DOCUMENT RESUME

ED 182 439 CE 023 746

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TITLE Industrial Education. Electricity/Electronics Curriculum Guide, Phase II. Instructional Modules, Level III.
INSTITUTION California State Dept. of Education, Sacramento. Bureau of Industrial Education.
PUB DATE Oct 79
NOTE 486p.: Not available in paper copy due to broken type. For related documents see CE 023 743-745.

EDRS PRICE MF02 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Career Exploration; Course Content; Curriculum Guides; *Electricity; *Electronics; Grade 10; *Industrial Arts; *Industrial Education; Learning Activities; Learning Modules; Occupational Information; Safety; Teaching Guides; Teaching Techniques; Units of Study
IDENTIFIERS California

ABSTRACT

Designed for students in the tenth grade, this electricity/electronics curriculum guide contains instructional modules for sixteen units of instruction: (1) orientation, (2) introduction to electricity/electronics, (3) electricity/electronics safety, (4) fundamental skills, (5) direct current circuits, (6) graphical illustrations, (7) circuit evaluation, (8) electrical energy and power, (9) project fabrication techniques, (10) alternating current fundamentals, (11) instrumentation, (12) capacitance, (13) inductance, (14) circuits, (15) vacuum tubes and solid-state electronics, and (16) exploring occupations in electricity and electronics. Each instructional module is divided into two sections. The first section is an instructor's guide which enables the instructor to have a lesson plan overview to the unit. This overview includes the title of the unit, time allocation, unit goal, unit objectives, evaluation, instructor references, unit overview, suggested presentation hnts/methodology, supplemental activities and demonstrations, and instructional module contents listing. Section 2 of the module contains the packet of materials to be utilized in the classroom. Each packet includes the following parts: unit outline/transparency master, pre-post test, vocabulary enrichment activities, student informational handouts, related quest activities, and answer keys. (LRA)

ED182439

INDUSTRIAL EDUCATION

ELECTRICITY / ELECTRONICS

CURRICULUM
GUIDE
PHASE II

INSTRUCTIONAL MODULES
LEVEL III

CE 023 746

STATE OF CALIFORNIA

BUREAU OF INDUSTRIAL EDUCATION DEPARTMENT OF EDUCATION

INSTRUCTIONAL MODULES

A set of 16 technical units which were specifically designed to support Electricity/Electronics instructors in the planning and presentation of their course materials.

THE AUTHORS:

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DEDICATION:

To our wives Christy, and Becky for their understanding and encouragement.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

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A special thanks is extended to the public schools, industries, and publishers whose input contributed greatly to the completion of this curriculum project. Thanks is also extended to James Herman, Chief (retired), Bureau of Industrial Education, California State Department of Education, and James Allison, acting Chief, Bureau of Industrial Education, California State Department of Education.

Other Contributors

An additional acknowledgement of gratitude must be extended to the California Council of Electronics Instructors, whose 400 Statewide membership actively provided valuable input towards the creation of the Instructional Modules.

PREFACE

Industrial Education, in the public schools of California, is a generic term which applies to all levels of education and training which relate directly to industrial occupations. Industrial Education includes the major subject matter fields of industrial arts, trade and industry, and technical and health careers and services. A comprehensive and reflective Industrial Education curriculum will assist and support students in selecting, preparing, and advancing in occupations or careers which currently exist or which are emerging.

Industrial Education programs are also those educational programs which pertain to the body of related subject matter organized for the development of understanding about the technical, consumer, occupational, recreational, organizational, managerial, social, historical, and cultural aspects of industry and technology.

In essence, Industrial Education curriculum is concerned with aiding the individual to respond and react sensitively to technological developments and to cope efficiently and effectively with the consequences in one's personal life.

In order to provide skills for students to meet their employment needs in the future, the educational system must meet its curriculum challenges today. One means of solving this problem was the development of the State Electricity/Electronics Curriculum Guide Phase I, that centered on a competency-based cluster approach to derive curriculum. Phase II provides the necessary Instructional Learning Modules including classroom materials for a realistic curriculum foundation which will assist in developing student competencies for entry level occupations and/or technical specialization. Statewide application of these materials will allow for student mobility because of standardization and it avoids duplication of high cost instruction.

It is sincerely hoped that the educational materials contained in this curriculum project will serve as the foundation for improving instruction in the area of Electricity/Electronics within the school systems of California.

INTRODUCTION

Philosophical Background

One of the primary purposes of the public schools in our society is to acquaint the young with the nature of the culture within which they live and operate. The American culture is distinctly technological; therefore, it is the responsibility of our educational system to acquaint our youth with the nature of this technological culture. The tmememdous acceleration of industrial technology has had and will continue to have an overwhelming impact on society.

One fundamental concept behind Industrial Education in our educational system is that technical experiences, curriculum, instruction, and guidance assist the student in preparation for economic independence and an appreciation for the dignity of work. Another main thrust is to prepare students for a successful life of work by increasing their options for occupational choice, by eliminating barriers to attaining job skills, and by enhancing learning achievement in all subject areas.

Irrespective of what the future may hold, individuals living in our present day environment will be handicapped unless they are reasonably well informed concerning the vast Electrical/Electronic technological applications in our daily living. Our present civilization is scarcely conceivable without the applications of Electricity/Electronics which have become identified with the industrial growth of our country and our thousands of everyday conveniences. The Electricity/Electronics subject field is an integral part of the Industrial Education curriculum, and this field provides employment for millions of individuals annually.

