Zeros to the LEFT of a decimal point with no number other than zero to their LEFT are added only to make it very clear that the number is a decimal and can be dropped when you multiply. Thus, 0.4 is the same as .4 and 0.23 is the same as (   ).

4.04202

34. Can you drop the zero in 0.45 without changing the value of the number? (   )

.23

35. Can you drop the zero in 0.75638 without changing the value of the number? (   )

Yes

(Because the "0" is only there so that you will be sure to realize that the number is .45, NOT the whole number 45.)

36. Can you drop the zeros in 100.1 without changing the value of the decimal? (   )

Yes

37. Can you drop the underlined zero in 1600.0 without changing the value of the number? (   )

No

3

38. Can you drop the zeros in 1500? ( )

Yes

39. 0.19 x 0.20 = ( ).

No

40. 0.034 x 0.025 = ( ).

0.038 or by dropping the zero .038

41. 0.890 x 0.010 = ( ).

0.00085 or .00085

42. 0.04 x 1600.0 = ( ).

0.0089 or .0089

43. 4.12 x 5.75 = ( ).

64.0 or 64

END OF SET

23.69

662

MULTIPLICATION AND DIVISION

(Decimals)

(Part Two)

44. 28.9 x 0.982 = ( ).

45. 800.0 x 0.05 = ( ).

28.3798

46. As with multiplication, you DIVIDE decimals exactly like you do whole ( ) and then you find the decimal place.

40.0 or 40

47. After dividing decimals you must find the ( ) ( ).

numbers

48. For example: dividing 126 by 6 gives 21 as an answer

```
    21
 6 /126
    12
     06
      6
      0
```

and dividing 12.6 by 6 gives the answer 2.1

```
     2.1
  6 |12.6
     12
      06
       6
       0
```

The division is done exactly the same except for adding the ( ) place in the answer.

decimal place

49. Division of decimals is exactly the (a) ( ) as division of whole numbers except that you must find the (b) ( ) ( ) in your answer.

decimal

50. A division can either be written as $\frac{a}{b}$ or ? $\sqrt{a}$

(a) same
(b) decimal place

51. $\frac{x}{y}$ means x divided by ( ).

b

52. $\frac{a}{b}$ = b $\sqrt{a}$, and means a ( ) by b.

y

53. $\frac{Z}{U}$ means Z (a) ( ) by (b) ( ).

divided

54. $\frac{w}{d}$ means ( ) ( ) ( ) ( )

(a) divided
(b) U

711

663

55. In the division $\frac{1.22}{4.1}$, 1.22 is the DIVIDEND and the divisor is ( ).

w divided by d

56. In $\frac{a}{b}$, a is the (a) ( ) and b is the (b) ( ).

4.1

57. The result of a division is called a QUOTIENT. In $\frac{4}{2} = 2$, 2 is the result, or ( ).

(a) dividend
(b) divisor

58. The result of a division is called a ( ).

quotient

59. In $\frac{24.0}{6.0} = 4.0$, 4.0 is the ( ).

quqtient

60. In dividing a decimal by a WHOLE NUMBER, the decimal place in the quotient goes directly over the decimal place in the dividend.

Thus $\overset{.22}{2\overline{).44}}$ the decimal place in .22 is directly ( ) the decimal place in .44.

quotient

61. $\frac{.888}{2}$ means $2\overline{).888}$ and could be written $\frac{0.888}{2.0}$ because zeros may be added or ( ) for clarification.

over or above

62. $\frac{0.888}{2.0} = 2\overline{).888}$. This problem is solved exactly like $\overset{444}{2\overline{)888}}$ except that you must add a ( ) place in the answer.

dropped or subtracted

63. Solve: $\overset{?}{2\overline{).888}}$

decimal

64. Solve: $\frac{0.44}{2.0} = \overset{?}{2\overline{).44}}$

.444

65. In division, the decimal place in the quotient goes directly (a) ( ) the decimal place in the (b) ( ).

.22

66. Solve: $\frac{0.624}{24.0} = \overset{?}{24\overline{).624}}$

(a) over, above
(b) dividend

67. In division, the decimal place in the quotient goes directly over ( ).

0.026 or .026

712

68. $\frac{12.48}{8.0} = 8\overline{)12.48}^{?}$

the decimal place in the dividend

69. $\frac{376.56}{12.0} = ($ $)$.

1.56

70. $\frac{4.86}{6} = ($ $)$.

31.38

71. Any time there is a space or a number of spaces between the decimal point and the first number of your answer, you must add zeros to complete your answer.

Thus, in $8\overline{)\,.248}^{.\ 31}$ you must add a ( ) after the decimal point and before the 3.

.81 or, of course, 0.81 to make it clear that .81 is a decimal and not 81.

72. As a result, the problem and correct answer would look like this:

$$8\overline{)\,.248}^{.031}$$

In the problem $19\overline{)\,.1748}$ you must add (a) ( ) zeros after dividing. Your answer would be (b) ( ).

zero

73. $\frac{.888}{222} = ($ $)$.

(a) 2
(b) .0092

74. $\frac{.600}{300} = ($ $)$.

.004

75. $\frac{0.800}{800.0} = ($ $)$.
(Remember, some of the zeros may be dropped when you divide)

.002 or 0.002

76. $\frac{0.008}{800.0} = ($ $)$.

0.001 or .001 $(800\overline{)\,.800})$

77. To carry out a division as far as necessary, you must often add ZEROS to the dividend.

Thus in $\frac{.9}{2} = 2\overline{)\,.90}^{.45}$ it was necessary to add a ( ) to the dividend, in this case changing .9 to 90.

.00001 or 0.00001

78. It is often necessary to add ( ) to the DIVIDEND in order to carry out division as far as possible or desired.

zero

79. Solve: $\frac{.7}{2} = 2\overline{)\,.70}$

zeros

80. $\frac{17.1}{2.0} = 2\overline{)17.10}^{?}$

.35

81. $\frac{0.06}{300.0} = ($ $)$.

8.55

82. $\frac{14.5}{4.0} = ($ $)$.

.0002 or 0.0002

83. $\frac{16.5}{12.0} = ($ $)$.

3.625

84. $\frac{9.02}{8.0} = ($ $)$.

1.375

85. When the DIVISOR is a decimal, you may change it to a whole number by moving the decimal point to the RIGHT. When dividing by a decimal change the divisor to a whole ( ).

1.1275

86. In a problem like $\frac{.88}{.4}$ or $.4\overline{).88}$, you must change the DIVISOR (.4) to a whole number before dividing. By moving the decimal point one place to the right, .4 becomes 4.0 or just 4. It is then a ( ) ( ).

number

87. **To change a decimal to a whole number move the decimal point to the ( ).**

whole number

88. **When the decimal point is moved in the divisor, it must be moved the SAME number of places in the dividend. If you move the decimal TWO places in the divisor, you must also move it TWO places in the ( ).**

right

89. **To divide $\frac{0.88}{0.2}$ you must change .2 to a ( ) ( ).**

dividend

END OF SET

whole number

6<6

MULTIPLICATION AND DIVISION

(Decimals)

(Part Three)

90. To change 0.2 to a whole number, you must move the decimal point ( ) place(s) to the right.

1

91 In $\frac{0.88}{0.2}$, when you move the decimal point 1 place to the right for 0.2, you must also move it ( ) place(s) to the right for 0.88.

1

92. When you change the divisor of $\frac{0.88}{0.2}$ to a whole number, you have $\frac{8.8}{?}$.

2.0 or 2

93. $\frac{178}{16.8} = (\frac{?}{?})$. (Change divisor to whole number and remember that you must move the decimal in the dividend the same number of places.

$\frac{1,780}{168}$

94. $\frac{0.88}{0.2} = (\frac{?}{?})$ (change divisor to whole number) (Hint: Remember to move the decimal place in the dividend also.)

$\frac{8.8}{2.0}$

95. $\frac{0.001}{0.109} = (\frac{?}{?})$ (change divisor to whole number)

$\frac{1.0}{109.0}$

96. $\frac{800.0}{0.02} = (\frac{?}{?})$
(change divisor to whole number)

$\frac{80,000}{2.0}$

97. $.34 \overline{)2.685} = ? \overline{)?}$

(Change divisor to a whole number and change the dividend as required.)

$34 \overline{)268.5}$

98. $.483 \overline{)41.34} = ? \overline{)?}$

(Change divisor and dividend.)

$483 \overline{)41,340.}$

(By moving the decimal place 3 places in divisor and in dividend)

99. Once the divisor has been changed to a whole number, you divide exactly as before and put the decimal point in the quotient directly over the decimal point in the ( ).

dividend

100. Remember, if you move the decimal place in the divisor, you must move it an equal number of places in the ( ).

dividend

101. Now then: $\frac{16.0}{0.4} = \frac{16}{.4}$ (By dropping unnecessary zeros) and by moving the decimal we have - $\frac{160}{4}$. $4\overline{)160}$ (2 written above the 6)

dividend

102. $\frac{1.98}{0.2} = 2\overline{)19.8}$ (2 written above the 9)

40 or 40.0

(since 160 may be written 160.0)

103. $\frac{14.9}{0.02}$ = (   )

9.9

104. $\frac{0.084}{1.2}$ = (   )

745 or 745.0

105. $\frac{0.0012}{0.002}$ = (   )

.07 or 0.07

106. $\frac{1.8}{0.0012}$ = (   )

.6 or 0.6

107. Fractions can be both COMMON fractions and DECIMAL fractions.

$\frac{2}{5}$ is a common (   ).

1,500 or 1,500.0

108. $\frac{1}{3}$ is a (   ) fraction.

fraction

109. $\frac{11}{16}$ is a (   ) (   ).

common

110. **The number ABOVE the dividing line in a common fraction is the numerator. In the common fraction $\frac{2}{3}$, the numerator is (   ).**

common fraction

111. **In the common fraction $\frac{1}{3}$, 1 is the (   ).**

2

112. **In a common fraction, the numerator is (   ).**

numerator

113. **The number BELOW the dividing line in a common fraction is the DENOMINATOR. In the common fraction $\frac{2}{3}$, the denominator is (   ).**

the number above the dividing line

114. **In the common fraction $\frac{11}{12}$, 12 is the (   ).**

3

115. **Define the denominator of a common fraction.**

denominator

668

116. In $\frac{6}{11}$, the numerator is (a) ( ), and the denominator is (b) ( ).

the number below the dividing line

117. In $\frac{17}{41}$, the DENOMINATOR is (a) ( ) and the numerator is (b) ( ).

(a) 6
(b) 11

118. A common fraction can be converted to a decimal fraction (also called simply a decimal) by dividing the numerator by the denominator. To convert $\frac{1}{3}$ to a decimal, you would divide the number ( ) by ( ).

(a) 41
(b) 17

119. To convert a common fraction to a decimal, you divide the numerator by the ( ).

1 (by) 3

120. How do you convert a common fraction to a decimal?

denominator

121. Convert $\frac{1}{2}$ to a decimal.

(Hint: That is, divide $2\overline{)1.00}$)

divide the numerator by the denominator

122. Convert $\frac{7}{8}$ to a decimal.

.5 or 0.5

123. $\frac{1.964}{0.16} = ($ $)$.

.875 or 0.875

124. $\frac{18.97}{1.4} = ($ $)$

12.275

125. Convert $\frac{8}{5}$ to a decimal.

13.55

126. $\frac{146.4}{2.44} = ($ $)$.

1.6

127. $\frac{1.9}{.004} = ($ $)$.

60 or 60.0

END OF SET

475 or 475.0

669

FURTHER INSTRUCTIONS

If you missed less than 7 of the items in Mathematics I, you have done a good job. Now read the summary, and you are ready to go on to Mathematics II.

If you missed 7 or more of the items, read the following summary and then WORK THROUGH the program again.

SUMMARY

1. Fractions can be both COMMON FRACTIONS and DECIMAL FRACTIONS. Numbers in the form $\frac{2}{5}$ are common fractions. Numbers in the form 0.75 are decimal fractions, or simply decimals.

2. In a common fraction, the NUMERATOR is the number ABOVE the dividing line and the DENOMINATOR is the number BELOW the dividing line. For example, in the fraction $\frac{2}{3}$, 2 is the numerator and 3 is the denominator.

3. To convert a common fraction to a decimal, divide the numerator by the denominator. For example, to convert $\frac{1}{4}$ to a decimal, divide 1 by 4.

4. Decimals are multiplied exactly like whole numbers and then decimal place is added.

5. The number of decimal places in a number is the number of digits to the RIGHT of the decimal point.

6. **The number of decimals places in the product of a multiplication is the SUM total of the decimal places in the numbers that were multiplied together.**

7. **Zeros written to the RIGHT of a decimal point with no number other than zero to their RIGHT may be dropped without changing the value of the decimal. For example, the zeros in 41.200 can be dropped.**

8. **Zeros to the LEFT of a decimal point with no number other than zero to their LEFT are added only for clarity and can be dropped without changing the value of the decimal. For example, the zero in 0.24 can be dropped.**

9. **Decimals are divided exactly like whole numbers and then the decimal place is added.**

10. **Divisions in the form $\frac{x}{y}$ mean x divided by y; x is the dividend and y the divisor. The result of a division is called a QUOTIENT.**

11. **In dividing a decimal by a whole number, the decimal place goes directly over the decimal place in the dividend. For example,**

$$3\overset{.33}{\overline{)\,.99}}$$

12. **When dividing by a DECIMAL, change the divisor to a whole number by moving the decimal point to the right, move the decimal point in the dividend the same number of places to the right, and then divide as before. For example,**

$$\frac{0.88}{0.2} = \frac{8.8}{2.0} = 2\overset{4.4}{\overline{)\,8.8}}$$

670

MULTIPLICATION AND DIVISION

Cancellation

(Part Four)

INTRODUCTION

The following form is often found in problem solution:

$$\frac{9 \times 36 \times 63}{3 \times 6 \times 42.}$$

There are two ways to solve such problems.

When you are faced with a problem like $\frac{9 \times 36 \times 63}{3 \times 6 \times 42}$, a great deal of multiplication and division may be avoided through cancellation. Thus, cancellation is one method of simplifying the solution of complex problems. It is done by dividing (canceling) numbers above and below the dividing line into each other. Though at first this may seem to be more difficult than normal multiplication and division, after you have practiced the method of cancellation, you will find that it is a much simpler way of solving complex problems of this type.

TURN THE PAGE

671

1. One way to solve such problems is to multiply the numbers in the numerator together to give a single numerator, and multiply the numbers in the denominator to give a single (   ).

2. Once a single numerator and denominator have been found, you can divide them together to give the result or (   ).

denominator

3. Thus: In the problem $\frac{9 \times 36 \times 63}{3 \times 6 \times 42}$ you would get $\frac{20,412}{756}$ or, by division, $756 \overline{)20,412}$ with the quotient 27. Your answer would be 27. Doing problems this way is a long, tedious process with a great possibility for error.

quotient or answer

4. Such problems are MORE EASILY SOLVED by first simplifying them through a process of CANCELLATION. All possible DIVISIONS are made before multiplication in the process of (   ).

No Answer Required

5. Thus, to simplify $\frac{9 \times 36}{3 \times 6}$ you will make all possible (a) (   ) before you (b) (   ).

cancellation

6. In the problem $\frac{\cancel{16} \times 15}{\underset{1}{\cancel{8}} \times 5}$ 8 will go into 16 two times and thus the 8 is canceled, as shown, and the figure 1 placed below it and the 16 is canceled, as shown, and the figure (   ) placed above it.

(a) divisions (cancellations)
(b) multiply

7. In $\frac{\overset{2}{\cancel{16}} \times 15}{\underset{1}{\cancel{8}} \times 5}$ after the 16 and 8 have been canceled, as shown, the 15 may be divided by 5 three times leaving the figure (a) (   ) over 15 and the figure (b) (   ) below 5.

2

8. With all possible cancellations made, the problem looks like this:

$\frac{\cancel{16} \times \cancel{15}}{\cancel{8} \times \cancel{5}}$ or $\frac{2 \times 3}{1 \times 1}$, and may be simplified to read (   ).

(a) 3
(b) 1

9. Any time a number or letter is "over" the number 1, the 1 may be dropped because it means "divided by 1." Thus, $\frac{10}{1}$ is 10 because 10 divided by 1 is 10. In the same way, $\frac{x}{1}$ = (   ).

$\frac{6}{1}$

720

672

10. Our problem now has been simplified to:

$$\frac{\overset{2}{\cancel{16}} \times \overset{3}{\cancel{15}}}{\underset{1}{\cancel{8}} \times \underset{1}{\cancel{5}}} = \frac{2 \times 3}{1 \times 1} = \frac{6}{1} = (\qquad).$$

x

11. As you have seen, we began with $\frac{16 \times 15}{8 \times 5}$ and ended up with $\frac{2 \times 3}{1 \times 1} = 6$. If we had multiplied out the original problem, we would have had $\frac{240}{40}$ and by division ($40\overline{)240}$ with 6 above), our answer would have been the same. Problems of this type are easier and faster when simplified by (   ).

6

12. It is possible to cancel diagonally as well as straight up and down.

Thus, in $\frac{63 \times 40}{8 \times 9}$, the 63 is divided by the 9, leaving (a) (   ) over 63 and (b) (   ) under 9.

cancellation

13. In $\frac{\overset{7}{\cancel{63}} \times 40}{8 \times \underset{1}{\cancel{9}}}$, after the 63 and 9 have been canceled as shown, the 40 is divided by 8, leaving (a) (   ) over 40 and (b) (   ) under 8.

(a) 7
(b) 1

14. What is the final answer to $\frac{\overset{7}{\cancel{63}} \times \overset{5}{\cancel{40}}}{\underset{1}{\cancel{8}} \times \underset{1}{\cancel{9}}}$ after all cancellations are made?

(a) 5
(b) 1

15. Not only is it possible to divide one number into another, but you may divide a number on both top and bottom by the SAME number if it goes into both an even number of times (without fractions).

In $\frac{35 \times 63}{40 \times 81}$, both 35 and 40 are divisable by 5, leaving (a) (   ) over 35 and (b) (   ) under 40.

$\frac{35}{1}$ or 35

16. In $\frac{\overset{7}{\cancel{35}} \times 63}{\underset{8}{\cancel{40}} \times 81}$, after 35 and 40 have been canceled as shown, both 63 and 81 are divisable by 9, leaving (a) (   ) over 63 and (b) (   ) under 81.

(a) 7
(b) 8

17. After all cancellations are made in $\frac{\overset{7}{\cancel{35}} \times \overset{7}{\cancel{63}}}{\underset{8}{\cancel{40}} \times \underset{9}{\cancel{81}}}$ as shown, you are left with $\frac{7 \times 7}{8 \times 9} = \left(\frac{?}{?}\right)$.

(a) 7
(b) 9

673

18. To make cancellation really effective, it is necessary to use the LARGEST POSSIBLE NUMBERS when dividing. Thus, given the problem

$\frac{60 \times 60}{30 \times 12}$, there are a lot of possible divisions but the fastest way would be to divide 60 and 30 by 30 and 60 and 12 by 12. Then your cancellation is all done in one operation. Remember to use the (   ) (   ) (   ) when canceling.

$\frac{49}{72}$

19. Solve the following problems, simplifying by cancellation when possible.

$\frac{15 \times 54}{15 \times 9} = ($ $)$.

largest possible numbers

20. $\frac{9 \times 36}{3 \times 6} = ($ $)$.

$$\frac{\overset{1}{\cancel{15}} \times \overset{6}{\cancel{54}}}{\underset{1}{\cancel{15}} \times \underset{1}{\cancel{9}}} = \frac{1 \times 6}{1 \times 1} = \frac{6}{1} = 6$$

21. $\frac{30 \times 45}{10 \times 5} = ($ $)$.

$$\frac{\overset{3}{\cancel{9}} \times \overset{6}{\cancel{36}}}{\underset{1}{\cancel{3}} \times \underset{1}{\cancel{6}}} = \frac{3 \times 6}{1 \times 1} = 18$$

22. $\frac{9 \times 36}{6 \times 27} = ($ $)$.

27

23. $\frac{125 \times 32 \times 10}{25 \times 8 \times 5} = ($ $)$.

$$\frac{\overset{1}{\cancel{9}} \times \overset{6}{\cancel{36}}}{\underset{1}{\cancel{6}} \times \underset{3}{\cancel{27}}} = \frac{1 \times 6}{1 \times 3} = \frac{6}{3} = 2$$

or

$$\frac{\overset{3}{\cancel{9}} \times \overset{4}{\cancel{36}}}{\underset{2}{\cancel{6}} \times \underset{3}{\cancel{27}}} = \frac{3 \times 4}{2 \times 3} = \frac{12}{6} = 2$$

24. **Further cancellations can often be made after numbers are canceled once. For example, in**

$$\frac{\overset{3}{\cancel{15}} \times \overset{1}{\cancel{3}},}{\underset{1}{\cancel{5}} \times \underset{3}{\cancel{9}}}.$$

after canceling each number once, you can further cancel the 3's, leaving as the answer (   ).

40

25. **In** $\frac{\overset{6}{\cancel{36}}}{9 \times \underset{1}{\cancel{6}}}$ **after the cancellations shown are made, the REMAINING 6 and 9 are both divisable by 3, leaving (a) (   ) over 6 and (b) (   ) under 9.**

$$\frac{1 \times 1}{1 \times 1} = \frac{1}{1} = 1$$

(1 divided by 1 always equals 1)

674

26. In $\dfrac{\overset{8}{\cancel{48}}}{\underset{1}{\cancel{6}} \times 18 \times 2}$, the 6 cancels 48 as shown, and then both 18 and 8 are divisable by 2, leaving (a) (   ) over 8 and (b) (   ) under 18.

(a) 2
(b) 3

27. In $\dfrac{\overset{\overset{4}{\cancel{8}}}{\cancel{48}}}{\underset{1}{\cancel{6}} \times \underset{9}{\cancel{18}} \times 2}$, after the cancellations shown are made, a further cancellation can be made by dividing 4 by 2, leaving (a) (   ) over 4 and (b) (   ) under 2.

(a) 4
(b) 9

28. After all cancellations are made,

$$\frac{\overset{\overset{\overset{2}{\cancel{4}}}{\cancel{8}}}{\cancel{48}}}{\underset{1}{\cancel{6}} \times \underset{9}{\cancel{18}} \times \underset{1}{\cancel{2}}} = \frac{2}{1 \times 9 \times 1} = \left(\frac{?}{?}\right).$$

(a) 2
(b) 1

29. It is important to remember that you may only cancel two numbers at a time. Thus, if you have the problem:

$$\frac{35 \times 25}{15}$$

you may cancel 5 into 15 (3 times) and then into EITHER 35 OR 25 but NOT both. In the problem:

$$\frac{9 \times 18}{3}$$

your answer would be (   ).

$\frac{2}{9}$

30. Solve the following problems, using cancellation where possible.

$$\frac{64 \times 20}{12 \times 4 \times 6}$$

$$\frac{\overset{3}{\cancel{9}} \times 18}{\underset{1}{\cancel{3}}} = \frac{3 \times 18}{1} = 54 \text{ correct}$$

or

$$\frac{9 \times \overset{6}{\cancel{18}}}{\underset{1}{\cancel{3}}} = \frac{9 \times 6}{1} = 54 \text{ correct}$$

but NOT

$$\frac{\overset{3}{\cancel{9}} \times \overset{6}{\cancel{18}}}{\underset{1}{\cancel{3}}} = \frac{18}{1} = 18 \text{ incorrect}$$

675

31. $\frac{72}{40 \times 90} = ($ $)$.

$$\frac{\overset{8}{\cancel{16}}\!\!\!\!\overset{}{\cancel{64}} \times \overset{5}{\cancel{20}}}{\underset{3}{\cancel{12}} \times \underset{1}{\cancel{4}} \times \underset{3}{\cancel{6}}} = \frac{40}{0} \text{ or } 4.44$$

32. $\frac{9 \times 36 \times 63}{3 \times 6 \times 42} = ($ $)$.

$\frac{1}{50}$ or 0.02

33. Remember, to simplify by cancellation, make ALL possible (a) ( ) before you (b) ( ).

27

34. $\frac{40 \times 24}{12 \times 64 \times 20} = ($ $)$.

(a) divisions (cancellations)
(b) multiply

35. $\frac{72 \times 90}{40} = ($ $)$.

0.0625 or $\frac{1}{16}$

36. Many problems with only a single numerator and denominator can be simplified through the process of ( ).

162

37. Such a problem as $\frac{4,500}{3,000}$ can first be simplified through a process of ( ).

cancellation

38. To simplify $\frac{4,500}{3,000}$, the numerator and denominator can be divided by 100, leaving $(\frac{?}{?})$.

cancellation

39. To further simplify $\frac{45}{30}$, you can divide the numerator and denominator by 15. leaving $(\frac{?}{?})$.

$\frac{45}{30}$

40. To simplify $\frac{1,600}{700}$, divide both numerator and denominator by ( ).

$\frac{3}{2}$ or $1\frac{1}{2}$

41. $\frac{1,400}{4,200} = ($ $)$.

100

42. To simplify $\frac{90}{72}$ you can first divide the numerator and denominator by (a) ( ) to give $\frac{10}{8}$, and then divide by 2 to give (b) ( ).

$$\frac{\overset{2}{\cancel{14}}\!\!\!\!\cancel{1400}}{\underset{6}{\cancel{42}}\!\!\!\!\cancel{4200}} = \frac{2}{6} = \frac{1}{3} \text{ or } 0.333$$

43. Problems in the form $\frac{4,500}{3,000} \times 20$ can also be simplified by the process of ( ).

(a) 9
(b) $\frac{5}{4}$

724

474

44. To solve the problem $\frac{4,500}{3,000}$ x 20, you first cancel in the fraction $\frac{4,500}{3,000}$ and then multiply the result times 20. Cancellation gives the result of $(\frac{?}{?})$ x 20.

cancellation

45. $\frac{4,500}{3,000}$ x 20 = (   ).

$\frac{3}{2}$

46. $\frac{8,000}{6,400}$ x 80 = (   ).

$$\frac{\overset{3}{\cancel{45}}\cancel{00}}{\underset{2}{\cancel{30}}\cancel{00}} \times 20 = \frac{3}{2} \times 20 = \frac{60}{2} = 30$$

Solve the following problems, leaving your answer as a decimal when necessary and simplifying by cancellation as much as possible.

47. $\frac{42 \times 120 \times 50}{25 \times 40 \times 6}$ = (   ).

100

48. $\frac{6,400 \times 42 \times 25 \times 800}{500 \times 60 \times 420 \times 20}$ = (   ).

42

49. $\frac{15 \times 54 \times 35 \times 49}{25 \times 30 \times 63 \times 42}$ = (   ).

21.333

50. $\frac{1,500}{4,500}$ x 60 = (   ).

0.7

51. $\frac{6,400}{16,000}$ x 42 = (

20

END OF SET

16.8

FURTHER INSTRUCTIONS

If you missed less than 4 of the items, you have done a good job. Now read the summary, and you are ready to go on to Mathematics III.

If you missed 4 or more of the items, read the following summary and THEN WORK through the program again.

SUMMARY

1. Problems in the form $\frac{9 \times 36 \times 63}{3 \times 6 \times 42}$ are often found in problem solution.

2. Such problems are most easily solved if they are first simplified by the process of cancellation.

3. In the process of cancellation, all possible divisions are made before multiplication.

4. Problems in the form $\frac{4,500}{3,000}$ and $\frac{4,500}{2,000}$ x 2) can also be simplified by cancellation.

726

Mathematics III

MULTIPLICATION

(Powers)

(Part One)

1. To square a number means to multiply that number by itself. To square 2 you multiply (   ) x (   ).

2 x 2

2. 2^2 means 2 squared.
4^2 means 4 (   ).

square

3. 3^2 means (   ) (   ).

3 squared

4. $2^2 = 2 \times 2 =$ (   ).

4

5. $4^2 = 4 \times 4 =$ (   ).

16

6. $3^2 =$ (   ).

9

7. $7^2 =$ (   ).

49

8. Z^2 means Z squared and the 2 is the EXPONENT. In W2, 2 is the (   ).

Exponent

9. In 3^2 the exponent is (   ).

2

10. In 4^3, 3 is the (   ).

exponent

11. In y^4 the exponent is (   ).

4

12. The EXPONENT tells you how many times to multiply a number by itself.

Thus, $a^2 = a \times a$; $a^4 = a \times a \times a \times a$; and $a^3 =$ (   ).

a x a x a

The exponent is 3 so you multiply "a" times itself twice. Always multiply the number by itself one LESS time than the number in the exponent.

13. Always multiply the number by itself (   ) (   ) time than the number of the exponent.

one less

14. 3^3 means multiply 3 times itself (   ) times.

15. W^4 = (   ).

2 times

16. Z^2 = (   ).

W x W x W x W

17. $2^3 = 2 \times 2 \times 2$ = (   ).

Z x Z

18. $1^4 = 1 \times 1 \times 1 \times 1$ = (   ).

8

19. 1^8 = (   ).

1

20. The number 1 multiplied by itself any number of times or raised to any power is always equal to (   ).

(Review note: To raise a number to a power is to multiply it times itself a given number of times, thus 1^4 means 1 raised to the fourth power and 2^2 means 2 raised to the second power, or 2 squared.)

1

21. 9^2 = (   ).

1

22. 3^3 = (   ).

81

23 3^4 = (   ).

27   (3 x 3 x 3)

24. 7^2 = (   ).

81   (3 x 3 x 3 x 3)

25. **The EXPONENT tells you to what power the number is to be raised. 9^2 means to SQUARE 9, or raise it to the (   ) power.**

49

26. **5^3 means 5 cubed, or to raise 5 to the (   ) power.**

second

27. **In general Z^n means to raise Z to the (   ) power.**

third

28. **W^n means (   ).**

nth

29. **To square a number means to raise it to the (   ) power.**

to raise W to the nth power.

30. **When you raise a number to the second power, you are said to (   ) the number.**

second

680

31. To raise a number to the third power is to CUBE a number. 5^3 means 5 (   ).

square

32. 5 cubed = 5^3 = 5 to the third power = (   ).

cubed

33. 2 cubed = (   ).

125   (5 x 5 x 5)

34. 3 to the third power = (   ).

8   (2 x 2 x 2)

35. Z^3 means to cube Z or raise it to the (   ) (   ).

27

36. To find the ROOT of a number is the exact opposite of raising a number to a (   ).

third power

37. The OPPOSITE of raising a number to a power is finding its (   ).

power

38. When you SQUARE 2, you get 4. Thus the opposite or SQUARE ROOT of 4 is 2. When you square 7, you get 49. The opposite or SQUARE ROOT of 49 is (   ).

root

39. **In general, the ROOT of a number is a quantity (number) which, when multiplied by itself a given number of times, gives the number.**

3 squared is 9 or 3 x 3 = 9. 3 is a (   ) of 9.

7   (Because 7 times 7 is 49)

40. The SQUARE ROOT of a number is indicated by the $\sqrt{\quad}$ which is called a radical. Thus $\sqrt{9}$ means the (   ) (   ) of 9.

root

41. **The sign $\sqrt{\quad}$ indicates you are to find the (   ) (   ).**

square root

42. $\sqrt{4}$ **means to find the SQUARE ROOT of 4 which is (   ).**

square root

43. $\sqrt{\quad}$ **means find the square root of a number or what number multiplied by itself equals the number under the radial ($\sqrt{\quad}$) sign.** $\sqrt{4}$ **means find the (   ) (   ) of 4.**

2   (since 2 x 2 is 4)

44. **4^2 = 4 squared = 4 x 4 = 16.**

The SQUARE ROOT of 16 ($\sqrt{16}$) is (   ). That is the number which multiplied by itself equals 16.

END OF SET

square root

681

Mathematics III

POWERS AND ROOTS

(Part Two)

45. $\sqrt{9}$ means find the SQUARE root of 9 or what number multiplied by itself equals 9. 3 x 3 equals 9, so 3 is the SQUARE root of 9.

$\sqrt{25}$ = (   ).

5 (5 x 5 equals 25)

46. 4 is the (   ) (   ) of 16.

square root

47. 6^2 = 6 squared = 6 x 6 = 36. The square root of 36 ($\sqrt{36}$) is (   ).

6

48. The square root of 81 = (   ).

9

49. 9 is the square root of (   ).

81

50. $\sqrt{49}$ = (   ).

7 (because 7 x 7 is 49)

51. In general, the radical sign $\sqrt{}$ over a number means you must find a (   ) of the number underneath it.

root

52. The square root of 1 = (   ).

1 (1 x 1 = 1)

53. $\sqrt[3]{27}$ means the CUBE root of 27. That is, what number multiplied by itself TWICE is 27. 3 x 3 x 3 = 27, so 3 is the cube root of 27. What is the cube root of 8?

2 (because 2 x 2 x 2 = 8)

54. $\sqrt[3]{125}$ = (   ).
(What is the cube root of 125?)

5 (5 x 5 x 5 = 125)

55. $\sqrt[3]{64}$ = (   ).

4 (4 x 4 x 4 = 64)

56. The number on the radical, as the 3 in $\sqrt[3]{W}$, indicates what root of a number to take. Thus, $\sqrt[3]{Z}$ means to take the cube or (   ) root of Z.

730

682

57. $\sqrt[4]{X}$ means to find the ( ) root of X.

third

58. $\sqrt[5]{100}$ means to find the ( ) root of 100.

fourth

59. 5^3 = ( ).

fifth

60. If the radical sign has no number on top of it ($\sqrt{\ }$), it means find the square root. If there is a number on top ($\sqrt[3]{\ }$, $\sqrt[10]{\ }$, $\sqrt[4]{\ }$), you must find the third, tenth, fourth, etc., root of the number underneath. $\sqrt[5]{32}$ means find the ( ) root of 32.

125

61. $\sqrt[5]{32}$ means find the fifth root of 32 or what number multiplied by itself ( ) times equals 32.

fifth

62. $\sqrt[5]{32}$ = ( ).

four

63. You can now see and remember the RULE that when finding ROOTS you must find the number which, when multiplied by itself ONE LESS TIME than the number ON the radical sign, will equal the number under the radical sign. Thus $\sqrt[3]{8}$, the cube or THIRD root of 8, means what number multiplied by itself TWO times equals 8. Of course, 2 x 2 = 4 and 2 x 4 = 8. To find the FOURTH root of 16 ($\sqrt[4]{16}$), how many times would you multiply the number by itself?

2
because
2 x 2 = 4 (2 squared)
2 x 4 = 8 (2 cubed)
2 x 8 = 16 (2 to the fourth power)
2 x 16 = 32 (2 to the fifth power)

64. $\sqrt[7]{128}$
How many times would you multiply the number by itself?

3 times
(2 x 2 = 4, 2 x 4 = 8, 2 x 8 = 16)

65. $\sqrt[5]{17}$
How many times would you multiply the number by itself?

6 times
2 x 2 = 4
2 x 4 = 8
2 x 8 = 16
2 x 16 = 32
2 x 32 = 64
2 x 64 = 128

66. The cube root of 27 = $\sqrt[3]{27}$ = ( ).

4 times

67. $\sqrt[3]{125}$ = ( ).

3

68. 5 is the cube root of ( ).

5

683

69. 4 is the ( ) ( ) of 64.

125

70. The cube root of 8 = ( ).

cube root

71. The cube root of 1 = ( ).

2

72. A ROOT of a number may also be indicated by a fractional exponent as $8^{1/3}$. This is the same as saying "find the cube root of 8." Thus $8^{1/3} = \sqrt[3]{8}$. Thus $27^{1/3}$ means find the cube root of 27. $27^{1/3}$ = ( ).

1

73. $4^{1/2}$ means "find the square root of 4." Thus, $4^{1/2} = \sqrt{4}$. $16^{1/2}$ means ( ).

$\sqrt[3]{27}$ or 3

74. $9^{1/2}$ means 9 to the 1/2 power or the ( ) root of 9.

find the square root of 16

75. $9^{1/2} = \sqrt{9}$ = ( ).

square
(not the "1/2 root of 9")

76. $8^{1/3}$ = ( ) (give final answer).

3

77. For a FRACTION EXPONENT the NUMERATOR of the fraction indicates the POWER to which the number is to be raised and the DENOMINATOR indicates the root to be found.

$12^{1/3}$ means to raise 12 to the first power and find its ( ) root.

2
(The cube root of 8)

78. Thus $9^{1/3}$ means to raise 9 to the first power and take its ( ) root.

cube

79. Raising a number to the first power does not change the number. Thus 9 raised to the first power = ( ).

square

80. A number is not changed by raising it to the ( ) power.

9

81. In general then, $Z^{\frac{R}{W}}$ means to raise Z to the R power and then find the ( ) root.

first

732

82. $Z^{\frac{N}{W}}$ means to raise Z to the (a) (   ) power and then find the (b) (   ) root.

W

83. A decimal power means the same thing as a fractional power. Thus $Z^{.4} = Z^{4/10}$ which means raise Z to the (a) (   ) power and then find the (b) (   ) root.

(a) N
(b) W

84. $9^{\frac{4}{10}} = \sqrt[10]{9^4}$ which means raise 9 to the (a) (   ) power and then find the (b) (   ) root.

(a) fourth
(b) tenth

85. $9^{.4}$ = (   ) (change to a fractional exponent).

(a) fourth
(b) tenth

86. $7^{.4}$ = (   ) (change to a fractional exponent).

$9^{\frac{4}{10}}$

87. $10^{.5}$ = (   ) (change to a fractional exponent).

$7^{\frac{4}{10}}$

Write the following 5 problems as whole number powers and roots: Example $2^{2/3} = \sqrt[3]{2^2}$

88. $7^{1/3}$ = (   ) =

$10^{\frac{5}{10}}$ or $10^{\frac{1}{2}}$

89. $9^{.4}$ = (   ).

$\sqrt[3]{7}$

90. $10^{\frac{2}{3}}$ = (   ).

$\sqrt[10]{9^4}$

91. $11^{\frac{1}{2}}$ = (   ).

$\sqrt[3]{10^2}$

92. $12^{.4}$ = (   ).

$\sqrt{11}$

END OF SET

$\sqrt[10]{12^4}$

685

FURTHER INSTRUCTIONS

If you missed less than 7 of the items, you have done a good job. Now read the summary, and you are ready to go on to Mathematics IV.

If you missed 7 or more of the items, read the following summary and then WORK THROUGH the program again.

SUMMARY

1. To square a number means to multiply that number by itself or raise it to the second power. For example, 4 squared or 4 raised to the second power means 4 x 4.

2. To cube a number or to raise a number to the third power means to use it three times in multiplication. For example, 4^3 means 4 x 4 x 4.

3. The exponent of a number tell you how many times to use that number in multiplication. For example, w^4 means w x w x w x w and the 4 is the exponent.

4. The number 1 raised to any power is always equal to 1.

5. To take the root of a number is the opposite of raising a number to a power. The root of a number is the quantity which, when multiplied by itself a given number of times, gives the number. For example:

$$\sqrt{9} = \sqrt{3 \times 3} = 3 \text{ and}$$
$$\sqrt[3]{8} = \sqrt[3]{2 \times 2 \times 2} = 2.$$

6. The number on the radical sign $\sqrt{\ }$ indicates what root of the number to take. For example, $\sqrt[3]{8}$ means to take the cube or third root of 8 and $\sqrt[4]{16}$ means to take the fourth root of 16. If no number is indicated as in $\sqrt{4}$, the square root is understood.

7. The root of a number may also be indicated by a fractional exponent as $8^{1/3}$ which means $\sqrt[3]{8}$.

8. The numberator of a fractional exponent indicates the power to which the number is to be raised and the denominator indicates the root to be taken. For example,

$$7^{2/3} \text{ means } \sqrt[3]{7^2}$$

9. A decimal power means the same thing as a fractional power. For example:

$$z^{.4} \text{ means } z^{\frac{4}{10}} \text{ which means } \sqrt[10]{z^4}.$$

734

686

POWERS OF TEN

1. Numbers are often written as small numbers times powers of 10. Such as 2×10^2 which would equal 2×100 = (   ).

200

2. 10^2 = (   ).

100

3. 10^4 = (   ).

10,000

4. $2 \times 10^3 = 2 \times 1{,}000$ = (   ).

2,000

5. To raise 10 to a power you must simply have a "1" plus as many zeros in your answer as the EXPONENT indicates. Thus, for 10^2 you have a "1" plus 2 zeros in your answer, and for 10^5 you have a "1" plus (   ) zeros in your answer.

5

6. 10^1 = (   ).

10

7. 10^3 = (   ).

1,000

8. How many zeros are there in 10^{10}? (   )

10

9. $1.5 \times 10^2 = 1.5 \times 100$ = (   ).

150

10. $4 \times 10^3 = 4 \times 1{,}000$ = (   ).

4,000

11. In the same way, when making a number like 100 into a power of ten you just use 10 plus the number of zeros in the given number. Thus, $1{,}000 = 10^3$ (three zeros in 1,000) and 100 = (   ).

10^2
(2 zeros in 100)

12. 10,000 = (   ).

10^4

13. 100,000,000 = (   ).

10^8

14. 4.5×10^2 = (   ).

15. 1.9×10^3 = (   ).

450
(4.5×100)

16. 3.6×10^5 = (   ).

1,900

17. 1.97×10^4 = (   ).

360,000

18. 4,000 = 4×10^3; thus 700 = (   ).

19,700

19. 6,400 = 6.4×10^3; thus 7,900 = (   ).

7×10^2

Write the following numbers (problems 20 - 26) as numbers BETWEEN 1 AND 10 times the proper power of 10.

20. 4,000 = (   ).

7.9×10^3

21. 600,000 = (   ).