The total impact of Electricity/Electronics on human life is of such magnitude that it necessitates a comprehensive technical program in our schools to produce informed individuals capable of effective and meaningful functioning in our society.

Project Purpose Phase I

During the Industrial Revolution, Industrial Education focused on primary or single skill development, and this approach was viable in an era that required the mastery of one skill for initial employment. However, present technological developments in the labor market have necessitated that individuals within the labor force have a multiplicity of skills to meet the needs of the nation's trade and technological communities.

In order to facilitate methods for students to meet their employment needs in the future, the educational system must meet its curriculum challenges today. One means of solving this problem is the development of an Electricity/Electronics instructional program that centers on a competency-based clustor approach to derive curriculum. Utilizing this approach, the student will have a realistic curriculum foundation which will provide access to the necessary competencies for entry level occupations and/or technical specialization.

The basic intent of the State Electricity/Electronics Curriculum Guide was to provide educators within Industrial Education a competency-based guide that can be adapted or adopted to any existing or new program without major cost expenditures. Hopefully, the guide will act as a catalyst for educators who desire a revision or restructuring of their Electricity/Electronics curriculum, yet the guide format provides the flexibility for teacher-based modifications related to methodology, instructional resources, textbooks, equipment, laboratory systems, etc. For the educator the heart of this guide was the curriculum outlines that were an outgrowth of the occupational tasks and/or competencies identified through various occupational needs assessments and tasks analysis inventories.

The following is a brief synopsis of each outline in terms of level of instruction and duration.

1. Curriculum Outline Level I - Grades 7-8
   a. 9 week unit outline
   b. 18 week unit outline
2. Curriculum Outline Level II - Grade 9
   a. 36 week unit outline
3. Curriculum Outline Level III - Grade 10
   a. 36 week unit outline
4. Curriculum Outline Level IV (Specialization Level) - Grades 11-14
   a. 36 week unit outline at each grade level

The contents of the curriculum outlines were generated to increase the efficiency of the Electricity/Electronics programs in the schools of this State, and the competency based structure was established for the students so that their complex and confusing world begins to take on order and their learning tasks are more relevant and readily attained.

Project Purpose Phase II

The State Electricity/Electronics Curriculum Guide was proposed as a comprehensive educational guide designed to eliminate the dichotomy between formal school and the world of work. Basically Phase II allowed the development of Learning Modules for the Guide, in an effort to improve the preparation of California's youth for their future in the world beyond the classroom.

Phase II also addressed itself to the development and use of Instructional Modules within the classroom as a vehicle to implement the Curriculum Outlines presented in Phase I.

Instructional Modules were based on each major unit topic within Levels I, II and III of the State Curriculum Guide for Electricity/Electronics. Approximately sixty Instructional Modules or packets were created for teacher/student use. Each module contains basically the following:

1. Goals and Objectives (unit)
2. Outline
3. Pre-Post Test (keyed)
4. Instructor References
5. Suggested Methodology
6. Demonstrations and Quest activities
7. Student Handouts--Informational
8. Vocabulary Enrichment List
9. Student Worksheets
10. Related Instructional Activities and Graphical Illustrations

ORIENTATION

Rationale

The Instructional Modules in this level were specifically designed to assist the electronics instructor in the planning, organization, and presentation of course materials. Care and emphasis throughout the modules has been given to the needs of technical instructors who must motivate and guide California's youth through the educational system. At the same time the authors of the Instructional Modules were fully cognizant of the need to present fundamental competencies, yet, not in the traditional dry fashion but with an eye towards:

Marketing the Subject Matter
Innovative Assignments
Eye Appeal
Constant Reinforcement
Educational Games
Doing Activities
Immediate Unit Evaluation
"State of the Art" Subject Matter
Diversity in Teaching Methodology

Scope

The Instructional Modules are generally divided into two sections, as follows:

Section I (Instructor's Guide)

This section is presented first in the module to enable the instructor to have a lesson plan overview to the unit. This overview includes;

1. Title of Unit
2. Time Allocation
3. Unit Goal
4. Unit Objectives
5. Evaluation
6. Instructor References
7. Overview (unit)
8. Suggested Presentation Hints/Methodology
9. Supplemental Activities and Demonstrations
10. Instructional Module Contents Listing

All of the suggestions in this section were designed to enhance the unit presentation and provide the most effective learning environment for utilization of all instructional materials. The contents of each module have been carefully prepared and scrutinized in order to establish a solid technical foundation for the student.

Section II (Instructional Module Materials)

This section contains the packet of materials to be utilized in the classroom. When appropriate each module includes;

1. Unit Outline/Transparency Master
2. Pre-Post Test (keyed)
3. Vocabulary Enrichment Activities
4. Student Informational Handouts
5. Related Quest Activities
6. Answer Keys

The Instructional Modules have been constructed and packaged so that the deletion of certain materials or the addition of pertinent information can be inserted or removed with minimal difficulty. Individual courses and instructors are not identical hence provision for flexibility is necessary in order to achieve a curriculum that is compatible with the instructor.

In the event a training program requires a radical change in the content of material presented within a module, the instructor may easily cut, insert, and paste masters to achieve the desired results which are tailored to the instructors specific needs.