4×10^3

22. 1,600 = (   ).

6×10^5

23. 420,000 = (   ).

1.6×10^3

24. 82,000,000 = (   ).

4.2×10^5

25. 155,000 = (   ).

8.2×10^7

26. 490,000,000 = (   ).

1.55×10^5

27 **To multiply numbers written as powers of 10 you simply MULTIPLY the NUMBERS (ignoring the 10's) and ADD the EXPONENTS of the 10's. Thus**

(2×10^2) $(2 \times 10^2) = 4 \times 10^4$, and

(4×10^2) (2×10^2) = (   ).

Review Note: The parentheses mean to multiply; thus (2×10^2) (2×10^2) means to multiply 2×10^2 times 2×10^2.

4.9×10^8

28. **You have just said that (4×10^2) $(2 \times 10^2) = 8 \times 10^4$. Working it out the long way you have (4×100) (2×100) = 400×200 = 80,000. $8 \times 10^4 = 8 \times 10 \times 10 \times 10 \times 10$ or $8 \times 10{,}000$. $8 \times 10{,}000$ = 80,000. You are doing the same thing in both cases. Now turn to the next page.**

8×10^4

29. $(9 \times 10^3)(8 \times 10^2) = 72 \times ($ $)$.

No answer required.

30. Remember, to multiply powers of 10 you simply ADD exponents. Thus to multiply $10^5 \times 10^4$ you would add 5 and ( ).

10^5

31. To multiply powers of 10 you simply ( ) exponents.

4

32. To multiply $10^2 \times 10^3$ you would add ( ) and ( ).

add

33. $10^3 \times 10^2 = ($ $)$ (leave answer as a power of 10).

2 and 3

34. Remember to multiply problems like $(2 \times 10^2)(3 \times 10^4)$ you must first (a) ( ) the numbers (ignoring the 10's) and then (b) ( ) the exponents of ten.

10^5

35. $(2 \times 10^2)(3 \times 10^4) = ($ $)$ (leave answer as power of 10).

Review Note: $(2 \times 10^2)(3 \times 10^4)$ means to multiply 2×10^2 times 3×10^4.

(a) multiply
(b) add

36. $(4 \times 10^5)(9 \times 10^6) = ($ $)$ (leave answer as a power of 10).

6×10^6

37. To DIVIDE powers you simply SUBTRACT exponents, thus $\frac{10^4}{10^2} = 10^2$; and to divide $\frac{10^5}{10^3}$ you would subtract 3 from ( ).

36×10^{11}

38. To divide powers you simply ( ) exponents.

5

39. To divide $\frac{10^6}{10^4}$ you would subtract 4 from ( ).

subtract

40. To divide $\frac{10^8}{10^7}$ you would subtract ( ) from ( ).

6

41. $\frac{10^4}{10^2} = ($ $)$ (leave the answer as a power of 10.)

7 from 8

42. $\frac{10^6}{10^3} = ($ $)$ (leave the answer as a power of 10).

10^2

43. When you divide numbers times powers of ten in the form:

$\frac{6 \times 10^8}{3 \times 10^5}$ you DIVIDE the 6 by the three leaving 2 and SUBTRACT the powers of ten, leaving 10^3. Your answer would then be 2×10^3.

$\frac{8 \times 10^4}{4 \times 10^2}$ = ( ).

10^3

44. $\frac{4 \times 10^6}{2 \times 10^3}$ = 2 x ( ).

2×10^2
(Remember that you DIVIDE 4 into 8. You do NOT subtract 4 from 8.)

45. $\frac{9 \times 10^4}{3 \times 10^2}$ = 3 x ( ).

10^3
(Because 4 DIVIDED BY 2 equals 2 and 10^3 subtracted from 10^6 equals 10^3.)

46. $\frac{7 \times 10^7}{4 \times 10^2}$ = 1.75 x ( ).

10^2

Divide the following (problems 47 - 50), leaving your answers in terms of a power of 10.

47. $\frac{16 \times 10^4}{4 \times 10^2}$ = ( ).

10^5

48. $\frac{24 \times 10^6}{8 \times 10^2}$ = ( ).

4×10^2

49. $\frac{4 \times 10^5}{2 \times 10^2}$ = ( ).

3×10^4

50. $\frac{36 \times 10^9}{4 \times 10^4}$ = ( ).

2×10^3

51. 9×10^5 = ( ).

9×10^5

52. 4×10^2 = ( ).

900,000

53. 2×10^3 = ( ).

400

END OF SET

2,000

738

69C

FURTHER INSTRUCTIONS

If you missed less than 3 of the items, you have done a good job. Now read the summary, and you are ready to go on to Mathematics V.

If you missed 3 or more of the items, read the following summary and then WORK THROUGH the program again.

SUMMARY

1. Numbers are often written as small numbers times a power of ten. For example, 200 can be written 2×10^2 and 62,000 can be written 6.2×10^4.

2. To raise 10 to a power, you must simply have as many zeros in your answer as the exponent indicates. For example,

   $10^2 = 100$, $10^4 = 10{,}000$ and
   $10^6 = 1{,}000{,}000$

3. To multiply powers of 10, you simply add the exponents of 10. For example,

   $10^2 \times 10^3 = 10^5$; $10^4 \times 10^8 = 10^{12}$.

4. To multiply numbers written as small numbers times a power of ten, you simply multiply the numbers, ignoring the tens, and then add the exponents of the tens. For example,

   $(4 \times 10^3)\ (2 \times 10^2) = 8 \times 10^5$.

5. To divide powers of ten, you simply subtract exponents. For example,

   $\frac{10^4}{10^2} = 10^2 \qquad \frac{10^8}{10^2} = 10^6$

6. To divide numbers written as small numbers times a power of ten, you simply divide the numbers, ignoring the tens, and then subtract the exponent of the tens. For example,

   $\frac{6 \times 10^5}{2 \times 10^2} = 3 \times 10^3$.

691

PREPARE THE MAN

PROGRAMMED TEXT 3ALR91630-II-IIc(1)

Department of Medicine
School of Health Care Sciences

Technical Training

CARDIOPULMONARY LABORATORY SPECIALIST

POWERS OF TEN

July 1973

10-6

Sheppard Air Force Base

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Designed For ATC Course Use

DO NOT USE ON THE JOB

692

ASSIGNMENT SHEET

This assignment sheet should be used when:

- You are to complete only a part of this text.
- Your assignment within this text is divided into two or more reading periods.

Your instructor will make assignments by identifying specific objectives, text material, and review questions.

ASSIGNMENTS

OBJECTIVES (by No)	TEXT MATERIAL (by page and/or frame)	REVIEW QUESTIONS (by No)

POWERS OF TEN

OBJECTIVES

1. Convert multiples of 10 to their equivalent powers of 10.
2. Convert numbers to equivalent numbers multiplied by specified powers of 10.
3. Convert numbers multiplied by specified powers of 10 to equivalent numbers multiplied by other specified powers of 10.
4. Convert numbers to scientific notation, rounded off to three significant digits.

Using powers of 10 and the laws of exponents

5. Solve multiplication problems.
6. Solve division problems.
7. Solve problems involving raising a power to the second power.
8. Extract square roots.
9. Solve problems involving various combinations of multiplication, division, extracting square roots, and raising a power to the second power.

SUGGESTED COMPLETION TIME 110 MINUTES

DIRECTIONS PAGE

This program contains 46 pages. Most pages (starting with page 4) are divided into 3 sections:

a TOP section, containing the answer to the problem on the preceding page;

a MIDDLE section, containing an example problem and its solution;

a BOTTOM section, containing a problem we want you to solve.

DO NOT take up valuable time solving the example problem in the middle section. Just examine it carefully step by step to see how we solved it. Next, solve the problem in the bottom section of the page. Then, check your answer with the correct answer at the top of the next page. Remember, do not waste valuable time solving the example problems. To remind you, we have placed a ● in front of the problems we want you to solve.

695

Introduction to Powers of 10

Example of a very large number: 100,000,000,000

Example of a very small number: .000000000006

Electrical measurements often involve very large and very small numbers. Working with large and small numbers can be time-consuming. Also, using numbers with many zeros may lead to mistakes. Powers of 10 are used to express these large and small numbers containing many digits as equivalent numbers containing only a few digits. Obviously, numbers containing fewer digits are easier to use.

Powers of 10 involve the use of exponents. An exponent is a small number written above and to the right of a number, which is the base number. The exponent indicates the number of times the base is to be taken as a factor.

For example: $10^3 = 10 \times 10 \times 10 = 1000$

A multiple of 10 greater than one can be expressed as the base 10 with a positive exponent.

For example: $10 = 10^1$ $100 = 10^2$ $1000 = 10^3$, etc.

Multiples of 10 less than 1 can be expressed as the base 10 with a negative exponent.

For example: $.1 = 10^{-1}$ $.01 = 10^{-2}$ $.001 = 10^{-3}$, etc.

The base 10 written without an exponent actually has an exponent of 1. Thus, $10 = 10^1$

The base 10 with an exponent of zero is equal to one. Thus, $10^0 = 1$.

No response required.

696

This table shows some decimals and whole numbers and their equivalent powers of 10. Study it for a moment.

$$10{,}000 = 10^4$$
$$1{,}000 = 10^3$$
$$100 = 10^2$$
$$10 = 10^1$$
$$1 = 10^0$$ Notice that $10^0 = 1$
$$.1 = 10^{-1}$$
$$.01 = 10^{-2}$$
$$.001 = 10^{-3}$$
$$.0001 = 10^{-4}$$

No response required.

Any number can be converted into 2 factors: A numerical factor times a power of 10. The numerical factor will have the same digit sequence as the original number. The power of 10 and its sign will be determined by the number of places and the direction the decimal point in the original number is moved.

Examples:

$7900 = 7.9 \times 10^3$	because	$10^3 = 1{,}000$
$.01 = 1 \times 10^{-2}$	"	$10^{-2} = .01$
$75 = 7.5 \times 10^1$	"	$10^1 = 10$
$.075 = 7.5 \times 10^{-2}$	"	$10^{-2} = .01$
$.075 = 75 \times 10^{-3}$	"	$10^{-3} = .001$
$.075 = 750 \times 10^{-4}$	"	$10^{-4} = .0001$

No response required.

Fill in the blanks with the equivalent powers of 10.

.0001	=	1 x	10^{-4}
.001	=	1 x	______
.01	=	1 x	______
.1	=	1 x	______
1	=	1 x	10^{0}
10	=	1 x	______
100	=	1 x	______
1000	=	1 x	______

Check your answers with the table on page 2

Any number may be converted into 2 factors: A numerical factor times a power of 10 factor. The numerical factor always has the same digit sequence as the original number. The exponent (power) of the base 10 is always equal to the number of places the decimal point is moved. The exponent is POSITIVE when the decimal point is moved to the LEFT; the exponent is NEGATIVE when the decimal point is moved to the RIGHT.

Fill in the blanks: To convert a number to a numerical factor times a power of 10,

move the decimal point ______ (LEFT/RIGHT), make the power of 10 ______ (POSITIVE/NEGATIVE);

or move the decimal point ______ (LEFT/RIGHT), make the power of 10 ______ (POSITIVE/NEGATIVE).

move the decimal point LEFT; make the power of 10 POSITIVE,

move the decimal point RIGHT; make the power of 10 NEGATIVE

Fill in the blank with the equivalent power of 10.

$.000001 =$ ____________

Solution: Move decimal point 6 places to the RIGHT; exponent is NEGATIVE 6.

Thus:

$.000001 = 1 \times 10^{-6} = \underline{10^{-6}}$

Fill in the blank with the equivalent power of 10.

$.001 =$ ____________

$.001 = 1 \times 10^{-3} = \underline{10^{-3}}$

Decimal point is moved 3 places RIGHT; exponent is NEGATIVE 3.

Fill in the blank with the equivalent power of 10.

100,000,000 = ______

Solution: Move decimal point 8 places LEFT; exponent is POSITIVE 8.

Thus:

$100{,}000{,}000 = 1 \times 10^8 = \underline{\quad 10^8 \quad}$

Fill in the blank with the equivalent power of 10.

1,000 = ______

700

$1{,}000 = 1 \times 10^3 = \underline{10^3}$

Decimal point is moved 3 places LEFT; exponent is POSITIVE 3.

Fill in the blanks with the proper numerical factors.

7. $3200 = \underline{\qquad\qquad} \times 10^4$

$3200 = \underline{\qquad\qquad} \times 10^{-4}$

Solution: Move the decimal point to the LEFT when the exponent is POSITIVE; and to the RIGHT when the exponent is NEGATIVE.

Thus: $3200 = \underline{.3200} \times 10^4$

$3200 = \underline{32{,}000{,}000} \times 10^{-4}$

---

8. Fill in the blank with the proper numerical factor.

$\text{:0,000} = \underline{\qquad\qquad} \times 10^{'}$

SP- 73-9095

701

50,000 = .005 x 10^7 The decimal point moves 7 places LEFT when the exponent is +7.

Fill in the blank with the proper value.

.000000000045 = ______________ x 10^{-12}

Solution: Move the decimal point 12 places RIGHT when the exponent is NEGATIVE 12.

Thus:

.000000000045 = 45 x 10^{-12}

Fill in the blank with the proper value.

.00056 = ______________ x 10^{-6}

$.00056 = \underline{\quad 560 \quad} \times 10^{-6}$ Exponent is NEGATIVE 6; the decimal point moves 6 places RIGHT.

Fill in the blank with the equivalent power of 10.

$.1 = \underline{\qquad\qquad}$

Solution: Move decimal point one place to the RIGHT; the exponent is NEGATIVE one.

Thus:

$.1 = 1 \times 10^{-1} = \underline{10^{-1}}$

Fill in the blank with the equivalent power of 10.

$.00000001 = 1 \times \underline{\qquad\qquad} = \underline{\qquad\qquad}$

$.00000001 = \underline{1 \times 10^{-8}} = \underline{10^{-8}}$ Exponent is NEGATIVE 8 when decimal point moves 8 places RIGHT.

Fill in the blanks with the proper values.

$9.15 \times 10^{3} =$ ________________ $\times 10^{6}$

$9.15 \times 10^{-3} =$ ________________ $\times 10^{-6}$

Solution: Move the decimal point to the LEFT when the change in exponent is in a POSITIVE direction.
Move the decimal point to the RIGHT when the change in exponent is in a NEGATIVE direction.

Thus:

$9.15 \times 10^{3} =$ ____.00915____ $\times 10^{6}$

$9.15 \times 10^{-3} =$ ____9,150____ $\times 10^{-6}$

Note: Changing from 10^3 to 10^6 means the exponent changes by 3 in a POSITIVE direction.
Changing from 10^{-3} to 10^{-6} means the exponent changes by 3 in a NEGATIVE direction.

Fill in the blank with the proper value.

$2.20 \times 10^{-2} =$ ________________ $\times 10^{0}$

2.20×10^{-2} = .0220 $\times 10^{0}$ Changing from 10^{-2} to 10^{0} means the exponent changes by 2 in a POSITIVE direction; so the decimal point moves 2 places LEFT.

Fill in the blank with the proper value.

3.33×10^{-4} = ____________ $\times 10^{-6}$

Solution: Changing from 10^{-4} to 10^{-6} means the exponent changes by 2 in a NEGATIVE direction; so the decimal point in 3.33 moves 2 places RIGHT.

Thus:

3.33×10^{-4} = 333 $\times 10^{-6}$

Fill in the blanks with the proper values.

5.83×10^{2} = ____________ $\times 10^{-1}$

1708

$5.83 \times 10^2 = \underline{5,830} \times 10^{-1}$

Changing from 10^2 to 10^{-1} means the exponent changes by 3 in a NEGATIVE direction; so the decimal point in 5.83 moves 3 places to the RIGHT.

Fill in the blank with the proper value,

$250,000 = \underline{\qquad\qquad\qquad} \times 10^5$

Solution: Move the decimal point 5 places LEFT when the exponent is POSITIVE 5.

Thus:

$250,000 = \underline{\quad 2.5 \quad} \times 10^5$

Fill in the blank with the proper value.

$13,460 = \underline{\qquad\qquad\qquad} \times 10^{-12}$

$13,460 = \underline{13,460,000,000,000,000} \times 10^{-12}$ When exponent is NEGATIVE 12, decimal point is moved 12 places RIGHT.

Fill in the blanks with the equivalent powers of 10. Do both problems before checking answers.

100,000 = ____________________

.001 = ____________________

$100{,}000 = \underline{10^5}$ Decimal point is moved 5 places LEFT; exponent is POSITIVE 5.

$.001 = \underline{10^{-3}}$ Decimal point is moved 3 places RIGHT; exponent is NEGATIVE 3.

Convert the following numbers to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

636.42 = ____________

.003492 = ____________

Solution: Converting a number to SCIENTIFIC NOTATION means to convert the number to a numerical factor between 1 and 10 times the proper POSITIVE or NEGATIVE power of 10.

Thus: Original number		In scientific notation, but NOT rounded off		In scientific notation, and rounded off to 3 significant digits
636.42	=	6.3642×10^2	=	$\underline{6.36 \times 10^2}$
.003492	=	3.492×10^{-3}	=	$\underline{3.49 \times 10^{-3}}$

Convert this number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

.000088885 = ____________

$.0000888885 = \underline{8.89 \times 10^{-5}}$

8.89 is a number between 1 and 10; decimal point moves RIGHT 5 places, so exponent is NEGATIVE 5.

Convert the following number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

45667 = ____________

Solution: Place the decimal point between the 4 and 5 so the number has a value between 1 and 10. Since the decimal point moves LEFT 4 places, the power of 10 is POSITIVE. 10^4. Remember, a number in SCIENTIFIC NOTATION is a number between 1 and 10 times a power of 10.

Thus:

$45667 = 4.5667 \times 10^4 = \underline{4.57 \times 10^4}$

Convert the following number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

4444.30 = ____________

4444.30 = 4.44×10^3

4.44 is between 1 and 10; decimal point moved 3 places LEFT; exponent is +3.

Fill in the blank with the proper value.

$$6.660 \times 10^{-4} = \underline{\hspace{6em}} \times 10^{-7}$$

Solution: Changing from 10^{-4} to 10^{-7} means the exponent changes by 3 in a NEGATIVE direction; so the decimal point in the original number 6.660 moves 3 places to the RIGHT.

Thus:

$$6.660 \times 10^{-4} = \underline{6{,}660} \times 10^{-7}$$

Fill in the blank with the proper value.

$$7.09 \times 10^{4} = \underline{\hspace{6em}} \times 10^{-1}$$

$7.09 \times 10^4 = \underline{709{,}000} \times 10^{-1}$

Changing from 10^4 to 10^{-1} means the exponent changes by 5 in a NEGATIVE direction; so the decimal point in 7.09 moves 5 places RIGHT.

Fill in the blanks with the proper values. Do both problems before checking answers.

$83{,}000 = \underline{\qquad\qquad} \times 10^6$

$.0000525 = \underline{\qquad\qquad} \times 10^{-12}$

$83,000 = \underline{.083000} \times 10^{6}$ POSITIVE 6 exponent; decimal point moves 6 places LEFT.

$.0000525 = \underline{52,500,000} \times 10^{-12}$ NEGATIVE 12 exponent; decimal point moves 12 places RIGHT.

Convert the following number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

665,878 = ____________

Solution: 6.65878 is a number between 1 and 10. Since decimal point moved 5 places LEFT, exponent of power of 10 factor is POSITIVE 5. 6.65878 is now rounded off to 3 significant digits.

Thus:

$665,878 = 6.65878 \times 10^{5} = \underline{6.66 \times 10^{5}}$

Convert the following number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

.00008887 = ________

7/2

$.00008887 = 8.8887 \times 10^{-5} = \underline{8.89 \times 10^{-5}}$

Fill in the blanks with the proper values.

$4.24 \times 10^{-6} = \_\_\_\_\_\_\_\_\_\_ \times 10^{-3}$

$6.28 \times 10^{4} = \_\_\_\_\_\_\_\_\_\_ \times 10^{-2}$

Page 18

713

$4.24 \times 10^{-6} = \underline{.00424} \times 10^{-3}$

Changing from 10^{-6} to 10^{-3} means the exponent changes by 3 in a POSITIVE direction; so decimal point in 4.24 moves 3 places to the LEFT.

$6.28 \times 10^{4} = \underline{6,280,000} \times 10^{-2}$

Changing from 10^{4} to 10^{-2} means the exponent changes by 6 in a NEGATIVE direction; so the decimal point in 6.28 moves 6 places to the RIGHT.

Convert the following numbers to SCIENTIFIC NOTATION, rounded off to 3 significant digits. Do both problems before checking answers.

.000034567 = ____________________

881.238 = ____________________

$000034567 = \underline{3.46 \times 10^{-5}}$

$881.238 = \underline{8.81 \times 10^{2}}$

Powers of 10 simplify problem solving. For example:

Multiplication: $2{,}000 \times 45{,}000 = (2 \times 10^{3}) \times (4.5 \times 10^{4}) = \underline{9 \times 10^{7}}$

Division: $\frac{66{,}000}{3{,}000} = \frac{6.6 \times 10^{4}}{3 \times 10^{3}} = \frac{6.6 \times 10^{4} \times 10^{-3}}{3} = \underline{2.2 \times 10^{1}}$ or $\underline{22}$

Extracting Square root: $\sqrt{4{,}000{,}000} = \sqrt{4 \times 10^{6}} = 2 \times 10^{6 \div 2} = \underline{2 \times 10^{3}}$

Squaring a number: $(20{,}000)^{2} = (2 \times 10^{4})^{2} = 4 \times 10^{4 \times 2} = \underline{4 \times 10^{8}}$

Study the above examples for a moment.

No response required on this page.

Page 20

718

Solve using powers of 10.

10,000 x 100 = ______

.0000001 x .001 = ______

10,000 x .001 = ______

23,000 x 500 = ______

6200 x .02 x 2000 = ______

Solution: To multiply two or more numbers using powers of 10, add the powers (exponents) and retain the base 10.

Thus:

$10{,}000 \times 100 = 1 \times 10^4 \times 1 \times 10^2 = 10^{4+2} = \underline{10^6}$

$.0000001 \times .001 = 1 \times 10^{-7} \times 1 \times 10^{-3} = 10^{-7+(-3)} = \underline{10^{-10}}$

$10{,}000 \times .001 = 1 \times 10^4 \times 1 \times 10^{-3} = 10^{4+(-3)} = \underline{10}$

$23{,}000 \times 500 = 2.3 \times 10^4 \times 5 \times 10^2 = 11.5 \times 10^{4+2} = \underline{11.5 \times 10^6}$

$6200 \times .02 \times 2000 = 6.2 \times 10^3 \times 2 \times 10^{-2} \times 2 \times 10^3 = 24.8 \times 10^{3+(-2)+3} = \underline{24.8 \times 10^4}$

Solve using powers of 10.

$10^6 \times 10^3 \times 10^{-3} \times 10^6 =$

$10^6 \times 10^3 \times 10^{-3} \times 10^6 = 10^{6+3+(-3)+6} = \underline{10^{12}}$ To multiply powers of 10, add exponents and retain the base 10.

Solve using powers of 10.

$300 \times 2200 \times .001 =$

Solution: To multiply, convert each factor to SCIENTIFIC NOTATION; multiply the numerical factors together and add the powers of 10.

Thus:

$300 \times 2200 \times .001 = (3 \times 10^2) \times (2.2 \times 10^3) \times (1 \times 10^{-3}) = 3 \times 2.2 \times 10^{2+3+(-3)}$

$= \underline{6.6 \times 10^2}$

Solve using powers of 10.

$3500 \times .0035 \times 8000 =$

717

$$3500 \times .0035 \times 8000 = (3.5 \times 10^3) \times (3.5 \times 10^{-3}) \times (8 \times 10^3)$$

$$= (3.5 \times 3.5 \times 8) \times 10^{3+(-3)+3}$$

$$= \underline{98 \times 10^3}$$

Solve using powers of 10.

$$\frac{10^7}{10^3} =$$

Solution: To divide, move 10^3 from the denominator to the numerator; change the sign of the exponent 3; then add the exponents.

Thus: $\frac{10^7}{10^3} = \frac{10^7 \times 10^{-3}}{1} = 10^{7+(-3)} = \underline{10^4}$

Solve using powers of 10.

$$\frac{660,000}{.0002} =$$

$$\frac{660,000}{.0002} = \frac{6.6 \times 10^5}{2 \times 10^{-4}} = \frac{6.6 \times 10^5 \times 10^4}{2} = \underline{3.3 \times 10^9}$$

Solve using powers of 10.

$$\frac{66,000}{.000003} =$$

Solution: Convert to SCIENTIFIC NOTATION (or small, easy to divide numbers); then divide using laws of exponents.

Thus:

$$\frac{66,000}{.000003} = \frac{6.6 \times 10^4}{3 \times 10^{-6}} = \frac{6.6 \times 10^4 \times 10^6}{3} = \underline{2.2 \times 10^{10}}$$

Solve using powers of 10.

$$\frac{45,000,000}{.005} =$$

$$\frac{45,000,000}{.005} = \frac{4.5 \times 10^{7}}{5 \times 10^{-3}} = \frac{4.5 \times 10^{7} \times 10^{3}}{5} = \underline{.9 \times 10^{10}} \text{ or } \underline{9 \times 10^{9}}$$

Solve using powers of 10.

$.00006 \times .144 \times .02 =$

Solution: Convert factors to SCIENTIFIC NOTATION; multiply the numerical factors; and add the powers of 10.

Thus:

$$.00006 \times .144 \times .02 = (6 \times 10^{-5}) \times (1.44 \times 10^{-1}) \times (2 \times 10^{-2})$$

$$= (6 \times 1.44 \times 2) \times 10^{-5+(-1)+(-2)}$$

$$= \underline{17.28 \times 10^{-8}}$$

Solve using powers of 10.

$1,200 \times 200 \times .0003 =$

$1200 \times 200 \times .0003 = (1.2 \times 10^3) \times (2 \times 10^2) \times (3 \times 10^{-4})$

$= (1.2 \times 2 \times 3) \times 10^{3+2+(-4)}$

$= \underline{7.2 \times 10^1}$

Solve using powers of 10.

$(10^4)^2 =$

Solution: To raise a power of 10 to the second power, multiply the power of 10 by 2.

Thus:

$(10^4)^2 = 10^{4\times2} = \underline{10^8}$

Solve using powers of 10.

$(10^6)^2 =$

721

$(10^6)^2 = 10^{6x2} = \underline{10^{12}}$

Solve using powers of 10.

$(30,000)^2 =$

Solution: Convert to SCIENTIFIC NOTATION; square the numerical factor; and multiply the power of 10 by the exponent 2.

Thus:

$(30,000)^2 = (3 \times 10^4)^2 = 3^2 \times 10^{4x2} = \underline{9 \times 10^8}$

Solve using powers of 10.

$(6 \times 10^3)^2 =$

$(6 \times 10^3)^2 = 6^2 \times 10^{3 \times 2} = \underline{36 \times 10^6}$

Solve using powers of 10.

$$\frac{.159}{.00003} =$$

Solution: Convert to easily divisible numbers times powers of 10; then divide.

Thus:

$$\frac{.159}{.00003} = \frac{159 \times 10^{-3}}{3 \times 10^{-5}} = \frac{159 \times 10^{-3} \times 10^5}{3} = 53 \times 10^2$$

Solve using powers of 10.

$$\frac{1}{.000005} =$$

723

$$\frac{1}{.000005} = \frac{1}{5 \times 10^{-6}} = \frac{1 \times 10^{6}}{5} = \frac{10 \times 10^{5}}{5} = \underline{2 \times 10^{5}}$$

NOTE: We converted the 1 to a 10 to make it easier to divide by 5.

Solve using powers of 10. Do both problems before checking answers.

$10^{7} \times 5 \times 10^{-2} \times 10^{6} =$

$.225 \times .002 \times .04 =$

724

$10^7 \times 5 \times 10^{-2} \times 10^6 = 5 \times 10^{7+(-2)+6} = \underline{5 \times 10^{11}}$

$.225 \times .002 \times .04 = (2.25 \times 10^{-1}) \times (2 \times 10^{-3}) \times (4 \times 10^{-2}) = \underline{18 \times 10^{-6}}$

Solve using powers of 10.

$\sqrt{10^8} =$

Solution: To extract the square root of a power of 10, divide the exponent by 2 and retain the base 10.

Thus:

$\sqrt{10^8} = 10^{8 \div 2} = \underline{10^4}$

Solve using powers of 10.

$\sqrt{10^6} =$

$\sqrt{10^6} = 10^6 = \underline{10^3}$

Solve using powers of 10.

$$\sqrt{30 \times 20 \times 2 \times 3 \times 10^2} =$$

Solution: Combine and convert the factors under the radical sign into 2 factors, a numerical factor and an ''EVEN'' power of 10.
By even, we mean that the power can be divided evenly by 2.

Thus:

$$\sqrt{30 \times 20 \times 2 \times 3 \times 10^2} = \sqrt{36 \times 10^2 \times 10^2}$$

$$= \sqrt{36 \times 10^4}$$

$$= 6 \times 10^{4 \div 2}$$

$$= \underline{6 \times 10^2}$$

Solve using powers of 10.

$$\sqrt{1000 \times 10^7} =$$

$$\sqrt{1000 \times 10^7} = \sqrt{10^3 \times 10^7} = \sqrt{10^{10}} = 10^{10 \div 2} = \underline{10^5}$$

Solve using powers of 10.

$$(400 \times 10^4)^2 =$$

Solution: Convert quantity in parentheses to SCIENTIFIC NOTATION; square the numerical factor; multiply the power of 10 by 2

Thus:

$$(400 \times 10^4)^2 = (4 \times 10^2 \times 10^4)^2 = 4^2 \times 10^{6 \times 2}$$

$$= \underline{16 \times 10^{12}}$$

Solve using powers of 10.

$$(12 \times 10^{-3})^2 =$$

$(12 \times 10^{-3})^2 = 12^2 \times 10^{-3 \times 2} = \underline{144 \times 10^{-6}}$

Solve using powers of 10. Do both problems before checking answers.

$$\frac{1}{500,000} =$$

$$\frac{10^8 \times 10}{10^{-5} \times 1000} =$$

$$\frac{1}{500{,}000} = \frac{1}{5 \times 10^5} = \frac{1 \times 10^{-5}}{5} = \frac{10 \times 10^{-6}}{5} = \underline{2 \times 10^{-6}}$$

$$\frac{10^8 \times 10}{10^{-5} \times 1{,}000} = \frac{10^9}{10^{-5} \times 10^3} = \frac{10^9 \times 10^5 \times 10^{-3}}{1} = \underline{10^{11}}$$

Solve using powers of 10.

$$\sqrt{81{,}000 \times 10^3} =$$

Solution: Convert the factors under the radical sign to a numerical factor times an ''EVEN'' power of 10 (divisible by 2).

Thus:

$$\sqrt{81{,}000 \times 10^3} = \sqrt{81 \times 10^6}$$

$$= 9 \times 10^{6 \div 2}$$

$$= \underline{9 \times 10^3}$$

Solve using powers of 10.

$$\sqrt{2500 \times 10^4} =$$

$\sqrt{2500 \times 10^4} = \sqrt{25 \times 10^6} = 5 \times 10^{6 \div 2} = \underline{5 \times 10^3}$

Solve using powers of 10. Do both problems before checking answers.

$(100 \times 10{,}000)^2 =$

$(3 \times 10^5)^2 =$

$(100 \times 10{,}000)^2 = (10^2 \times 10^4)^2 = (10^6)^2 = 10^{6\times2} = \underline{10^{12}}$

$(3 \times 10^5)^2 = 3^2 \times 10^{5\times2} = \underline{9 \times 10^{10}}$

Solve using powers of 10. Do both problems before checking answers.

$\sqrt{4 \times 3 \times 12 \times 10^4} =$

$\sqrt{160 \times 10^5} =$

731

$\sqrt{4 \times 3 \times 12 \times 10^4} = \sqrt{144 \times 10^4} = \underline{12 \times 10^2}$

$\sqrt{160 \times 10^5} = \sqrt{16 \times 10^6} = \underline{4 \times 10^3}$

Electronic problems are often combinations of multiplication, division, extracting square roots, etc.
It is suggested that combination problems be solved in this order:

(1) Convert all factors to SCIENTIFIC NOTATION, or to small, easy to handle numbers, multiplied by the proper powers of 10.

(2) Extract square roots (thus removing radical signs).

(3) Multiply, divide, etc., until solution is reached.

Study the above for several moments, then continue below.

Fill in the blanks:

To extract the square root of a power of 10, the power of 10 must be $\underset{\text{odd/even}}{\underline{\hspace{2cm}}}$.

If it is not $\underset{\text{odd/even}}{\underline{\hspace{2cm}}}$, it must be made $\underset{\text{odd/even}}{\underline{\hspace{2cm}}}$.

even even even

Solve using powers of 10.

$$\frac{1}{2\pi\sqrt{.03 \times 12 \times .000001}} =$$

Solution: This type of problem is very common in electronics. The factor π always has a numerical value of 3.14. Thus, $2\pi = 2 \times 3.14 = 6.28$

When you are asked to solve a problem containing $\frac{1}{2\pi}$, as in the problem above, you can simplify its solution by substituting 159×10^{-3} in place of the factor $\frac{1}{2\pi}$. This substitution is permissible because

$$\frac{1}{2\pi} = \frac{1}{2 \times 3.14} = \frac{1}{6.28} = .159 = 159 \times 10^{-3}$$

Thus:

$$\frac{1}{2\pi\sqrt{.03 \times 12 \times .000001}} = \frac{159 \times 10^{-3}}{\sqrt{.03 \times 12 \times .000001}} = \frac{159 \times 10^{-3}}{\sqrt{36 \times 10^{-8}}} = \frac{159 \times 10^{-3}}{6 \times 10^{-4}} = \underline{26.5 \times 10^{1}}$$

Study the above for several moments, then continue below.

Fill in the blanks.

$$\frac{1}{2\pi} = \frac{1}{2 \times 3.14} = \frac{1}{6.28} = \_\_\_\_\_\_\_\_ \text{ or } \_\_\_\_\_\_\_\_$$

733

$$\frac{1}{2 \times 3.14} = \frac{1}{6.28} = \underline{.159} \text{ or } 159 \times 10^{-3}$$

NOTE: This answer is very important. You will use this information many times, both in this program and in the weeks ahead. MEMORIZE IT.

Solve using powers of 10.

$$\frac{1}{2 \times 3.14 \sqrt{.00049 \times 2 \times .00002}} =$$

Solution: Rewrite problem to have 159×10^{-3} in the numerator; then solve.

Thus:

$$\frac{1}{2 \times 3.14 \sqrt{.00049 \times 2 \times .00002}} = \frac{159 \times 10^{-3}}{\sqrt{.00049 \times 2 \times .00002}} = \frac{159 \times 10^{-3}}{\sqrt{196 \times 10^{-10}}} = \frac{159 \times 10^{-3}}{14 \times 10^{-5}}$$

$$= \underline{11.4 \times 10^{+2}}$$

Solve using powers of 10.

$$\frac{1}{6.28 \sqrt{.04 \times 360 \times 10^{-7}}} =$$

$$\frac{1}{6.28\sqrt{.04 \times 360 \times 10^{-7}}} = \frac{159 \times 10^{-3}}{\sqrt{144 \times 10^{-8}}} = \frac{159 \times 10}{12} = \underline{13.25 \times 10} \text{ or } \underline{132.5}$$

Solve using powers of 10.

$$\frac{.159}{\sqrt{.0008 \times 32 \times 10^{-6}}} =$$

Solution: Convert .159 to 159×10^{-3}; then solve.

Thus:

$$\frac{.159}{\sqrt{.0008 \times 32 \times 10^{-6}}} = \frac{159 \times 10^{-3}}{\sqrt{8 \times 32 \times 10^{-4} \times 10^{-6}}} = \frac{159 \times 10^{-3}}{16 \times 10^{-5}} = \frac{159 \times 10^{-3} \times 10^{5}}{16}$$

$$= \underline{9.94 \times 10^{2}}$$

Solve using powers of 10.

$$\frac{1}{6.28 \times 240 \times .0006} =$$

735

$$\frac{1}{6.28 \times 240 \times .0006} = \frac{159 \times 10^{-3}}{2.4 \times 6 \times 10^{2} \times 10^{-4}} = \frac{159 \times 10^{-3}}{14.4 \times 10^{-2}} = \frac{159 \times 10^{-3} \times 10^{2}}{14.4} = \underline{11.04 \times 10^{-1}}$$

NOTE: $\frac{1}{6.28} = .159$ or 159×10^{-3}

Solve using powers of 10.

$$\frac{1}{2 \times 3.14\sqrt{.09 \times 4 \times 10^{-4}}} =$$

Solution: Rewrite problem to read 159×10^{-3} instead of $\frac{1}{2 \times 3.14}$.

Thus: $$\frac{159 \times 10^{-3}}{\sqrt{.09 \times 4 \times 10^{-4}}} = \frac{159 \times 10^{-3}}{\sqrt{36 \times 10^{-6}}} = \frac{159 \times 10^{-3}}{6 \times 10^{-3}} = \frac{159 \times 10^{-3} \times 10^{3}}{6} = 26.5$$

Solve using powers of 10.

$$\frac{.159}{\sqrt{.49 \times 4 \times 10^{-8}}} =$$

$$\frac{.159}{\sqrt{.49 \times 4 \times 10^{-8}}} = \frac{159 \times 10^{-3}}{\sqrt{49 \times 4 \times 10^{-10}}} = \frac{159 \times 10^{-3}}{14 \times 10^{-5}} = \frac{159 \times 10^{-3} \times 10^{5}}{14} = 11.36 \times 10^{2}$$

Solve using powers of 10. Do both problems before checking answers.

$6.28 \times 25{,}000 \times .000013 =$

$(18 \times 10^{-4})^2 \times 100{,}000 =$

Page 42

$$6.28 \times 25{,}000 \times .000013 = 6.28 \times (2.5 \times 10^{4}) \times (1.3 \times 10^{-5})$$

$$= 6.28 \times 2.5 \times 1.3 \times 10^{4} \times 10^{-5}$$

$$= 20.41 \times 10^{-1}$$

or

$$= \underline{2.041}$$

$$(18 \times 10^{-4})^{2} \times 100{,}000 = 18^{2} \times 10^{-8} \times 10^{5}$$

$$= \underline{324 \times 10^{-3}}$$

or

$$= \underline{3.24 \times 10^{-1}}$$

You have completed the program on Powers of Ten.

Notify your instructor.

REVIEW TEST FOR POWERS OF 10

1. Fill in the blanks with the equivalent powers of 10.

a. .0001 = ______________

b. 10,000 = ______________

c. .0000001 = ______________

d. 1,000,000 = ______________

e. .01 = ______________

2. Fill in the blanks with the proper values.

a. 6,000 = ______________ $\times 10^{3}$

b. 796,000 = ______________ $\times 10^{6}$

c. 12,350 = ______________ $\times 10^{-3}$

d. .0000000000033 = ______________ $\times 10^{-12}$

e. 300,000 = ______________ $\times 10^{2}$

3. Fill in the blanks with the proper values.

a. 2.82×10^{-3} = ______________ $\times 10^{-6}$

b. 7.00×10^{3} = ______________ $\times 10^{0}$

c. 8.19×10^{6} = ______________ $\times 10^{3}$

d. 3.14×10^{-5} = ______________ $\times 10^{-3}$

e. 4.72×10^{3} = ______________ $\times 10^{-2}$

4. Convert the following numbers to scientific notation, rounded off to three significant digits:

a. 554776 = ______________

b. 827.341 = ______________

c. .007776 = ______________

d. .00004666 = ______________

e. 22,222.9 = ______________

5. Solve the problems on this page using powers of 10.

a. $450 \times .025 \times 90{,}000 =$

b. $.00005 \times 8 \times 10^{-4} \times 10^{6} =$

c. $10^{-3} \times 10^{8} \times 4 \times 10^{7} =$

d. $.125 \times .0003 \times .05 =$

e. $33{,}000 \times 1{,}000{,}000 \times 300 =$

6. Solve using powers of 10.

a. $\frac{99{,}000}{.003} =$

b. $\frac{1}{2500} =$

c. $\frac{.00044}{11{,}000{,}000} =$

d. $\frac{550{,}000}{.000005} =$

e. $\frac{10 \times 10^{7}}{100 \times 10^{-4}} =$

7. Solve using powers of 10.

a. $(100)^2 =$

b. $(4 \times 10^{6})^2 =$

c. $(5000)^2 =$

d. $(10 \times 1000)^2 =$

e. $(10^3)^2 =$

8. Solve using powers of 10.

a. $\sqrt{10 \times 10^{9}} =$

b. $\sqrt{900 \times 10^{4}} =$

c. $\sqrt{36{,}000{,}000} =$

d. $\sqrt{10^{12}} =$

e. $\sqrt{20 \times 3 \times 6 \times 10^{3}} =$

9. Solve using powers of 10.

a. $(16 \times 10^{-3})^2 \times 10{,}000 =$

b. $6.28 \times 35{,}000{,}000 \times .0000017 =$

c. $\dfrac{1}{6.28 \times 120 \times .000008} =$

d. $\dfrac{.159}{\sqrt{.008 \times 1.8 \times 10^{-6}}} =$

e. $\dfrac{1}{2 \times 3.14\sqrt{.0004 \times 16 \times 10^{-12}}} =$

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741

PREPARE THE MAN PROGRAMMED TEXT 3ALR91630-II-6

Department of Medicine
School of Health Care Sciences

Cardiopulmonary Laboratory Specialist

Volume II

MATHEMATICS REVIEW

Simple Equations and Proportions

August 1973

10-6

SHEPPARD AIR FORCE BASE, TEXAS

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838

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Study Guides, Workbooks, Programmed Texts and Handouts are training publications authorized by Air Training Command (ATC) for student use in ATC courses.