<u>Support Systems</u>

No amount of planning or preparation can <u>guarantee</u> success in the classroom, because learning is such an intangible quality, yet, the lack of these ingredients in any program immediately guarantees dismal educational results. The most indispensable support system within the educational process is the teacher, who must have the expertise and enthusiasm that can propel students into the world of learning.

The instructor must also possess the drive and ambition to continuously improve and update the program, especially in this area, due to dramatic technological innovations.

The classroom should contain the necessary furniture to allow the course to be taught in a satisfactory manner. Good lighting is absolutely essential in terms of the activities that occur. Power outlets are of paramount concern for obvious reasons, and their location should allow for room flexibility. Tables, benches, and/or desks should contain locks to insure inventory control, and storage facilities for projects, equipment, parts, etc., must be readily available. Chalkboards and bulletin boards should be mounted for easy access within the classroom.

The field of Electricity/Electronics seems to be a natural interest area to many students and the laboratory portion can be used as the vehicle to generate a vast amount of enthusiasm along with necessary technical concepts. Whether an instructor utilizes individual experiments, project construction, training systems, or a combination approach in their laboratory is not critical; what is vital is that their selection reflects the goals and objectives that they want to attain within the course.

An individual school may have the best physical facility, equipment instructional materials, and administration, but in the final analysis it is the teacher who must promote, coordinate and maintain the program.