The STUDY GUIDE (SG) presents the information you need to complete the unit of instruction, or makes assignments for you to read in other publications which contain the required information.

The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

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743

INSTRUCTIONS

This programmed text was prepared under the technical supervision of the George Washington University Human Resources Research Office. The text provides a REVIEW of specific elementary mathematical skills. This text consists of two volumes. Volume I reviews multiplication and division of decimals, cancelation, and powers and roots. This volume reviews simple equations and proportions. To sucessfully complete this volume, you must know the mathematics covered in Volume I.

The contents of this text are presented in numbered statements or problems called "Frames." The answer to frame number 1 appears below frame number 2; number 2's answer follows frame number 3, etc. Read each frame carefully and fill in the word(s) or number(s) in the parentheses which will complete the statement CORRECTLY. For example: eight divided by four equals (2).

Next, compare the correct answer (below the next frame) with yours.

If your answer is correct, go to the next frame.

If your answer is wrong, reread the frame, draw a line through your answer and write the correct answer next to (or below) yours.

Complete each frame in sequence. Don't skip any of them. THIS IS NOT A TEST, so you may refer to previous frames at any time you want to. You may work at your own best speed. You are NOT being timed.

YOU MAY BEGIN

744

SIMPLE EQUATIONS

(Part One)

1. A simple equation is an algebraic expression with one unknown quantity. This "unknown" is indicated by an "x" or some other letter. $2x + 4 = 2$ is a simple ( ).

2. $4x = 16$. This is a simple ( ).

equation

3. In a simple equation, the LETTER stands for the unknown quantity. In the equation $6x + 9 = 14$, the letter ( ) stands for the unknown.

equation

4. In $4a + 1 = 12$, the letter "a" stands for the ( ).

x

5. In $7z = 14$, the unknown is ( ).

unknown

6. In $7z = 14$, replacing the unknown z by 2 and multiplying the 2 by 7 gives the number ( ) on the left side and on the right side.

z

7. In $2y + 4 = 10$, replacing y by 3, multiplying the 3 by 2, and adding 4 gives the number ( ) on both sides of the equation.

14

8. In $5z + 7 = 22$, replacing z by 3 gives the number ( ) on both sides of the equation.

10

9. In $6w + 4 = 10w$, replacing w by 1 gives the number ( ) on both sides of the equation.

22

10. A number which, when substituted for the unknown, makes both sides of an equation equal is said to satisfy the equation. In $2y + 7 = 9$, does 1 satisfy the equation? In other words, does $(2 \times 1) + 7 = 9$? ( )

10

11. Does 4 satisfy the equation $2z + 2 = 10$? That is, does $(2 \times 4) + 2 = 10$? ( )

Yes

12. Does 8 satisfy the equation: $4x = 20$? ( )

Yes

13. Does 5 satisfy the equation: $2x = 15$? ( )

No

14. Does 11 satisfy the equation: $7r + 4 = 81$? (   )

No

15. A number which satisfies an equation when substituted for the unknown is said to be a value of the unknown. Is 2 a value of the unknown z in $4z + 4 = 12$? That is: does $(4 \times 2) + 4 = 12$? (   )

Yes

16. Is 1 a value of x in $4x + 1 = 5$? (   )

Yes

17. Is 4 a value of y in the equation $4y - 8 = 10$? (   )

Yes

18. Does $z = 4$ in the equation $3z + 4 = 16$? (   )

No

19. In the equation $6x + 4 = 4 + x + 5$, does $x = 1$? (   )

(Hint: Substitute 1 for x on BOTH sides of the equation and see if the sides are equal.)

Yes

20. Does $r = 8$ in $r + 4 = 12$? (   )

Yes

21. Does $z = 2$ in $2z + 1 = 4$? (   )

Yes

22. To SOLVE a simple equation means to FIND the VALUE OF THE UNKNOWN which SATISFIES the EQUATION. Is $x = 2$ a solution of $4x + 1 = 9$? (   )

No

23. Is $e = 4$ a solution of $4e = 2e + 8$? (   )

Yes

24. Is $r = 1$ a solution of $r + 8 = r - 8$? (   )

Yes

25. Is $y = 4$ a solution of $y - 2 = 2$? (   )

No
(Because $1 + 8$ does not equal $1 - 8$; $1 + 8 = 9$ and $1 - 8 = -7$.)

26. A term can be moved from one side of an equation to the other by CHANGING ITS SIGN either from plus to minus or minus to plus. In the equation $x + 1 = 4$ you can move $+1$ to the right side and write the equation $x = 4 - 1$. Subtracting 1 from 4 you get $x = ($ $)$.

Yes

27. In the equation $x + 4 = 9$ you can move $+4$ to the right to give $x = 9 - 4$ or $x = 5$. In the equation $2x + 7 = 12$, move $+7$ to the right and write the resulting equation. (   )

(Hint: Remember to CHANGE THE SIGN.)

$x = 3$

28. To move a term from one side of an equation to the other. you must change its (   ).

$$2x = 12 - 7$$
or
$$2x = 5$$

29. To move a term from one side of an equation to the other and change its sign is to TRANSPOSE the term. To transpose, you must change the (   ).

sign

30. In $2x + 4 = 8$, transpose $+4$ and write the resulting equation. (   )

(Hint: Remember to CHANGE THE SIGN.)

sign

31. To move a term from one side of an equation to the other and change the sign is to (   ) the term.

$$2x = 8 - 4$$
or
$$2x = 4$$

32. Transpose -5 in the equation $x - 5 = 0$ and write the resulting equation. (   )

transpose

33. Transpose the x on the right side of $2x = 4 + x$ and write the resulting equation. (   )

$$x = 5$$

34. Is $x = 4$ a solution of $2x = 4 + x$? (   )

$$2x - x = 4$$
or
$$x = 4$$

35. Solve the equation $x - 4 = 8$ by transposing -4. (   )

Yes

36. Solve $x + 6 = 12$ by transposing $+6$. (   )

$$x = 12$$

37. Find the value of z in $2z = 4 + z$ by transposing the z from the right to the left side of the equation. (   )

$$x = 6$$

38. $r - 4 = 6$. $r =$ (   ).

$$z = 4$$

39. $e + 4 = 8$. $e =$ (   ).

10

40. $r + 6 = 2$. $r =$ (   ).

4

41. $3y = 2y + 8$. $y =$ (   ).

-4

747

42. As you can now see, the idea of TRANSPOSING letters and numbers from one side of an equation to the other is that you must get ALL of the UNKNOWNS ON ONE SIDE and all of the PLAIN NUMBERS ON THE OTHER. Thus, in the equation $x + 6 = 2x + 5$ you would want to get the unknowns, x and 2x, on one side and the numbers (   ) and (   ) on the other.

8

43. You transpose to get unknowns (a) (   ) (   ) (   ) and (b) (   ) on the other.

6 (and) 5

44. In the equation: $4y + 6 = y - 9$ you would transpose to get (   ) and (   ) on one side and 6 and -9 on the other.

(a) on one side   (b) numbers

45. In the same equation: $4y + 6 = y - 9$ you transpose (changing signs) and get $4y - y = -9 - 6$. (?   ) = -15 (by subtraction).

4y (and) -y

46. $2z + 4 = z + 12$.   z = (   ).

(Hint: transpose both +4 and z)

3y

47. $8z - 6 = 4z + 10$.   z = (   ).

8

48. $9y + 4 = y - 30 + 10$.   y = (   ).

4

49. A COEFFICIENT is the number placed before a letter. In the equation $\underline{4x} = 8$, 4 is the coefficient. In the equation $7x = 20$, the coefficient of x is (   ).

-3

50. In the equation $10z = 40$, the coefficient of z is (   ).

7

51. In the equation $5w + 10 = 3w + 20$, the coefficients of w are (   ) and (   ).

10

52. To solve an equation with a coefficient of the unknown, you must eliminate the coefficient so that the unknown will be all alone on one side of the equation. Thus in $5b = 10$, the unknown, b, is not alone; it still has a coefficient, 5. Is the unknown alone in $6r = 12$? (   )

5 (and) 3

53. Is the unknown alone in $r = 2$? (   )

No

To solve an equation with a coefficient of the unknown, you must divide both sides of the equation by that coefficient. For example, in the equation $6r = 12$, you divide 6r by 6 and 12 by 6 giving you $\frac{6r}{6} = \frac{12}{6}$ and dividing by 6 you have $1r = 2$, or since 1r is the same as r, $r = 2$.

(Continue on with next problem)

Yes

844

744

54. In the equation $4b = 16$, you must divide both 4b and 16 by 4, the coefficient of b. You thus have $4b = 16$ and, after dividing, b = (   ).

55. In $3y = 12$, find the value of y by dividing both sides by 3, the coefficient of y. (   )

4

56. Divide both sides of $2x = 4$ by 2, the coefficent of x, and write the resulting equation. (   ).

$y = 4$

57. Find the value of z in $4z = 8$ by dividing both sides of the equation by 4, the coefficient of z. (   )

$x = 2$

58. $5x = -10$.   x = (   ).

$z = 2$

59. $6x = 24$.   x = (   ).

-2

END OF SET

4

5

Mathematics V

SIMPLE EQUATIONS

(Part Two)

60. In many equations it is necessary to first transpose terms, then collect terms, and finally divide by the coefficient of the unknown. For example, to solve the equation $3d + 6 = 12$, transpose to get $3d = 12 - 6$, collect terms to get $3d = 6$, and divide by the coefficient to get $d =$ ( ).

61. In $4z - 9 = 6 - 3$, you get $4z = 6 - 3 + 9$ after transposing and $4z =$ ( ) after combining terms.

2

62. $4z = 12$. $z =$ ( ).

12

63. In $10y + 4y - 2 = 4y + 8$, you get $10y + 4y - 4y = 8 + 2$ after transposing and after combining terms you have $10y =$ ( ).

3

64. $10y = 10$. $y =$ ( ).

10

65. Remember that when solving equations you first get all of the (a) ( ) with their coefficients on one side and all the plain (b) ( ) on the other side. This is done by transposing.

1

66. Then you ( ) terms.

(a) unknowns (b) numbers

67. Finally, you divide by the ( ) of the unknown to find what the unknown equals.

collect (combine)

68. Solve $2a + 5 = 9$ by transposing, collecting terms, and then dividing by the coefficient of a. ( )

coefficient

69. $16r + 4 = 10r + 16$. $r =$ ( ).

$a = 2$

70. $2e + 10 = 30$. $e =$ ( ).

2

71. $4x - x - 5 = 0$. $x =$ ( ).

10

72. $14w + 6 - 4 = 2w + 28 - 2$. $w =$ ( ).

$\frac{5}{3}$ or $1\frac{2}{3}$ or 1.667

73. $6y + 12 - 2 = 3y + 7$. $y =$ ( ).

2

750

74. ALL the signs in an equation, both plus and minus, can be changed without changing the value of the equation. Thus. $-2z = -4$ can be written $2z = 4$ and $-y = 2$ can be written (   ).

-1

75. Change ALL of the signs in $-x = -3$ and write the resulting equation. (   ).

$y = -2$

76. Change all the signs in $-2x = 4$ and write the resulting equation. (   ).

$x = 3$

77. In $-x = 2$. $x = (\quad)$.

$2x = -4$

78. In $-y = -5$. $y = (\quad)$.

-2

79. $-2z = 8$. $z = (\quad)$.

5

80. $5y + 3 = 6y$. $y = (\quad)$.

-4

81. $2z - 4 = 4z$. $z = (\quad)$.

3

82. $40w + 6 = 45w + 8 - 7$. $w = (\quad)$.

-2

83. The same operations that are used for all simple equations are also used for simple equations which use letters in place of numbers. Thus if $ab = c$; $a = \frac{c}{b}$ and if $xy = c$; $x = (\quad)$.

1

84. $2x = 6b$ can be solved for x by dividing both sides by 2. Thus the solution would be $x = (\quad)$.

$\frac{c}{y}$

(y may be considered to be the coefficient of x in this case)

85. $8x = 16z$. $x = (\quad)$.

3b

$$\left(\frac{\overset{1}{\cancel{2}}x}{\underset{1}{\cancel{2}}} = \frac{\overset{3}{\cancel{6}}b}{\underset{1}{\cancel{2}}} = x = 3b\right)$$

86. $3r = 6t$. $r = (\quad)$.

2z

87. $3z = w$. $z = (\quad)$.

2t

7

751

88. $d = rz$. $r = (\quad\quad)$.

$\frac{w}{3}$

89. $E = IR$. $I = (\quad\quad)$.

$\frac{d}{z}$

90. $I = PRT$. $R = (\quad\quad)$.

$\frac{E}{R}$ or E/R

91. $PV = RT$. $T = (\quad\quad)$.

I/PT

92. $V = CR^2H$. $H = (\quad\quad)$.

PV/R

93. $PV = RT$. $R = (\quad\quad)$.

V/CR^2

94. $PV = RT$. $P = (\quad\quad)$.

PV/T

95. Up to this point we have been interested only in equations of the type $2x + 5 = 10$. Some equations are of a fractional type. An example of this $\frac{x}{6} = 4$. This could be written $\frac{1}{6}x = 4$ or stated one-sixth of x equals 4. $\frac{x}{3} = 9$ could be stated (   ).

RT/V

96. For our equation $\frac{x}{6} = 4$ or $\frac{1}{6}x = 4$, we must change x from a fraction into a whole number in order to solve the equation. To do this we multiply both sides of the equation by 6 giving us $\frac{6x}{6} = 4 \times 6$ or $\frac{6}{6}x = 24$. Since $\frac{6}{6}$ equals 1 we are left with the answer $x = 24$. $\frac{x}{4} = 3$. $x = (\quad\quad)$.

one-third of x equals 9

(or $\frac{1}{3}x = 9$)

97. In the equation $\frac{x}{5} = 2$, this means $\frac{1}{5}x = 2$. If "one-fifth of x is 2." ALL of x must be 2 times 5, or 10. Multiplying both sides by 5 we get $\frac{5}{5}x = 2 \times 5$ or $x = 10$. $\frac{b}{2} = 3$, so $b =$ (   ).

12

98. To solve the equation $\frac{c}{5} = 1$, you must multiply both sides of the equation by 5. You thus have $\frac{c}{5} = 1$ and multiplying by 5 you have $\frac{5c}{5} = 1 \times 5$ and canceling $\frac{5}{5}$ on the left (since $\frac{5}{5}$ equals 1) gives c (   ).

6

(if $\frac{1}{2}$ of b is 3, all of b is 6.)

99. Solve $\frac{z}{4} = 1$ by multiplying both sides by 4. $z = (\quad\quad)$.

(Hint: $\frac{1}{4z} = 1$. Thus $\frac{4}{4}z$ or $z = (\quad)$.)

5

848

100. Solve the equation $\frac{x}{2} = 4$ by multiplying both sides by 2. x = (   ).

4

101. Solve $\frac{y}{6} = 4$ by multiplying by 6. y = (   ).

8

102. $\frac{x}{3} = -2$.   x = (   )

24

103. $\frac{w}{9} = 2$.   w = (   ).

-6

104. $\frac{t}{-4} = 3$.   t = (   ).

18

105. $\frac{4y}{3} = 4$.   y = (   ).

(Hint: first multiply by 3, then divide by 4 since the problem states that $\frac{4}{3}y = 4$.)

-12

106. $\frac{2z}{5} = 6$.   z = (   ).

3

107. $\frac{r}{4} = -4$.   r = (   ).

15

108. Many problems require a combination of all techniques of solving. Solve $\frac{3x}{4} - 12 = -9$ by first transposing -12, then multiplying both sides by 4 and then dividing by 3, the coefficient of x.   x = (   ).

-16

109. To solve $\frac{6p}{3} + 8 = 12$, you must transpose +8 to get $\frac{6p}{3} = 12 - 8$, then combining terms gives $\frac{6p}{3} = 4$, then multiplying by 3 gives 6p = 12, then dividing both sides by 6 gives p = (   ).

4

110. Solve $\frac{4z}{5} + 4 = 7$ by transposing, multiplying, and dividing.   z = (   ).

2

111. $\frac{x}{2} + 1 = 3$.   x = (   ).

$\frac{15}{4}$ or 3.75

112. $\frac{x - 1}{2} + 5 = 7$.   x = (   ).

(Hint: you can handle x - 1 as if it were a single number.)

4

113. $\frac{a}{b} = c$. a = (   ).

(Hint: multiply both sides by b.)

$$\frac{x - 1}{2} = 7 - 5$$

$$\frac{x - 1}{2} = 2$$

$$x - 1 = 4$$
$$x = 5$$

114. $\frac{R}{L} = I$. R = (   ).

bc

115. $\frac{s}{t} = v$. s = (   ).

LI

116. $\frac{s}{t} = v$. t = (   ).

(Hint; first multiply both sides by t, then divide both by v.)

tv

117. $\frac{x}{y} = \frac{a}{b}$. x = (   )

$\frac{s}{v}$

118. An equation of the type $\frac{x}{2} + \frac{x}{6} = 10$ is much the same as those you have been doing except that you must multiply it by a LOWEST COMMON DENOMINATOR in order to eliminate the fractions. The first step in solution would thus be to find the (   ) (   ) (   ).

$\frac{ay}{b}$.

119. To solve an equation in the form $\frac{x}{9} + \frac{x}{18} = 4$, you must first multiply the ENTIRE EQUATION by the (   ) (   ) (   ).

lowest common denominator

120. The lowest common denominator is the smallest number that all denominators will divide into evenly. For example: in the equation $\frac{x}{9} + \frac{x}{18} = 4$, the lowest common denominator of $\frac{x}{9}$ and $\frac{x}{18}$ is 18. In the equation $\frac{x}{5} + \frac{x}{10} = 5$, the lowest common denominator of $\frac{x}{5}$ and $\frac{x}{10}$ is (   ).

lowest common denominator

121. In the equation $\frac{x}{6} + \frac{x}{12} = 10$, the lowest common denominator of $\frac{x}{6}$ and $\frac{x}{12}$ is (   )

10

END OF SET

12

 754

SIMPLE EQUATIONS

(Part Three)

122. The first step in solution of an equation involving fractions is to multiply the ENTIRE equation by the lowest common denominator. Thus in the equation $\frac{x}{2} + \frac{x}{4} = 20$, you must multiply the entire equation by the lowest common denominator which is (   ) in this equation.

123. In an equation involving fractions you must multiply EVERY TERM in the equation by the (   ) (   ) (   ).

4

124. Now these problems are the same as the earlier ones except for the common denominator. In the equation $\frac{x}{2} + \frac{x}{4} = 3$, multiplying by 4, the common denominator, gives $\frac{4x}{2} + \frac{4x}{4} = (4)\ (3)$ and then canceling on the left gives $2x + x = 12$ and combining terms gives $3x = 12$. $x =$ (   ).

lowest common denominator

125. Multiply the equation $\frac{w}{6} + \frac{w}{12} = 2$ by the lowest common denominator and write the resulting equation.

(Hint: remember to multiply every term on BOTH SIDES of the equation.)

4

126. Now find the final solution of the equation $2w + w = 24$. $w =$ (   ).

$$2w + w = 24$$
or
$$3w = 24$$
or
$$\frac{12w}{6} + \frac{12w}{12} = 2 \times 12 = 24$$

127. Solve: $\frac{x}{2} + \frac{x}{4} = 6$. $x =$ (   ).

(Hint: find the LOWEST common denominator, multiply BOTH SIDES of the equation by it, combine terms, and divide by the coefficient of x.)

8

128. Solve: $\frac{r}{6} - \frac{r}{2} = 20$. $r =$ (   ).

(Hint: remember to multiply EVERY TERM in the equation.)

8

129. In the equation $\frac{x}{7} + \frac{x}{3} = 5$ there is no common denominator already in the problem, as was the case previously. By multiplying $7 \times 3 = 21$, you have a number divisible by BOTH 7 and 3 and thus a common denominator. Since there is no smaller number divisible EVENLY by both 7 and 3, 21 is the LOWEST common denominator. In the equation $\frac{x}{5} + \frac{x}{8} = 10$, the LOWEST common denominator is (   ).

-60

755

130. In the equation $\frac{y}{7} + \frac{y}{2} = 15$, the lowest common denominator of $\frac{y}{7} + \frac{y}{2}$ is ( ).

40

131. In solving the equation $\frac{z}{5} + \frac{z}{2} = 7$, you must first multiply every term in the entire equation by the lowest common denominator which is ( ) in this equation.

14

132. In the equation $\frac{z}{5} + \frac{z}{2} = 7$, multiplying by 10, the common denominator, gives $\frac{10z}{5} + \frac{10z}{2} = (7)\ (10)$ and then canceling on the left gives $2z + 5z = 70$ and combining terms gives $7z = 70$. $z =$ ( ).

10

133. $\frac{x}{3} + \frac{x}{6} = 4$. $x =$ ( ).

(Hint: remember to multiply BOTH sides of the equation by the common denominator.)

10

134. Remember, in solving an equation involving fractions you must multiply every term on BOTH SIDES of the equation by the ( ) ( ) ( ).

$7\frac{1}{2}$ or 7.5

135. Solve: $\frac{d}{3} - \frac{d}{7} = 8$. $d =$ ( ).

lowest common denominator

136. Equations involving only one fraction as $x + \frac{x}{2} = 6$, must simply be multiplied by the denominator of the fraction. Thus, in the equation given you must multiply every term by ( ) to eliminate the fraction.

42

137. In solving the equation $x + \frac{x}{2} = 6$, you must multiply both sides by 2 giving $2x + \frac{2x}{2} = (6)\ (2)$ and canceling on the left gives $2x + x = 12$. $3x = 12$. $x =$ ( ).

2

138. In order to eliminate the fraction in the equation $\frac{x}{4} - x = 10$, multiply every term by 4 and write the resulting equation. ( ).

4

139. Solve the equation $x + \frac{x}{4} = 10$ by multiplying BOTH sides by 4. $x =$ ( ).

$$\frac{4x}{4} - 4x = 40$$

$$x - 4x = 40$$

140. Solve: $x + \frac{x}{5} = 12$. $x =$ ( ).

8

756

141. Solve: $\frac{x}{7} + x = 8.$ $x = ($ $)$.

10

142. Solve: $x + \frac{2x}{3} = 5.$ $x = ($ $)$.

7

143. In some cases the lowest common denominator is neither one of the denominators nor is it the product of the denominators. For example, in the equation $\frac{x}{10} + \frac{x}{15} =$ 5, the multiply would be 150, yet both 10 and 15 divide evenly into 30. Thus, 30 is the ( ) ( ) ( ).

3

144. In the equation $\frac{x}{6} + \frac{x}{9} = 5$, the lowest common denominator of $\frac{x}{6}$ and $\frac{x}{9}$ is ( ).

lowest common denominator

145. In the equation $\frac{r}{4} + \frac{r}{6} = 10$, the lowest common denominator of $\frac{r}{4}$ and $\frac{r}{6}$ is ( ).

18

146. In the equation $\frac{r}{4} + \frac{r}{6} = 10$, the lowest common denominator is 12. Multiplying every term by 12 gives $\frac{12r}{4} + \frac{12r}{6} = (10)\ (12)$ and then canceling on the left gives $3r + 2r = 120$. $r = ($ $)$.

12

147. In the equation $\frac{x}{10} + \frac{x}{15} = 5$. multiply both sides by the lowest common denominator and write the resulting equation.

24

148. Now find the final solution of the equation $3x + 2x = 150$. $x = ($ $)$.

$$\frac{30x}{10} + \frac{30x}{15} = (30)\ (5)$$

$$3x + 2x = 150$$

149. $\frac{x}{6} + \frac{x}{9} = 10.$ $x = ($ $)$.

30

The following problems are practice problems involving all of the methods of solution you have learned. Now go on to the next item.

150. Solve: $\frac{2x}{1} - \frac{x}{4} - 3 = x + 6$

$x = ($ $)$.

(Hint: remember to multiply EVERY TERM by 4.)

36

151. $\frac{x}{4} + 3 = \frac{x}{8} + 4.$ $x = ($ $)$.

(Hint: this looks different but really is not. Just TRANSPOSE FIRST and solve as before.)

$$8x - x - 12 = 4x + 24$$

$$8x - x - 4x = 36$$

$$x = 12$$

152. Solve: $\frac{4z}{5} - z = 6$. $z = (\quad)$.

8

153. Solve: $2r - 4 = 14 - r$. $r = (\quad)$.

-30

154. Solve: $p = vt$. $v = (\quad)$.

6

155. Solve: $\frac{h}{3} + \frac{2h}{9} = h - 4$. $h = (\quad)$.

(Hint: multiply EVERY term by lowest common denominator.)

$v = \frac{p}{t}$

156. Solve: $6p - 5 = p + 63$. $p = (\quad)$.

9

157. Solve: $\frac{2z}{12} - \frac{3z}{9} = 3 - z$. $z = (\quad)$.

$13\frac{3}{5}$ or 13.6

END OF SET

$3\frac{3}{5}$ or 3.6

854

Further Instructions

If you missed less than 8 of the items, you have done a good job. Now read the summary. and you are ready to go on to Mathematics VI.

If you missed 8 or more of the items, read the following summary and then WORK THROUGH the program again.

Summary

1. A simple equation is an algebraic expression with a single unknown quantity.

2. The letter in a simple equation stands for the unknown quantity.

3. A number which, when substituted for the unknown, makes both sides of an equation equal is said to satisfy the equation.

4. A number which satisfies an equation when substituted for the unknown is said to be a value of the unknown.

5. To solve an equation means to find the value of the unknown which satisfies the equation.

6. All the signs in an equation can be changed without changing the value of the equation.

7. There are 4 basic types of equations.

a. $x + 1 = 4$ or $x - 1 = 4$.

b. $2x = 4$.

c. $\frac{x}{2} = 4$.

d. $\frac{x}{2} + \frac{x}{4} = 4$.

8. To solve equations of the type $x + 1 = 4$ or $x - 1 = 4$, you must transpose terms. To transpose terms, you move them from one side of the equation to the other and CHANGE THEIR SIGN.

9. To solve equations of the type $2x = 4$, you must divide both sides of the equation by the COEFFICIENT of the unknown. A coefficient is a number written with a letter.

10. To solve equations of the type $\frac{x}{2} = 4$, you must multiply both sides of the equation by the same quantity.

11. To solve equations of the type $\frac{x}{2} + \frac{x}{4} = 4$, you must multiply both sides of the equation by the lowest common denominator of the fractions.

12. In most equations it is necessary to use a combination of some or all of these techniques.

13. It is usually necessary to collect terms in solving an equation.

14. All of the techniques for solving equations can be used for equations which involve letters rather than numbers.

759

PROPORTIONS

(Part One)

1. An expression in the form $\frac{a}{b} = \frac{c}{d}$ is called a PROPORTION and is read "a is to b as c is to (   )."

2. $\frac{a}{b} = \frac{c}{d}$ is called a (   ).

d

3. $\frac{x}{y} = \frac{w}{z}$ can be stated verbally as "x is to y as (   ) is to (   )."

proportion

4. In mathematical form "h is to 4 as r is to 9" would be $\frac{h}{4} = ?$

w (is to) z

5. "2 is to r as 4 is to 9" in mathematical form would be $\frac{2}{?} = \frac{4}{?}$.

$\frac{r}{9}$

6. Write the proportion "f is to 3 as 4 is to 5" in mathematical form.

$\frac{2}{r} = \frac{4}{9}$

7. Write the proportion "r is to x as w is to z" in mathematical form.

$\frac{f}{3} = \frac{4}{5}$

8. Write "z is to 6 as 4 is to 8" in mathematical form.

$\frac{r}{x} = \frac{w}{z}$

9. In the proportion $\frac{z}{6} = \frac{4}{8}$, the value of z is unknown. The proportion can be solved for z by multiplying z x 8 and 6 x 4 and writing the equation 8z = (   ).

$\frac{z}{6} = \frac{4}{8}$

10. 8z = 24; z = (   ).

24

11. To solve a proportion you cross-multiply; that is, you multiply the left numerator by the right denominator and the right numerator by the left (   ).

3

12. To cross-multiply, you multiply the left numerator by the right denominator and the right numerator by the left denominator. Thus, for $\frac{7}{x}$ $\frac{4}{3}$ you would multiply, as shown, giving 4x = (   ).

denominator

13. Cross-multiply the proportion $\frac{z}{6}$ $\frac{4}{8}$, as shown gives you 8z = (   ).

24

14. Cross-multiply the proportion $\frac{2}{y}$ $\frac{4}{3}$ you have 4y = (   ).

24

856

760

15. The first step in solving a proportion is (   )-multiplication.

6

16. To cross-multiply $\frac{4}{r} = \frac{3}{9}$, you would multiply 4 x 9 and r x (   ).

cross

17. When you cross-multiply a portion, you EQUATE the products; that is, you connect both products by an equals sign. Thus, cross-multiplying $\frac{7}{z} = \frac{6}{1}$ you would have $6z = ($).

3

18. In the equation $\frac{12}{13} = \frac{z}{19}$, CROSS-multiplying gives you 12 x 19 (or 228) = (   ).

7

19. Cross-multiply $\frac{w}{16} = \frac{1}{2}$ and write the resulting equation.

13z
(13 z means 13 x z or z x 13)

20. Cross-multiply $\frac{2}{7} = \frac{4}{x}$ and write the resulting equation.

$2w = 16$ or $w = 8$

21. Once a proportion is cross-multiplied and the equation written, you can solve this equation exactly like you have solved any simple equation. Thus

$\frac{2}{4} = \frac{3}{z}$ gives you $2z = 12$ and $z = ($).

$2x = 28$ or $x = 14$

22. Cross-multiplying $\frac{12}{x} = \frac{4}{6}$ gives you $4x = 72$ and dividing by 4, the coefficient of x, you have $x = ($).

6

23. Solve the proportion $\frac{7}{3} = \frac{14}{z}$ by cross-multiplying and then dividing by the coefficient of z.

18

24. $\frac{9}{r} = \frac{6}{2}$ $r = ($).

$z = 6$

25. $\frac{10}{2} = \frac{w}{9}$ $w = ($).

3

26. $\frac{4}{9} = \frac{q}{18}$ $q = ($).

45

27. $\frac{4}{7} = \frac{64}{p}$ $p = ($).

8

17

28. $\frac{z}{1} = \frac{4}{6}$ $z = ($ $)$.

112

29. $\frac{x}{2} = \frac{12}{6}$ $x = ($ $)$.

$\frac{4}{6}$ or $\frac{2}{3}$ or 0.66

30. Write the proportion "h is to 2 as 4 is to 8" in mathematical form and solve for h.

4

31. Find the value of z for the proportion "7 is to z as 4 is to 21."

$\frac{h}{2} = \frac{4}{8}$ $h = 1$

32. The same techniques for solving proportions are used when letters are used instead of numbers. Thus, cross-multiplying $\frac{r}{x} = \frac{p}{y}$ gives $ry = ($ $)$.

$z = 36.75$ or 36-3/4

33. Cross-multiply $\frac{z}{8} = \frac{x}{2}$ and write the resulting equation.

px or xp

34. Write the proportion "h is to 2 as r is to 4" in mathematical form.

$2z = 8x$ or $z = 4x$

35. Write "r is to i as p is to v" in mathematical form.

$\frac{h}{2} = \frac{r}{4}$

36. When two similar letters are used in a proportion $\frac{w}{w} = \frac{d}{d}$, they are differentiated by the use of SUBSCRIPTS. A subscript is a number placed just below and to the right of a number or letter. Thus, in $\frac{w_1}{w_2} = \frac{d_1}{d_2}$ the 1's and 2's are ( ).

$\frac{r}{i} = \frac{p}{v}$

37. w_1 and w_2 is just the same as marking two hammers with a "1" and a "2" so that you can tell them apart. In the proportion, $\frac{b_1}{b_2} = \frac{x_1}{x_2}$ the 1's and 2's are ( ).

subscripts

38. When solving a proportion with subscripts, you simply cross-multiply as before. Thus, in $\frac{x_1}{x_2} = \frac{y_1}{y_2}$, your answer would be $x_1y_2 = x_2y_1$. Cross-multiply $\frac{b_1}{b_2} = \frac{a_2}{a_1}$ and write the resulting equation.

subscripts

39. Cross-multiply $\frac{w_1}{w_2} = \frac{d_1}{d_2}$ and write the resulting equation.

$b_2a_2 = b_1a_1$

762

40. Cross-multiplying $\frac{1}{r_2} = \frac{1}{p_2}$ gives $r_1p_2 = r_2p_1$ and dividing by p_2 gives $r_1 =$ ( ).

$w_1d_2 = w_2d_1$

41. $\frac{n_2}{m_2} = \frac{m_1}{n_1}$ $n_1 =$ ( ).

$\frac{r_2p_1}{p2}$

42. $\frac{2}{z} = \frac{4}{y}$ $y =$ ( ).

$n_1n_2 = m_1m_2$

$n_1 = \frac{m_1m_2}{n_2}$

43. $\frac{a}{b} = \frac{c}{d}$ $c =$ ( ).

2z

44. $\frac{w_1}{w_2} = \frac{d_1}{d_2}$ $w_2 =$ ( ).

$\frac{ad}{b}$

45. A problem like $\frac{w_1^3}{w_2^2} = \frac{d_4^{1/3}}{d_2^3}$ include both SUBSCRIPTS and EXPONENTS. Even though this may LOOK difficult, it is solved in the same way as before. Thus, when cross-multiplying, just IGNORE the subscripts and exponents. Thus,

$w_1^3\, d_2^3 = w_2^2\, d_4^{1/3}$ Cross-multiply.

$$\frac{x_1^2}{x_2^3} = \frac{y_2^{1/3}}{y_1^{2/3}} = (\qquad)$$

$\frac{w_1d_2}{d_1}$

46. Cross-multiply: $\frac{b_1^{4/5}}{b_2^{2/3}} = \frac{n_1^{3/5}}{n_2^2}$

$x_1^2\, y_1^{2/3} = x_2^3\, y_2^{1/3}$

47. To solve $\frac{x_1^2}{x_2^{1/3}} = \frac{y_1^3}{y_2^4}$ for $x_2^{1/3}$, you cross-multiply to get $x_1^2y_2^4 = x_2^{1/3}\, y_1^3$.

Thus, by division, $x_2^{1/3} = \frac{x_1^2y_2^4}{y_1^3}$.

Solve $\frac{b_1^2}{b_2^3} = \frac{a_1^{4/5}}{a_2^4}$ for $b_1^2 =$ ( ).

$b_1^{4/5}n_2^2 = b_2^{2/3}n_1^{3/5}$

48. Cross-multiply: $\dfrac{x_1^2}{x_2^{1/3}} = \dfrac{y_1^3}{y_2^4}$

$$b_1^2 a_2^4 = b_2^3 a_1^{4/5}$$

$$b_1^2 = \frac{b_2^3 a_1^{4/5}}{a_2^4}$$

49. Solve: $\dfrac{x_1^2}{x_2^{4/3}} = \dfrac{n_1^{10}}{n_2^5}$ for n_1^{10}

$$x_1^2 y_2^4 = x_2^{1/3} y_1^3$$

50. Solve: $\dfrac{x_1^2 y_1^3}{a_1^4} = \dfrac{x_2^{3/2} y_2^{1/2}}{a_2^2}$ for a_1^4

(Hint: Just cross-multiply and solve as before.)

$$n_1^{10} x_2^{4/3} = x_1^2 n_2^5$$

$$n_1^{10} = \frac{x_1^2 n_2^5}{x_2^{4/3}}$$

51. Write the proportion "x is to y as 2 is to 3" and solve for x.

$$x_1^2 y_1^3 a_2^2 = x_2^{3/2} y_2^{1/2} a_1^4$$

$$\frac{x_1^2 y_1^3 a_2^2}{x_2^{3/2} y_2^{1/2}} = a_1^4 \text{ or}$$

$$a_1^4 = \frac{x_1^2 y_1^3 a_2^2}{x_2^{3/2} y_2^{1/2}}$$

52. Solve the proportion "z is to x as a is to b" for b.

$$\frac{x}{y} = \frac{2}{3}$$

$$3x = 2y$$

$$x = \frac{2y}{3}$$

53. $\dfrac{x}{y} = \dfrac{a}{1}$ $\quad y = ($ $\qquad\qquad\qquad)$.

$$\frac{z}{x} = \frac{a}{b}$$

$$bz = ax$$

$$b = \frac{ax}{z}$$

54. $\dfrac{xy}{z} = \dfrac{ab}{c}$ $\quad c = ($ $\qquad\qquad)$.

$$\frac{x}{a}$$

55. The proportion x is to y as a is to 1 would be written $\frac{x}{y} = \frac{a}{1}$. However, when a 1 is UNDERNEATH a letter or number, it is always DROPPED. Thus, the proportion would be written $\frac{x}{y} = a$.

764

a 1 under a so you get $1x = ay$ or $x = ay$.

Solve: $\frac{b}{c} = n$. $b =$ ( ).

$cxy = zab$

$c = \frac{zab}{xy}$

(Note: Remember that it makes no difference what order you put the letters in since zab means $z \times a \times b$. Just like $z \times 4 \times 6$ could be written $4 \times 2 \times 6$, etc., $\frac{zab}{xy}$ could be written $\frac{zba}{yx}$, $\frac{abz}{yx}$, etc.)

56. $\frac{z}{w} = r$ $z =$ ( ).

cn or nc

57. In the proportion $\frac{z}{w} = r$, we have found by cross-multiplication that $z = rw$. If we were asked to find w, we would divide z by r. Thus, $w = \frac{z}{r}$ and in the same way $r = \frac{z}{w}$. $\frac{x}{c} = b$; $c =$ ( ).

rw

58. $\frac{y}{r} = m$

$r =$ ( ).

$x = cb$

$c = \frac{x}{b}$

or

$\frac{x}{b} = c$

59. $x = \frac{p}{n}$.

$n =$ ( ).

(Remember that $x = \frac{p}{n}$ is the same as $\frac{x}{1} = \frac{p}{n}$.)

$y = rm$

$r = \frac{y}{m}$

or

$\frac{y}{m} = r$

60. $\frac{b}{c} = \frac{a}{r}$ $r =$ ( ).

$xn = p$

$n = \frac{p}{x}$

61. $n = \frac{q}{z}$

$z =$ ( ).

$br = ca$

$r = \frac{ca}{b}$

END OF SET

$zn = q$

$z = \frac{q}{n}$

765

PROPORTIONS

(Part Two)

62. $\frac{r}{x} = y$

$x = ($ $)$.

63. If $\frac{a}{b} = \frac{6}{9}$ and you are given $b = 6$, you can substitute 6 for b in the proportion, giving you $\frac{a}{6} = \frac{6}{9}$. Solving the same as before, $a = ($ $)$.

$r = xy$

$x = \frac{r}{y}$

or

$\frac{r}{y} = x$

64. If $\frac{r}{z} = \frac{1}{9}$ and you are given $r = 3$, substitute 3 for r in the proportion. Write the resulting equation and solve for z.

4

65. If $\frac{x}{y} = \frac{2}{3}$ and you are given $y = 6$, what is the value of x?

$\frac{3}{z} = \frac{1}{9}$

$z = 27$

66. $\frac{w_1}{w_2} = \frac{1}{3}$; given $w_1 = 8$, find the value of w_2.

4

67. In $\frac{a}{4} = \frac{b}{c}$ you are given $c = 2$ and $a = 18$. Substitute 2 for c and 18 for a and write the resulting equation.

$\frac{8}{w_2} = \frac{1}{3}$

$w_2 = 24$

68. $\frac{18}{4} = \frac{b}{2}$; $b = ($ $)$.

$\frac{18}{4} = \frac{b}{2}$

or

$4b = 36$

69. $\frac{a}{b} = \frac{2}{c}$; given $a = 12$ and $b = 60$, find c.

9

70. $\frac{w_1}{w_2} = \frac{d_1}{d_2}$; given $w_1 = 410$, $d_1 = 40$, and $d_2 = 60$, find w_2.

$c = 10$

71. Proportions can be both direct and inverse (indirect). If two quantities are DIRECTLY PROPORTIONAL, it means that as one increases, the other increases, and as one decreases, the other ( ).

$w_2 = 615$

764

72. If x and y are directly proportional, x will INCREASE as y ( ).

decreases

73. If a increases as b increases, and decreases as b decreases, a is said to be ( ) proportional to b.

increases

74. If x and y increase and decrease together they are said to be ( ) ( ).

directly

75. If two quantities are INVERSELY PROPORTIONAL, it means that as one increases, the other decreases, and as one decreases, the other ( ).

directly proportional

76. If r INCREASES as p DECREASES, r is ( ) proportional to p.

increases

77. If one quantity increases as another decreases, and vice versa, the quantities are said to be ( )( ).

inversely

78. Now let us review a little. Quantities are said to be DIRECTLY proportional if one (a) ( ) as the other increases and (b) ( ) as the other decreases.

inversely proportional

79. Quantities are said to be INVERSELY proportional when one increases as the other (a) ( ) and decreases as the other (b) ( ).

(a) increases
(b) decreases

80. You might remember that for a ( ) ( ) both quantities move in the SAME direction, up or down. BOTH increase or BOTH decrease.

(a) decreases
(b) increases

81. When are quantities said to be directly proportional?

direct proportion

82. The more meat you buy, the larger the total cost; therefore, we could say that the cost of meat is ( ) proportional to the weight.