MODULE LISTING

Curriculum Guide Phase II

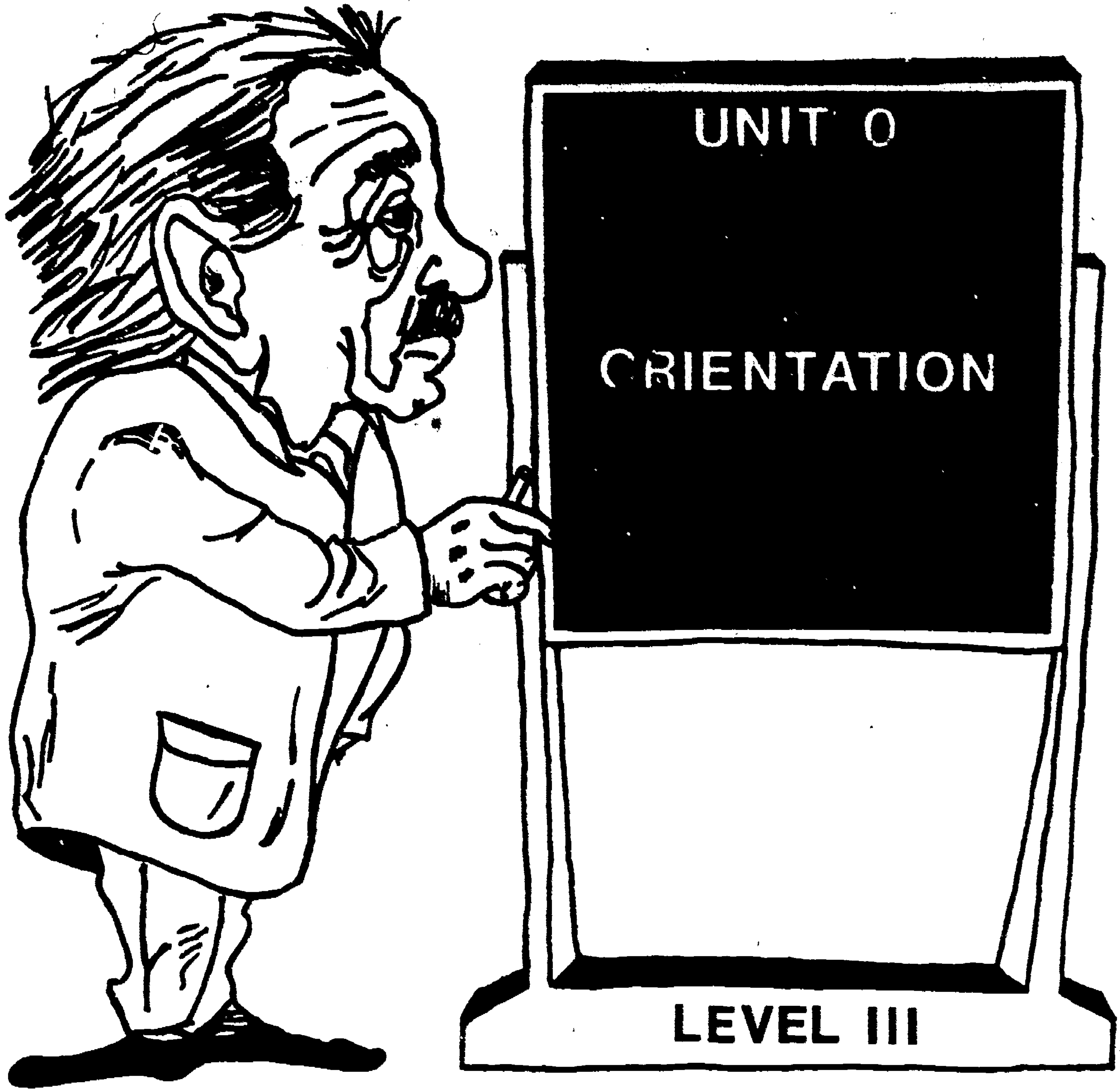
Level III Instructional Modules*

Unit	0	Orientation
Unit	I	Introduction to Electricity/Electronics
Unit	II	Electricity/Electronics Safety
Unit	III	Review of Fundamental Skills
Unit	IV	Direct Current Circuits
Unit	V	Graphical Illustrations
Unit	VI	DC Circuit Evaluation
Unit	VII	Electrical Energy and Power
Unit	VIII	Project Fabrication Techniques
Unit	IX	AC Fundamentals
Unit	X	Instrumentation
Unit	XI	Capacitance
Unit	XII	Inductance
Unit	XIII	Circuits Containing R, C, and L
Unit	XIV	Vacuum Tubes and Solid-State Electronics
Unit	XV	Exploring Occupations in Electricity and Electronics

*Instructional Module contents are coordinated with the California Industrial Education Electricity/Electronics Curriculum Guide, Level III, Curriculum outlines.

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________

DATE STARTED__________

DATE COMPLETED________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Orientation

Time Allocation: Several Days

Unit Goal:

To communicate those competencies which will allow an awareness of course goals, objectives, and basic requirements.

Unit Objectives:

The student will be able to:

1. describe examples of the technical nature of our modern society and the need for technical instruction in the area of Electricity/Electronics.

2. explain basic course requirements and the system of student evaluation.

3. demonstrate an awareness of the general course objectives and verify the significance of each within this educational program.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral, or written testing procedures.

Instructor References:

Industrial Education Electricity/Electronics Curriculum Guide Grade Levels 7-14. Published by the State of California, 1977.

Innovative Programs In Industrial Education. Leslie H. Cochran, McKnight and McKnight Co., 1970. Chapters 5, 6, and 7.

Planning and Organizing Instruction. Ralph C. Bohn and Harold Silvius, McKnight and McKnight Co., 1976.

Overview:

This unit, along with Unit 1, will serve as the course orientation and introduction into Electricity/Electronics area respectively, hence, it is imperative that the instructor generate a positive, enthusiastic, and organized appearance from the outset—to set the pace of instruction.

The unit should be introduced by examining the course goals and objectives, not merely an instructor/student exercise in reading, but a brief discussion in reference to each item while also highlighting their overall significance.

Basic school or classroom rules and regulations, or operating procedures require attention early and this may be a good opportunity to present those to the class.

The next topic should emphasize specific course requirements and the method for student evaluation. Time should be allocated in such a manner that it will allow extensive descriptions as needed.

A variety of alternative subject matter can also be added or inserted in this unit such as: textbook utilization, study tips, room or laboratory familiarization, career information, field trips and other related activities.

This unit will not conclude with an examination as with other modules, because of the length and nature of the subject matter presented.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. This unit can afford the instructor an unusual opportunity to learn about important qualities the student possesses. The Student Questionnaire for example can act as a means to discover a wealth of information, so read through it carefully upon completion, then file all student forms by periods in one notebook for a handy reference.
2. Another idea to keep the class motivated from the beginning is to take slides, prior to the start of school, of the shop facility. Show these slides indicating special work areas, workstations, projects being constructed or any activity that needs explanation. Generally, at the start of the school calendar most teachers are constantly lecturing so slides are a welcome relief for many students.
3. The handout labeled "Student Performance Record" can serve several functions as desired. First, it can be placed at the front of the students' notebook as a title page. Or it can be graded periodically to indicate unit performance as evaluated by instructor. Finally, this handout could be a quick Table of Contents for students in terms of specific course content and/or subject matter chronology.

Methodology continued:

4. When introducing the Informational Handout - Electricity/Electronics, (area description) have each student read out loud a small portion. This will immediately draw your attention to those students that might need special attention.
5. Remember detailed Rules for Conduct and Procedure are located in the safety unit and will be taught at a later time. This unit in only concerned with basic classroom conduct and proceuures.
6. In addition to a questionnaire some instructors take a small card on the first day and have students write their name on it, this then becomes a temporary roll sheet that is easy to handle until enrollment stabilizes.

Supplemental Activities and Demonstrations:

1. Initial room impressions are important so if possible have the bulletin boards adequately displayed, materials stored properly, safety signs posted, etc. These kinds of things, such as shop appearance develop student attitudes that will affect their own craftmanship or performance.

2. Contact component manufactures for wall charts and/or visual materials. Capacitor, resistor, tube, transistor, battery, and integrated circuit companies are generally most generous to schools.

3. During the first week of school many students can be disenchanted with the "paper shuffling" so try to demonstrate a technical device that can catch their imagination. If a strobe light, color organ, or even a microcomputer is available use it to generate enthusiasm about the program.

Instructional Module Contents:

1. Unit Outline (overhead)

2. Informational Handout (Course Goals and Objectives)

3. Informational Handout (Electricity/Electronics Area Description)

4. Informational Handout (Student Questionnaire)

5. Informational Handout (Student Performance Record)

6. Informational Handout (Student Evaluation System)

7. Exam Answer Sheet (Master)

O. Orientation

A. Course Objectives and Goals

B. Rules for Conduct and Procedures

C. Course Requirements

Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

COURSE GOALS AND OBJECTIVES

This Electricity/Electronics program is a technical educational program designed to insure that all individuals are prepared with "entry" level skills to enter either the world of work or to continue to post-secondary education.