When they increase and decrease together (or any equivalent answer).

83. The volume of a gas decreases as its temperature decreases, therefore we would say that volume is ( ) ( )to temperature.

directly

84. To state a DIRECT proportion mathematically, you must include a CONSTANT in the expression. Thus, to state mathematically that a is directly proportional to b, you have a = Kb and K is a ( ).

directly proportional

767

85. The constant (K) really has no mathematical function as far as solving a problem is concerned. It just indicates a ( ) proportion.

constant

86. $x = Ky$ means that x is directly proportional to y and K is a ( ).

direct

87. $z = Ky$ means that z is ( ) ( ) to y.

constant

88. Write "r is directly proportional to p" in mathematical form.

(Hint: Remember the constant.)

directly proportional

89. $y = Kx^2$ means that y is directly proportional to the square of ( ).

$r = Kp$

90. $y = Kx^3$ means that y is directly proportional to the ( ) of x.

x

91. What does $a = Kb$ mean?

cube

92. $a = K\sqrt{b}$ means a is ( ) ( ) to the square root of b.

a is directly proportional to b

93. $n = K\sqrt[3]{w}$ means n is directly proportional to the ( ) ( ) of w.

directly proportional

94. $z = Kr^2$ means z is (a) ( ) ( ) to the (b) ( ) of r.

cube root

95. Write in mathematical form that "x is directly proportional to the square root of z".

(a) directly proportional
(b) square

96. Write in mathematical form that "r is directly proportional to the CUBE of z".

$x = k\sqrt{z}$

97. Write in mathematical form that "w is directly proportional to the cube root of r".

$r = Kz^3$

98. In problem solution with proportions, if the variables are x and y, you will be given a value of x for one value of y and asked to find the value of x for another value of ( ).

$w = K\sqrt[3]{r}$

764

99. In such problems with proportions it is best to let one value of x equal x_1 and the other value of x equal x_2 and let one value of y equal y_1 and the other value of y equal (   ).

y

100. If x and y are variables, let the two old values be x_1 and y_1, and the two new values be x_2 and (   ).

y_2

101. If you are given x = 2 when y = 4 and are asked to find the value of x when y = 6, let $x_1 = 2$ and $y_1 = 4$ and let x_2 = the unknown and y_2 = (   ).

y_2

102. If x is directly proportional to y, the original proportion is x = Ky. Now to set up two proportions with x_1, x_2, y_1 and y_2, you will have $x_1 = Ky_1$ and (   ) $= Ky_2$.

6

103. If you are given $x_1 = Ky_1$ and $x_2 = Ky_2$, you can eliminate K by dividing one proportion by the other. Thus $\frac{x_1}{x_2} = \frac{Ky_1}{Ky_2}$

and cancelling K, you have $\frac{x_1}{x_2} = \frac{?}{?}$.

x_2

104. If you are given $z_1 = Kr_1^2$ and $z_2 = Kr_2^2$, when you divide one proportion by the other you have $\frac{?}{?} = \frac{r_1^2}{r_2^2}$.

$\frac{y_1}{y_2}$

105. If z is directly proportional to the SQUARE of r, the original proportion will be z = K (   ).

$\frac{z_1}{z_2}$

106. If $z = Kr^2$ and z = 6 when r = 1, to find z when r = 2, you will let $z_1 = 6$, z_2 = the unknown, $r_1 = 1$, and r_2 = (   ).

r^2

107. If $z = Kr^2$ and $z_1 = 6$, $r_1 = 1$, $r_2 = 2$; to find z_2, set up the proportion $\frac{z_1}{?} = \frac{r_1^2}{r_2^2}$.

2

108. If $z = Kr^2$ and $z_1 = 6$, $r_1 = 1$, $r_2 = 2$; to find z_2 set up the proportion $\frac{z_1}{z_2} = \frac{r_1^2}{r_2^2}$ and substituting the proper values, gives you $\frac{6}{z_2} = \frac{?}{?}$.

z_2

109 If $\frac{6}{z_2} = \frac{1}{4}$, find z_2.

$\frac{1^2}{2^2}$ or $\frac{1}{4}$

110. If x is directly proportional to y and $x = 2$ when $y = 6$, find the value of x when $y = 1$.

Hint: $\frac{x_1}{x_2} = \frac{y_1}{y_2}$; $x_1 = 2$ x_2 = unknown

$y_1 = 6$ $y_2 = 1$

24

111 If the price of meat is directly proportional to the weight and 5 pounds cost 4 dollars, to find how much 14 pounds cost you can set up the proportion as $\frac{5 \text{ (pounds)}}{14 \text{ (pounds)}} = \frac{4 \text{ (dollars)}}{x \text{ (dollars)}}$

x (dollars) = (   ).

$x = \frac{2}{6}$ or $\frac{1}{3}$

112. If x is directly proportional to y and $x = 2$ when $y = 12$, to find the value of x wher $y = 8$ you can set up the proportion $\frac{2}{x} = \frac{12}{8}$; x = (   ).

11.2 dollars

113. If r is directly proportional to q SQUARED and if $r = 9$ when $q = 8$, to find the value of r when $q = 6$, you can set up the proportion

$$\frac{r_1}{r_2} = \frac{q_1^2}{q_2^2} \text{ which becomes } \frac{9}{?} = \frac{8^2}{6^2}$$

when the proper values are inserted.

$\frac{4}{3}$ or $1\frac{1}{3}$

114. If x is directly proportion to z^2 and $x = 4$ when $z = 8$, what is the value of x when $z = 4$?

Hint: $\frac{x_1}{x_2} = \frac{z_1^2}{z_2^2}$

r_2

115. If a is directly proportional to the cube ROOT of b, and $a = 6$ when $b = 8$, find the value of a when $b = 125$.

1

116. The volume of a gas is directly proportional to the square root of its temperature. The volume of a certain gas is 3 cubic feet at a temperature of 81°. What is its volume when the temperature is lowered to 36°?

Hint: $\frac{v_1}{v_2} = \frac{\sqrt{t_1}}{\sqrt{t_2}}$

15

117. The SPEED at which a bomb hits the ground is DIRECTLY PROPORTIONAL to the height from which it was dropped. A certain bomb is dropped from 1,000 feet and hits the ground at a speed of 800 miles per hour. At what altitude must it be dropped if it is to hit the ground at 1,400 mph?

2 cu ft

118. The DISTANCE to which damage occurs to some types of structures is DIRECTLY PROPORTIONAL to the CUBE ROOT of the YIELD of the weapon involved. If a certain structure is damaged out to a distance of 600

yards by a weapon with a 1-KT yield, how far out would the same type of structure be damaged by a 125-KT weapon?

A = altitude

$$\frac{1,000}{A} = \frac{800}{1,400}$$

A = 1,750 feet

119. The initial speed of a rocket is directly proportional to the SQUARE of the explosive force of the fuel. If an explosive force of 10 KT produces an initial speed of 3,000 mph, what explosive force will be necessary to produce an initial speed of 27,000 mph?

$$\frac{600}{D} = \frac{\sqrt[3]{1}}{\sqrt[3]{125}}$$

$$\frac{600}{D} = \frac{1}{5}$$

D = 3,000 yards

120. The initial speed of a rocket is directly proportional to the square of the explosive force of the fuel. If the initial speed is 3,000 mph when the explosive force is 10 KT, what will the initial speed be for an explosive force of 3 KT?

F = explosive force

$$\frac{3,000}{27,000} = \frac{10^2}{F^2}$$

$$3,000\ F^2 = 27,000 \times 100$$
$$F^2 = 900$$
$$F = \sqrt{900} = 30\ \text{KT}$$

121. The distance to which damage occurs to some types of structures is directly proportional to the cube root of the weapon yield involved. If a certain type of structure is damaged out to a distance of 2,000 yards by a 64-KT weapon, how far out will the same type of structure be damaged by a 1-KT weapon?

270 mph

END OF SET

500 yards

771

Further Instructions

If you missed less than 7 of the items, you have done a good job. Now read the summary.

If you missed 7 or more of the items, read the following summary and then WORK THROUGH the program again.

Summary

1. An expression in the form $\frac{a}{b} = \frac{c}{d}$ is called a proportion and is read "a is to b as c is to d".

2. A proportion stated verbally as "2 is to 9 as r is to x" would be written in mathematical form as

$$\frac{2}{9} = \frac{r}{x}$$

3. To solve a proportion for the unknown you must cross-multiply and equate the products. For example, in the proportion $\frac{z}{6} = \frac{4}{8}$, cross-multiplying gives $8z = 24$ and $z = 3$.

4. If two quantities are DIRECTLY PROPORTIONAL, then one increases as the other increases and decreases as the other decreases.

5. If two quantities are INVERSELY PROPORTIONAL, then one increases as the other decreases and decreases as the other increases.

6. To state a direct proportion mathematically, you must include a CONSTANT in the expression. For example, to state mathematically that "x is directly proportional to y^2," you would write $x = Ky^2$.

7. If you have two proportions involving different values of the same unknown, you can divide one proportion by the other and thus eliminate the constant. For example, if $x_1 = Kz_1$ and $x_2 = Kz_2$, then $\frac{x_1}{x_2}$ and cancelling K, you have $\frac{x_1}{x_2} = \frac{z_1}{z_2}$.

8. To solve a stated problem involving a proportion, you must set up a proportional relationship such as $\frac{a_1}{a_2} = \frac{b_1}{b_2}$, substitute the proper values for the letters, and solve for the unknown quantity.

898

772

Department of Medicine
School of Health Care Sciences

Cardiopulmonary Laboratory Specialist

PROCEDURE FOR ARTERIAL PUNCTURE

July 1973

SHEPPARD AIR FORCE BASE, TEXAS

Supersedes SHO 3ALR91630, Aug 1972

Designed For ATC Course Use

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PREFACE

There is no substitute for experience; it is a trite saying, a true saying and a depressing thought to one just starting out. This manual will help you in a number of ways since it contains the experience of others. Let their experience hasten yours.

We assumed only two characteristics about you as we began this manual: we assume that part of your present occupation is to learn how to draw arterial blood and we assume that you have had no practice. Our main criteria for including certain topics was:

> On our first attempt at drawing arterial blood, what would we have liked to have known, and what points of interest would best orient us (fill out the picture) in accomplishing the job.

In light of these criteria, allow two points to be made. First, theoretical analysis of results are omitted; they are the province of the physician. Second, we won't expect you to approach the patient's bedside with manual and syringe in hand on your first attempt. Do the reading of these pages beforehand, but be guided at the bedside by one who has the experience you lack. (Puncturing the skin for the first time can be as traumatic for you as for the patient.)

If you can find a willing colleague (They are in short supply when asked to view you behind the barrel of a syringe.), ask him to be your first subject, but again only with that experienced person beside you.

Here, then, is the technical story. Our hope is that you will read further in many of the outstanding books available for the theory that has not been included.

775

GENERAL CONSIDERATIONS

The analysis of arterial blood for the parameters of PO_2, PCO_2, and pH provides basic information about cardiopulmonary function. An indication of how well this dual system is functioning is contained in these three measurements.

PO_2 and PCO_2 are gas tensions, sometimes called "partial pressures". This derives from Dalton's Law which states that the pressure exerted by each component in a gaseous mixture is independent of two other gases, and the total pressure of the mixture is the sum of the separate partial pressures. The total pressure of the air we breathe is atmospheric or barometric pressure. The partial pressure of atmospheric oxygen, for example, is approximately 21% of the total barometric pressure. Arterial blood gas tensions are expressions of the amount of oxygen or carbon dioxide in the blood. These gases may be carried in blood in physical solution and in chemical combination. In either case, the amount of gas depends on the gas pressure to which the blood has been exposed and reflects what is being transported to the tissues. Thus PO_2 is the pressure exerted by oxygen carried in chemical combination with hemoglobin and dissolved in plasma. PCO_2 is the pressure exerted by carbon dioxide in blood. pH is a measure of hydrogen ion concentration, the limits for which are quite narrow in man.

Since PO_2 and PCO_2 (note the "P") are measures of gas pressures, the units are in millimeters of mercury (mm Hg). Typical adult values (at 37° C) in our laboratory (altitude 2300 ft.) are given below.

	Arterial	Venous
pH	7.35 - 7.45	7.32 - 7.42
PCO_2	35 - 45 mm Hg	41 - 51 mm Hg
PO_2	80 - 90 mm Hg	25 - 40 mm Hg

These parameters may vary with altitude. They are of vital importance in certain acutely ill patients. Many failing body systems (lung, heart, kidneys, among others) can make their degree of impairment known through these measurements. Only a complete clinical picture, of which arterial blood gases are a part, can help the physician in diagnosis and therapy. In patients receiving oxygen therapy or on mechanical ventilators, measurement of arterial blood gases are essential.

As indicated earlier, we will not dwell at length over interpretation of results. Nevertheless, a chart is included in this manual that is readily understandable (see Fig. 1, next page). For example, a pH of 7.50 accompanied by a PCO_2 of 45 mm Hg reveals a patient in Metabolic Alkalosis. Locate this point on the chart: pH = 7.25 and PCO_2 = 45. It falls outside the two shaded areas: Metabolic Acidosis and Acute Hypercapnia. The patient's picture is unclear. The physician may wait a period of time and examine the blood again or he may alter treatment and ask for another blood analysis. In any event serial testing is indicated to determine the resolution of the patient's problem.

A physician may require arterial blood gas studies done on a patient who

University of Arizona
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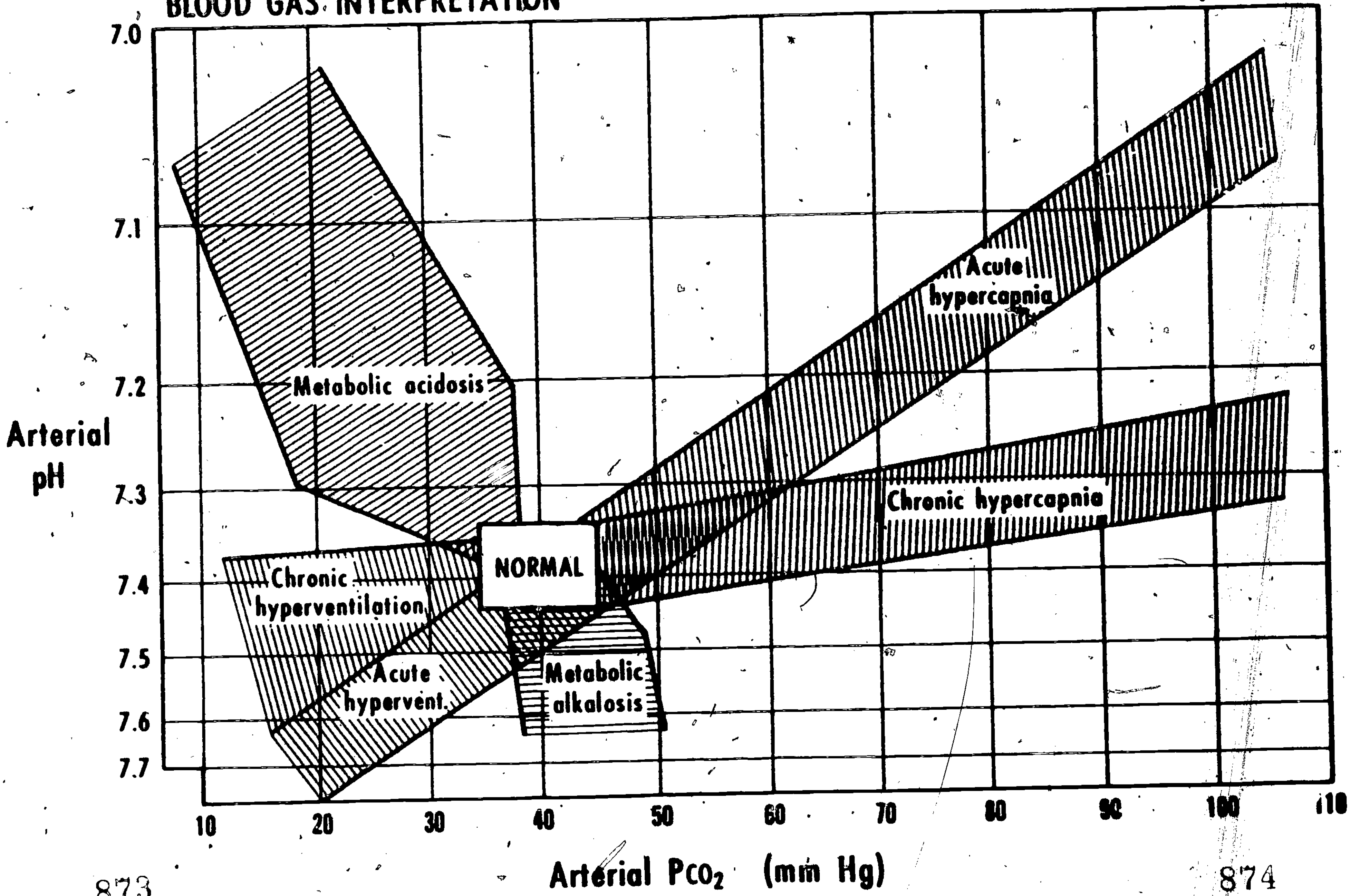
BLOOD GAS INTERPRETATION



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874

FIG. 1

complains of respiratory distress, or to follow the progress of a patient who is undergoing oxygen therapy. Many times blood analysis will be done on post-operative patients (or blood will be taken during surgery). Various cardiac insufficiencies may also indicate a need for arterial blood gas analysis.

Before progressing further, let's try two questions. First, the easy one. Why isn't venous blood taken since it is easier to obtain? (Before reading farther, think of a good answer.)

The pH of venous blood is close enough to arterial blood value so that often pH is found on venous blood.

PCO_2 of venous blood is indicative of tissue metabolism and not much else. A PCO_2 for venous blood won't give any information about the efficacy of lung function (the main reason for such an investigation) since the venous blood hasn't arrived at the lungs yet.

PO_2 of venous blood is equally worthless. A low value won't tell you about originial amounts in the blood as the blood arterialized in passage through the lungs.

In short, values for venous blood depend on the metabolism and rate of blood flow through the tissues as well as the O_2 and CO_2 originally in arterial blood. Only values derived from arterial blood adequately reflect pulmonary function.

Now the harder question. Below are some values from our laboratory. Study them and venture a prognosis for the patient (getting better or worse) and support your answer. She was on a ventilator.

Date	Time	PO_2	PCO_2	pH	Status
4/14	0530	58.8	44.9	7.330	60% 02
4/14	1015	81.4	22.6	7.404	60% 02
4/14	1320	182.0	28.7	7.444	60% 02

Within seven hours time the patient tripled her PO_2 while the inhaled oxygen concentration remained constant. This shows an excellent resolution of her problem (and now the O_2 is too great for her physiological needs).

THE BLOOD-GAS TRAY

The basic blood-gas tray containing arterial puncture materials should include the following items:

a) 10 cc glass syringes
b) hypodermic needles
c) glycerin or a viscous mineral oil
d) sodium heparin (1,000 USP units/cc)
e) alcohol preps
f) 4 x 4 gauze pads
g) labels and syringe caps
h) a container for storage of the sample
i) cotton tipped swabs
j) a local anesthetic (Xylocaine - 1%)
k) 2.5 cc plastic syringes

PREPARATION OF A SYRINGE

Using a cotton-tipped swab, place a light ring of glycerin around the plunger, then move the plunger up and down inside the barrel. This makes a previously loose plunger much tighter and thus benefits for two reasons: first, a loose plunger may slip out while manipulating the syringe during testing; and second, it prevents air from moving into the sample between the plunger and the barrel. A needle of a desired gauge, length, and bevel is then placed on the syringe. An alcohol swab is used to cleanse the rubber top of a heparin multiple-dose container. While holding the syringe vertically under the heparin container, inject 0.5 cc of air into the heparin container, and then withdraw approximately the same amount of heparin into the syringe. Remove the needle from the bottle. While still holding the syringe vertically, rotate the plunger slowly down the barrel so as to heparinize approximately 4/5 of the wall of the syringe. Finally, bring the plunger back near the tip, eject any air that was admitted, force out a few drops of heparin so that the needle is full and cap the needle.

Heparin is an anti-coagulant and thus prevent the blood from coagulating once it has entered the needle and the syringe.

If too much glycerin has been applied or if the heparin is rotated inside the barrel too many times, the plunger may loosen and the reasons for the application of the glycerin will be negated. It is for this reason that one last check should be done - this is for a "heparin leak". Hold the syringe vertically in a downward position, if heparin leaks out of the needle, begin again with a new syringe. If there is no leak, the syringe is ready.

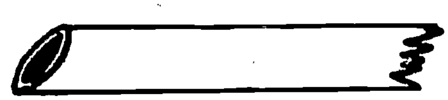
WHICH NEEDLE TO USE?

Needles have three characteristics, each to be considered in turn: length, gauge and bevel.

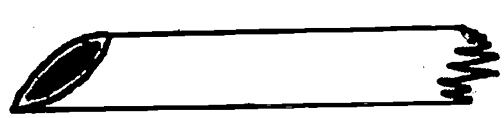
a) LENGTH. A long needle is needed for brachial puncture, one and one-half inches being sufficient. A one inch needle is good for the radial artery. These lengths will give you a good half inch insurance.

b) GAUGE. The greater the gauge number the smaller the diameter of the needle. A 26 gauge needle will not permit a flow of blood into your syringe. A 16 gauge needle would cause much trauma. A 20 or 21 gauge needle is adequate for both puncture sites.

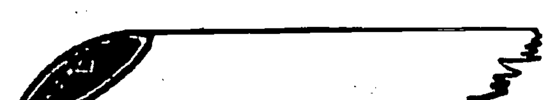
c) BEVEL. A needle isn't just pointed, it is sheared off and sharpened at a very specific angle.
A short bevel looks like this:



and a medium bevel:



and a long bevel:



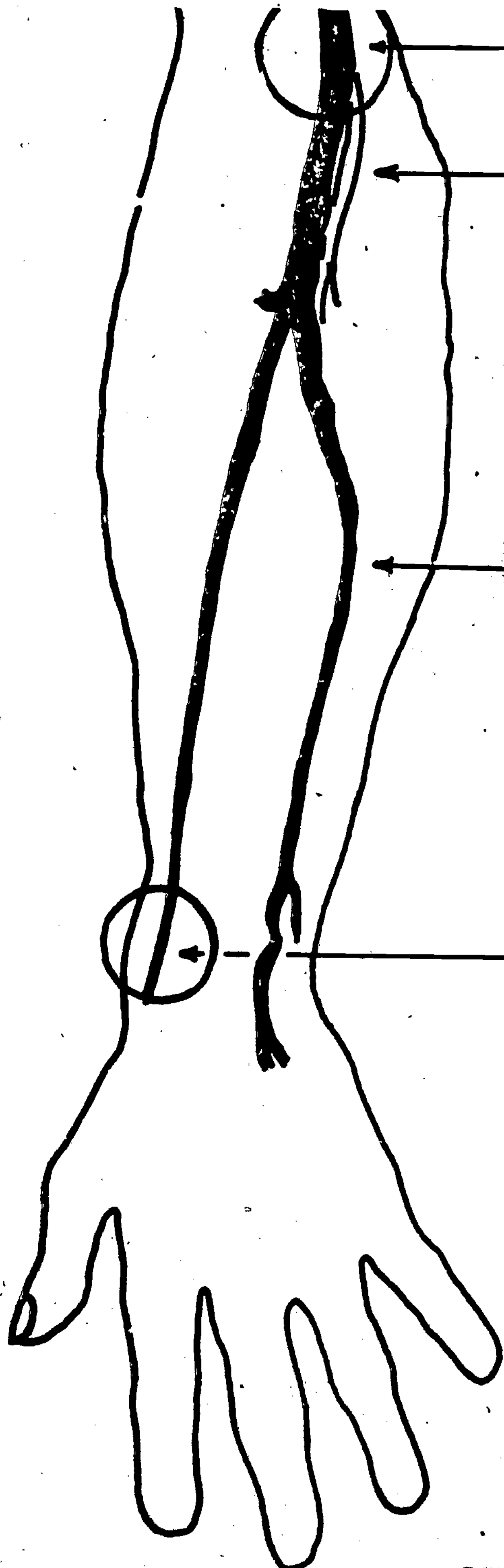


Fig.2. PUNCTURE SITES (Palm-up view). The brachial artery is punctured above the crease of the elbow; the radial artery at the wrist joint.

A short bevel punctures the skin more painfully than the others. A long bevel may help you to puncture the artery twice, front and back. We recommend:

brachial: 20 gauge, 1½", medium or long bevel.
radial: 21 gauge, 1", medium or short bevel.

PUNCTURE SITES

A technician in our lab, when drawing arterial blood, is limited to the radial or the brachial artery of either arm. The laws governing technicians and the drawing of arterial blood vary from state to state. Some states allow the technician to draw from the femoral artery also, but on the other hand, some states do not allow the technician to draw arterial blood at all.

If the situation permits, all the possible puncture sites should be checked. When deciding which site to enter, the technician should keep these considerations in mind: which site offers the easiest access, which artery has the strongest pulse, which artery has the least tendency to move, and which artery is the most palpable.

In hospital situations, the technician may not have a choice of a puncture site because of the condition of the patient (e.g. casts, I V, limb elevation, amputation, or soaks). In such cases, the technicians will have to make the best of the situation and consider only those sites readily available.

The technician should take certain facts about arteries into consideration when deciding which site to puncture. The brachial artery is a larger vessel than is the radial artery and because of its size should be easier to puncture (see Fig. 2). However, the radial artery is usually more suferficial to the skin, and because of this, it may be easier to palpate and hence puncture. But some individuals present anomalies, so consequently, all possibilities should be examined.

You can rapidly find a pulse if you note the following observations from figure 2. With the arm extended palm-up, the brachial artery is opposite the thumb side, and the radial is on the same side as the thumb.

TECHNIQUE FOR PUNCTURE

There are basically two techniques for the arterial puncture. One method is to enter the skin at a shallow angle (25° - 45°) - almost as though one were trying to thread into the artery. If this angle is taken, the technician has a greater area of arterial wall ahead of his needle. The needle is then advanced through tissue, hopefully on an intersection course with the artery. A finger is <u>always</u> kept on the artery distal to the puncture site - even as the needle is moved farther into tissue. It is obvious that the greater the amount of tissue traversed by the needle, the greater is the pain potential to the patient.

The other method is to enter the skin and the artery at a greater angle (60° - 80°). This method requires a precise reading of the pulse and insertion of the needle. Extra care must be taken to avoid going completely through the artery. Speed in this maneuver is to be discouraged. However, because of the angle, less tissue is traversed during insertion and there is less discomfort for the patient.

The technician may, however, wish to try both methods to determine which affords him the greater success. Ultimately, the easier it is for him, the easier it will be for the patient.

A word of caution concerning any puncture should be mentioned. Regardless of the technique employed by the technician and regardless of the pulsation of the artery, no entry should be attemped unless the technician has a reasonable chance of success.

Because this may be a painful experience for some patients, extreme care must be taken to keep the patient at ease. If a patient is very apprehensive about the needle and syringe, this anxiety will definitely affect the results, especially the PCO_2 and the pH. Therefore, always take maximum care to keep the pain at a minimum. Although this is not always possible, if one is careful to choose the best puncture site, is careful in selecting the right spot for the puncture, and exercises a great amount of care in the puncture and withdrawal, the procedure will go much more smoothly than most patients ever expected.

Nevertheless, don't deceive the patient by telling him that it won't be painful. It is wise to inform the patient that there will be pain as the needle penetrates the skin. (The amount of pain after that depends upon the expertise of the technician.)

There is no satisfactory topical skin anesthetic now on the market. Those that are available work well topically on the mucous membranes, but these will not penetrate the skin to deaden nerve endings.

If the puncture is to be on a child or on a person who is hypersensitive to pain, it may be desirable to have a doctor inject a local anesthetic. Hence the Xylocaine on the tray. This will minimize or eliminate the pain of the arterial puncture. The technician should not assume responsibility for the administration of a local anesthetic.

Another situation where an anesthetic may need to be administered is in the case of the multiple puncture. If the technician has attempted a puncture a few times without success, and the patient becomes anxious, it is wise to either have a doctor perform the puncture or to have him inject a local anesthetic, again to minimize or eliminate the pain. The decision to ask a doctor to perform the puncture is a decision that is left to the discretion of the technician and should not be made too hastily. The technician should not give up easily but, on the other hand, should not persist to the point of frustration of both him and the patient. (more below)

First of all, let us discuss briefly the "reading of the pulse". When feeling the pulse, the best finger to use is the forefinger. It is very sensitive, and it is easy to maintain a continuous palpation of pulse while inserting the needle through the skin and into the subdermal tissue. This continuous palpation is important because the technician wants to be certain the spot he has entered is correct. It also can tell the technician if the artery has moved because of downward pressure of the needle.

In order to make the artery most accessible, a small, firm, pillow should be placed under the elbow of the patient in order to hyperextend this joint as much as possible. This makes the brachial artery more taut which in turn brings it more to the surface and less apt to roll. The pillow under the wrist also extends the radial artery just enough. In some cases, the hyperextension of the radial artery will cause its pulse to be more difficult to palpate. 782

Because of the nature of arterial blood, the technician should not employ a tourniquet, but rather he should ask the patient to relax him muscles as much as possible. This is because arteries, particularly the brachial, is usually located under, among, or very close to a great deal of muscle, more particularly the tendon of the lower attachment of the biceps. Swab the area with 70% alcohol, let it air dry, and puncture the skin.

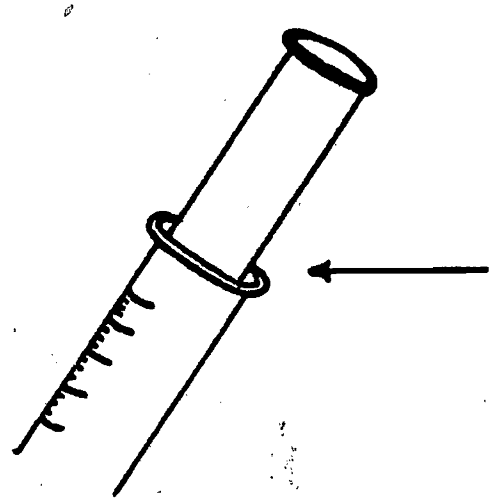
WITHDRAWING THE BLOOD

When the artery has been entered, the blood pressure within the artery will almost immediately cause the blood to flow into the syringe of its own accord. Pulling back on the plunger is not necessary: this may cause air to be admitted into the sample. The blood sample must be anaerobic! So, it is important to allow arterial blood to flow into the syringe by itself. However, it the patient's blood pressure is very low and the blood enters the syringe very slowly, it may be desirable to lightly draw back on the plunger to help the flow along. If this is necessary, be sure to release the plunger occasionally to maintain certainty that the blood is indeed flowing in of its own accord, i.e. is arterial blood. Again, if the slight drawing back is necessary, be sure that no air is admitted.

If on your first attempt into tissue you don't find the artery, never move the needle right or left to locate it. An artery severed by your needle tip will require a cut-down and suturing. Instead bring your needle back to just under the skin surface, locate the pulse again, and advance the needle.

REMOVING THE NEEDLE

When your syringe is full (about 8 cc.), advance your forefinger up the barrel to the junction of plunger and barrel.



Exert pressure at this point. Place a 4 x 4 over the needle and puncture site. As you pull away the syringe, cover the site with the 4 x 4 and press firmly.

AFTER-CARE OF THE PATIENT

Immediately upon the withdrawal of the needle, firm pressure must be applied to the area of the puncture for at least five minutes, or longer in the case of a patient who is on anti-coagulants or has a tendency to bleed. This will prevent the occurance of a hematoma, hematoma being a localized, subdermal mass of effused blood caused by arterial or venous bleeding; it has the appearance of a bruise or blue welt or swelling. This situation must and can be easily avoided.

When applying pressure, use a 4 x 4 gauze pad and take care to press firmly not only on the spot of entry on the skin but to cover the surrounding area as well. The arterial puncture may not be directly under the skin puncture. If this "Five Minute Pressure" rule is always followed, the problem of hematoma should never arise. If the patient still has some slight oozing externally after five minutes, continue the pressure until it stops. A dressing is not necessary, but the patient should be told to keep the joint straight for about half an hour.

STORAGE OF THE SAMPLE

Also immediately upon the withdrawal of the needle, the syringe should be capped and the blood thoroughly mixed by giving the syringe a vigorous shaking. It should then be placed in iced water or a cold container to prevent any further cell metabolism within the blood. At body temperature the leucocytes will continue to utilize oxygen and release carbon dioxide thus affecting the PO_2 and PCO_2.

An example of how the temperature of storage affect acid-base values is shown by the following table:

TEMP. OF STORAGE	ΔpH/HR.	ΔPCO_2/HR.
38° C.	- 0.062	+ 4.8 mm Hg
22-24° C.	- 0.024	+ 2.5 mm Hg
0-4° C.	- 0.006	+ 0.6 mm Hg

Cold storage ensures the best results through least change in parameters.

Now a problem arises for technician: immediately upon finishing the puncture, he is supposed to apply pressure to the area of the puncture, cap the syringe, mix the blood, and put it in a cold container. How can all these things be done immediately by one person? Five solutions are presented:

1) The technician can do it all himself. He must have all the necessary equipment, such as 4 x 4 gauze pads, a syringe cap, and the cold container, readily available. While exerting pressure on the puncture site with the heel of the left hand, he can manipulate the syringe well enough to cap it, shake it, and store it. (Assume you are right handed.) If the heel of the left hand is over the puncture, the fingers of that hand can be used to remove the needle from the syringe as it is rotated by the right hand. The cap, if at the finger tips of the left hand, can be raised and held as the syringe is inserted and the whole made tight. The right hand is then used to insure mixing of heparin and blood by shaking the syringe, which is then put into the cold container.

2) Upon finishing the puncture, the technician can stick the needle of

the syringe into a rubber stopper being careful to get the entire bevel of the needle inside the rubber. This method will prevent air from coming into contact with the sample, but makes no provision for the shaking and storing of the sample.

3) Another method which serves is to simply bend the needle to such an angle so as not to permit air to leak in.

4) If the patient is judged capable and has tolerated the procedure well he can be of service to the technician in this situation. If the patient is able, the technician may ask him to put firm pressure on the area until he gets the syringe capped, shaken, and stored, at which time the technician can resume applying pressure. This method should not be employed unless the technician remains with the patient.

5) The last method may well be the best. If there is a nurse or other medical person close by, she may apply the pressure while the technician caps, shakes, and stores the sample and returns it to the lab for analysis.

When considering the storage of blood samples, mention should be made concerning the two different types of syringes, glass and plastic.

Through much research it has been shown that plastic syringes allow for a considerable degree of gas exchange. With high initial oxygen tension or with blood of low hemoglobin concentration the exchange can result in errors in PO_2 of up to 6% in two minutes and 16% in 30 to 60 minutes (and is temperature dependent). With glass syringes the exchange was much slower.

Carbon dioxide is up to eight times as permeable as oxygen in plastic and more than thirty times as soluble in blood. From these properties it can be estimated that the storage of blood samples in plastic syringes will cause errors in measured PCO_2 which are smaller than the worst errors in PO_2, but are not negligible.

It should be noted that glass syringes should be used when possible since even delays of a minute or two in the sampling of blood with a high initial tension could cause errors of 5% in PO_2 with the use of plastic syringes, even if tested immediately.

A COMPLICATION

You've brought your needle and syringe into view. The patient blanches. You poise it above the skin. A few drops of perspiration are noticed on his forehead and his skin feels clammy. He says he feels a little dizzy. You penetrate the skin and he faints. Now lets back up and worry about the unconscious patient in a later paragraph.

Needle puncture is an invasive procedure (a threat or attack with a weapon, if you like). In nearly every case the patient can balance feelings of threat and their physiological manifestations against the simple fact that in some way the results of the procedure will benefit him. (Hence the disappearance of your normal friends when asked to submit to puncture.)

It is only a theory, but it may be the case that there are patients whose dominant thought is one of threat without the softening influence of benefit.

785

Now to return to our fainted friend. At his point treat him as just that and use your medical knowledge in treating him or summoning a doctor. (Watch for signs of shock). The points to be made here are two.

1) Puncture should not have been attempted after perspiration and dizziness were in evidence.

2) To procede or not depends upon your ability to wait until the patient returns to normal and to reasure him that all will be well during the puncture. You may have an assistant hold the patient's hand, have him look away, or if in doubt, let the doctor take over.

A fainting episode is unusual (easily less than 1%) and if the signs are mentioned here, our caution may prevent it from ever happening.

CONTAGIOUS DISEASE, BLOOD GASES, AND THE TECHNICIAN

Because of the contagious nature of certain diseases, precautions must be exercised when taking and testing the blood of a patient whose diagnosis included anthrax, burns infected with Staphylococcus aureus, diptheria, eczema, rabies, rubella, congenital rubella syndrome, smallpox, staphylococcal entero-colitis, staphylococcal pneumonia, vaccinia, hepatitis, melioidosis, plague, or neonatal vesicular disease.

In the case of the technician having to draw arterial blood from a patient with any of these diseases the following precautions should be taken:

1) Use only disposable items including a plastic syringe:
2) Enter the room with a heparanized syringe, needle, alcohol prep, 4 x 4 gauze pad, a syringe cap, and a "Baggie". Wear gloves.
3) Obtain the blood, remove the needle, cap the syringe. Put the syringe in the baggie and seal it.
4) Put all other items in a receptacle in the room; remove only the "Baggied" syringe.
5) Have an assistant stationed at the door with an open Baggie; drop your package into his Baggie and have the assistant seal it. (This is called the Double-bag method of sealing contaminated articles.)
6) Remove your gloves and discard appropriately. Return to lab.

Testing the blood also requires certain precautions. These will depend on the equipment used in your lab. General points to consider, however, are:

1) Wear gloves to test the blood.
2) Double-bag the plastic syringe, cap, 4 x 4's, baggies, and gloves. Seal and label as CONTAMINATED to ready it for incineration.

This type of situation may arise only rarely but when it does, this information will be very important and should be followed closely. The lines of the blood-gas machine will be contaminated and copious amounts of proper cleaning agent should be flushed through. Again, your particular machine will determine the steps you take to clean it after your analysis.

WHAT IF YOU MISS?

It happens. A well-muscled person will give you a diffuse pulse reading. A mobile artery may react to downward needle pressure by moving extensively. An irritable artery may go into spasm (contract). Blood pressure may suddenly fall in the acutely ill. Whatever the reason, whatever the experience, there are occasional failures.

After two skin punctures, a third is probably not advisable. It is time to consult with the doctor who ordered the test, who in turn may postpone it, try the same sites himself, or out of necessity, do a femoral puncture.

SPECIALIZED PROCEDURES

Newborns, infants and pediatric cases require more knowledge, patience and specialized equipment than adult puncture cases. In addition, many blood samples required serially over a short period of time are usually taken after the insertion of a long-dwell needle. A short word about each situation is in order at this point.

NEWBORNS. If distress at birth is noted, and blood samples will be considered likely, the umbilical artery will be kept open for several days by cannula allowing small samples of blood to be taken periodically.

INFANTS. After closure of the umbilical artery, the sampling of arterial blood in the newborn or infant or young child is difficult. A technique frequently resorted to, though never as reliable as a true arterial sample, is the "arterialization" of capillary blood with an accompanying heel stick, the blood being drawn into fine capillary tubes containing from 75 - 120 microliters. The foot is first warmed (40° C) by wrapping it in wetted towels for at least five minutes. This increases the blood flow through the extremity capillary bed, the hope being that increased flow will allow a greater amount of arterial blood into the area.

PEDIATRIC PATIENTS. Aging brings on a toughening and thickening of the dermal layers of the foot. Puncture is now nearly impossible. It is a very skilled technician who can consistently draw arterial blood from a child without local anesthesia. At our institution, physicians draw blood from these patients because of the usual need for anesthesia at the puncture site.

LONG-DWELL SAMPLES. A hypothetical, though realistic situation might be the doctor's order that a resting sample of blood be taken, another under stress (exercise) and another after a patient has breathed 100% O_2. It is especially important that blood be taken as soon after exercise as possible (while still under stress). There is no time to puncture in the usual way. The doctor will thread a special needle (length about 2½") into the artery and secure it. A local anesthetic is used to infiltrate the tissues before insertion. Then at any time during the procedures, a syringe can be attached to the cannula and a sample drawn.

TEMPERATURE

Usually blood is analysed at 37° C, the temperature of the patient from whom the blood came. If, however, the patient is in a febrile or hypothermic state, some interesting results come to light. An example first:

At our analysis temperature of 37° C:

$PO_2 = 80$ $\qquad$ $PCO_2 = 40$ $\qquad$ $pH = 7.40$
(all normal values)

becomes under hypothermia, (open heart surgery, perhaps), 30° C:

$PO_2 = 54$ $PCO_2 = 30$ $pH = 7.504$

The apprently normal has become in actuality moderately alkalotic with moderate hypoxemia.

Before we go on to make an observation locate the point for the hypothermic patient's pH and PCO_2 on the Blood Gas Interpretation Chart. Classify the patient before reading farther.*

As the temperature rises pH falls and conversely. As the temperature rises PO_2 and PCO_2 rise and conversely.

Always note the condition of the patient when you draw blood or receive it from the wards. Whether you correct for temperature changes in your lab is a decision to be made by your director. It is worth doing if requested. Always record the amount of oxygen being given the patient, if any.

* A fairly complete assessment would include: There is moderate hypoxemia. Mild hypocapnia, moderate alkalosis . . . compatible with acute hyperventilation.