Listed below for your review are some general objectives that will be accomplished with the successful conclusion of this course!

- An appreciation of the influence the Electricity/Electronics area has on our social and economic life.
- The ability to select, care for, and utilize electronic products equipment and tools.
- An awareness of safe habits and attitudes regarding materials, tools, and equipment.
- Opportunities to explore leisure-time activities within this subject field.
- An appreciation of design, construction techniques, and craftmanship.
- An understanding of the occupational composition of the Electricity/Electronics area within the world of work.
- The ability of problem-solving technical data by utilizing sound judgements based on valid knowledge and experience.
- A consciousness in regards to energy conservation and its significance.
- An awareness of consumer products and their technical operation and application.
- Demonstrations of basic technical proficiency skills that apply to a range of occupational jobs in Electricity/Electronics.
- The recognition of specific competencies essential for employment in a job area and the formation of realistic occupational goals.

Name: ____________________

Date: ____________________

INFORMATIONAL HANDOUT Period: ____________________

ELECTRICITY/ELECTRONICS

Our grandparents would never recognize the world in which we live nor many of the gadgets which are so common to us. Hundreds of electronic wonders which we readily accept in our society were unknown sixty years ago, and have become familiar objects only through the development of a new industry that is called electronics. This industry is now one of the largest in the United States, and a major portion of its research and production plants are located in California.

This school has recognized that present technology and consumer demands offer a special opportunity for students who want occupations which are interesting and challenging and where the chance for advancement and salary are unlimited. The electronics field is one in which continuous research is always adding new products to be made, tested, marketed, and operated. There will be a steady increase in the number of persons employed in this industry, according to statistics developed by the State of California.

The student in Electricity/Electronics studies basic electrical theory, laboratory techniques, use of test instruments, care and use of hand tools, shop safety, circuits, construction or project building. The skills which one can develop may be applied to the areas of communication, transportation computers, research and development, etc.. If the student is deeply interested in his/her work, has abilities, and is willing to study and learn, s/he can progress to an entry level occupation or to continue further technical training.

Basically, electronics is a field that is a combination of the study of mathematics and physical science, and its principles can be understood by the individual who is willing to . . . .**WORK!**

Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

STUDENT QUESTIONNAIRE

PLEASE PRINT

1. Name ______________________________ Phone ____________
   Last First Middle
2. Address ______________________ Grade in School ____________
3. Age _____ Birthdate ______________________
   Month Day Year
4. Father or Guardian's name ______________________________
   Last First Middle
5. Occupation ______________________________
6. Mother or Guardian's name ______________________________
   Last First Middle
7. Occupation ______________________________
8. What are your hobbies? ______________________________

   ____
9. Do you have a job? ______ What? ______________________
10. What occupation would you like to follow? ____________
11. What type of education do you think is required for this occupation?

    ____
12. Previous shop courses

Previous shop courses	School	Grade level	Letter Grade
A. General Shop			
B. Drafting			
C. Woodwork			
D. Auto Shop			
E. Metal Shop			
F. Electricity			

13. List machines you have used in school or at home: ____________

    ____

    ____

    ____

Name: ____________________

14. List hand tools you have used in school or at home: ____________________

____

____

____

15. Why are you enrolled in this class? ____________________

____

16. Whom to contact in case of an accident ____________________

Address ____________________ Phone ____________________

17. School Activities (athletic teams, clubs, etc.) ____________________

____

18. School Attended last year ____________________

19. List classes taken last year and letter grade for last semester.

	Class	Teacher	Grade
1.			
2.			
3.			
4.			
5.			
6.			

20. Class schedule this year.

Period	Class	Teacher	Room
1.			
2.			
3.			
4.			
5.			
6.			

21. Counselor ____________________

22. Write a brief autobiography, include where you were born, schools attended, interest, goals etc..

SCORE:
GRADE:

Name: ____________________

Date: ____________________

Period: ____________________

ELECTRICITY / ELECTRONICS

STUDENT PERFORMANCE RECORD

Name of Student ____
Last First Middle

UNIT			Unsatis-factory	Satis-factory	Excel-lent
O.	Orientation	O.			
I.	Introduction to Electricity/Electronics	I.			
II.	Electricity/Electronics Safety	II.			
III.	Review of Fundamental Skills	III.			
IV.	Direct Current Circuits	IV.			
V.	Graphical Illustrations	V.			
VI.	DC Circuit Evaluation	VI.			
VII.	Electrical Energy and Power	VII.			
VIII.	Project Fabrication Techniques	VIII.			
IX.	AC Fundamentals	IX.			
X.	Instrumentation	X.			
XI.	Capacitance	XI.			
XII.	Inductance	XII.			
XIII.	Circuits Containing R, C, and L	XIII.			
XIV.	Vacuum Tube and Solid-State Electronics	XIV.			
XV.	Exploring Occupations in Electricity and Electronics	XV.			

Rating

(Place this sheet in the front of your notebook as a title page).

______________________________ ______________________________
School Instructor

Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

STUDENT EVALUATION SYSTEM

Students are graded as follows each quarter:

CITIZENSHIP: _____%

The citizenship grade is determined by attitude, cooperation, work habits, clean-up, oral participation, and attendance.

This grade may be lowered as follows:

1. Unexcused absences.
2. Unexcused tardies.
3. Improper attitude or behavior.
4. Shop rule ations.

LABORATORY AND HOMEWORK: _____%

The laboratory/homework grade is based on the quality and quantity of the work completed at the end of each quarter.

This grade may be lowered as follows:

1. Quantity and quality below ability.
2. Inconsistent work or progress.
3. Required laboratory experiments, projects, or homework not completed.
4. Failure to observe safety regulations.

TESTS: _____%

This grade is determined by averaging quizzes, tests, and final examinations

NOTEBOOK: _____%

Notebooks will be collected and graded periodically. Notes will be neat, clear, and in proper sequence. They will contain all materials and assignments completed by students, and also those handed out by the instructor.

FINAL GRADE: _____%

The final grade is determined by a collection of grades in the following areas:

1. Laboratory and homework.
2. Citizenship/behavior.
3. Tests
4. Notebook

SCORE:

GRADE:

Name: ______

Date: ______

Period: ______

ANSWER SHEET

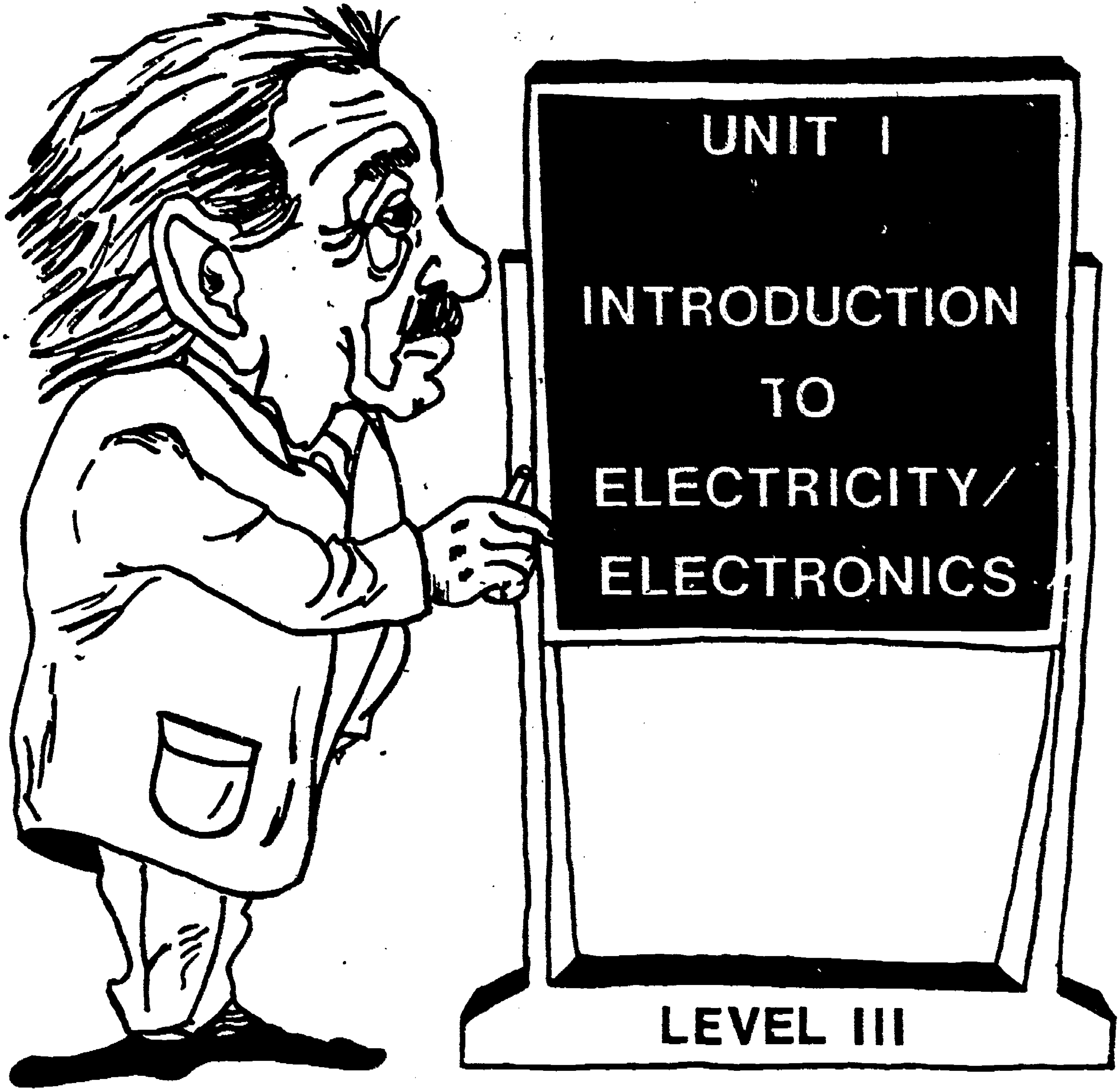
EXAM ____

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.					26.					51.					76.				
2.					27.					52.					77.				
3.					28.					53.					78.				
4.					29.					54.					79.				
5.					30.					55.					80.				
6.					31.					56.					81.				
7.					32.					57.					82.				
8.					33.					58.					83.				
9.					34.					59.					84.				
10.					35.					60.					85.				
11.					36.					61.					86.				
12.					37.					62.					87.				
13.					38.					63.					88.				
14.					39.					64.					89.				
15.					40.					65.					90.				
16.					41.					66.					91.				
17.					42.					67.					92.				
18.					43.					68.					93.				
19.					44.					69.					94.				
20.					45.					70.					95.				
21.					46.					71.					96.				
22.					47.					72.					97.				
23.					48.					73.					98.				
24.					49.					74.					99.				
25.					50.					75.					100.				

*Show work for problems on back of answer sheet.

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________________
DATE STARTED____________
DATE COMPLETED__________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Introduction to Electricity/Electronics

Time Allocation: Several Days (Units 0 and 1 = 1 week)

Unit Goal:

To disclose those competencies which will assist students in viewing the Electricity/Electronics area as an essential source of energy for the Twentieth Century, and to aid students in perceiving the area as continually expanding its circle of influence due to technological advancements.

Unit Objectives:

The student will be able to:

1. indicate 5 major areas that utilize electricity as a source of energy or power for its operation.

2. identify and state the definitions for each of the areas or categories that are classified within the field of Electricity/Electronics.

3. explain and justify the need for mastering fundamental theories in order to successfully progress in the Electricity/Electronics field.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which may utilize a combination of oral, or written testing procedures.

Instructor References:

Electricity and Electronics. Walter B. Ford and William B. Steinberg, American Technical Society, 1974. Units: 1-3.

Essentials of Electricity-Electronics. William Osterheld and Morris Slurzberg, McGraw-Hill Book Co., 1965. Chapter: 1.

Exploring Electronics. Howard H. Gerrish, Goodheart-Willcox Co., 1971. Unit: I.

Overview:

The primary purpose of this unit is to provide an introduction or initial exposure into the Electricity/Electronics area of instruction. The central theme, however, is to provoke an awareness of the phenomenal expansion of electrical principles and applications which have occured in the Twentieth Century. The unit lesson should be concentrated on first depicting the early needs for electricity as a source of energy and then showing the dramatic evolution during the past fifty years into a broad and ever expanding technical field.

Next, a philosophical presentation on the reasons which necessitates the learning of fundamental theories and principles and their direct relationship as a foundation for future, more sophisticated application.

The instructor should emphasize that the Electricity/Electronics field is a precise science and that the student must have a definite desire to learn, which among other qualities requires a dedicated attitude towards studying. A short description on methods or ways to study effectively may be appropriate at this point. Emphasize also that this persistence and dedication to studying will be rewarded as ideas, theories or concepts begin to jell together as the student progresses through the course work.

This unit will not conclude with an examination as will other modules, because of the length and nature of the subject matter presented.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. The unit outline contains a listing of major areas within the field of Electricity/Electronics and this permits the instructor an opportunity to discuss technical careers. Information about careers is most effective when it is integrated throughout the course, rather than just a separate unit of instruction
2. No specific problems, for the instructor, should be encountered in the lesson presentation dealing with the expanding field of Electricity/Electronics. The most difficult explanation will probably be for the area of cryogenics. However, by using the Instructor References as provided an appropriate explanation can be found.
3. Some students are hesitant to admit that they are confused or that a concept is not clear to them. The student should be aware that in this class there is no penalty for admitting that they are technically bewildered and in need of further explanation.
4. When instructing students about basic components and circuits explain that no matter how complex the circuit of an electronic item might be, basically it will consist of two or more of these fundamental circuits - series or parallel. Indicate what these terms mean by drawing some simple objects on the board in the proper configuration.

Methodology continued:

5. Inform the class that reading well is a skill that is gained by doing a great deal of reading. It is also highly important as they begin their studies in this field that they realize that technical reading requires a slower pace due to the illustrations, schematics, and other graphics that must be digested. Indicate that about 90% of all our knowledge is obtained through our eyes, and for this reason it is important that they utilize their eyes effectively and learn to read proficiently.

Supplemental Activities and Demonstrations:

1. With the class, itemize all the uses of electricity that they can think of and then list them on the chalkboard. From this list discuss the significance of this subject field to their daily life and the world around them.
2. Prior to this unit write or contact the Edison Institute at 90 Park Avenue, New York, New York, 10016, for a variety of materials on uses of electric power.
3. Write to the National Aeronautics and Space Administration (NASA), Washington, DC 20546, for information on NASA's computer-controlled space operation including the functions of the following NASA divisions:
   Goddard Space Flight Center
   Jet Propulsion Laboratory
   John F. Kennedy Space Center
   White Sands Test Facility
   Lyndon B. Johnson Space Center
   Many of these materials can be used as bulletin board displays for the classroom.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Technical Glossary
3. Worksheet (vocabulary) - Scrambled Word Puzzle
4. Quest Activities

I. Introduction to Electricity/Electronics

A. The Area of Electricity as a Source of Energy to Operate
   1. Lights/residential power
   2. Home appliances
   3. Industrial equipment
   4. Communication equipment
   5. Railway transportation equipment

B. Expanding Field of Electronics Encompasses
   1. Communications
   2. Industrial
   3. Automation
   4. Instrumentation
   5. Computers
   6. Data processing
   7. Therapeutics

8. Bionics

9. Military

10. Space

11. Cryogenics

C. Need for Understanding Fundamental Principles
   1. Basic components and circuit remain the same

   2. Mastering fundamentals enables future application

Name: ____________________

Date: ____________________

Period: ____________________

TECHNICAL GLOSSARY

AUTOMATION:	The use of machines to perform tasks previously done by a person. This type of machinery is controlled electronically, using memory and electro-mechanical circuitry to perform a series of programmed operations.
BIONICS:	The word roots for the term bionics come from; bio(logy and electro)nics. Bionics is the study of physical and mental tasks and the design of electronic circuits to simulate these tasks.
COMMUNICATIONS:	Electronic circuitry designed and developed for "transmitting" or "receiving" information. Many communications systems or techniques exist, such as, radio, telegraph, radar, laser, television, etc..
COMPUTER ELECTRONICS:	The development of electronic devices capable of accepting information, processing or working on the information, and supplying data or results. A computer usually consists of an input and output device, storage, arithmetic/logic units, and a control unit.
CRYOGENICS:	The study and use of devices and materials at extremely low temperatures (absolute zero). At these temperatures large current changes can be obtained from relatively small magnetic-field changes. Another interesting phenomenon occuring at cryogenic temperatures is that friction and resistance is almost nonexistant.
DATA PROCESSING:	The processing of information (storage, retrieval, and sequencing) by electronic machines. Data processing techniques utilize key punch cards, magnetic tape, floppy discs, etc. for information handling.
FUNDAMENTAL PRINCIPLE:	A basic fact, law, or electrical action which forms the basis for developing and understanding complex systems.
INDUSTRIAL ELECTRONICS:	The application of electronic principles and circuits to industrial or manufacturing processes such as measurement, machine control, timing, etc..
INSTRUMENTATION:	An area of electronics concerned with the design, development, and service of measuring devices which utilize electrical or electro-mechanical circuitry.
MILITARY ELECTRONICS:	The application and design of electronic circuitry to serve military needs. Typical applications include radar, shoran, loran, combat computers, weapons control equipment, intelligence and servalence devices, etc..

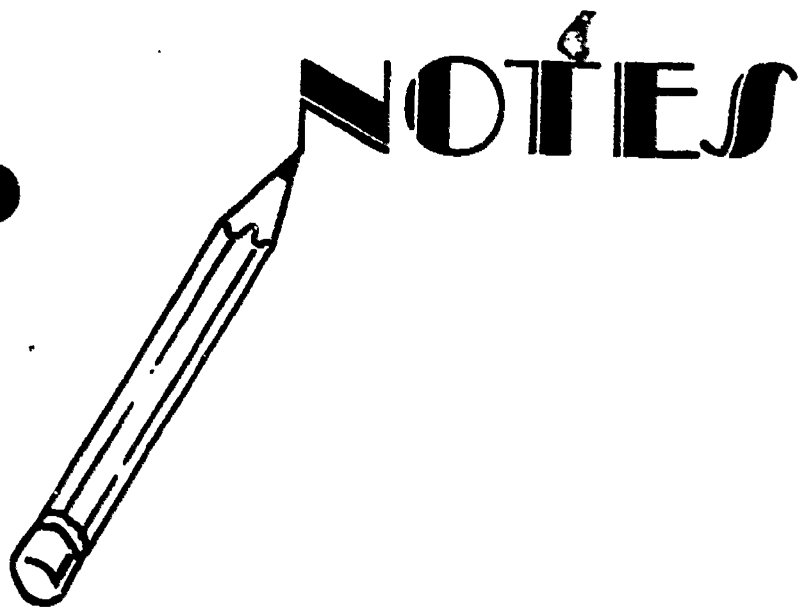
Name: ____________________

Date: ____________________

Period: ____________________

SPACE TECHNOLOGY: The design and development of electronic systems and specialized components utilized in the control and operation of space vehicles. These systems must meet many extraordinary design requirements such as utmost reliability, subminiature size, and stable operation regardless of extreme changes in temperature, pressure, and humidity. Many of the techniques developed through space technology become directly or indirectly applicable to consumer products.

THERAPEUTIC ELECTRONICS: Sometimes referred to as medical electronics, this field is concerned with the use of electronics to assist in the prevention, diagnosis and treating of illness. Modern developments such as the "laser scalpel", body scanner, intensive care monitors, and specialized diagnostic equipment have greatly increased the capabilities of the medical community.



SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

VOCABULARY - SCRAMBLED WORD PUZZLE

Unscramble the letters below to uncover the electronic terms.

EXAMPLE:

A.	MAPLEEX	A.	EXAMPLE
1.	APECS	1.	
2.	SINCIBO	2.	
3.	RLIMITYA	3.	
4.	TERMCOUP	4.	
5.	DINRSTLAUI	5.	
6.	GOSCICNEYR	6.	
7.	TAPREETCHUI	7.	
8.	MOTOAATINU	8.	
9.	SRENTOMUTTINANI	9.	
10.	TUMSCANMOONIIC	10.	
11.	ADAT GINPROSCES	11.	
12.	FLATMADUENN LERNPIPIC	12.	

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

QUEST ACTIVITY

"UNIT 1"

You probably realize that electronics is a rapidly changing and progressive field. As current technology is improved or new discoveries are made, innovative products are developed. For example, a device called a microprocessor was first developed in 1971, by 1977 the microprocessor made possible such items as the home computer, cartridge TV games, programmable timers for microwave ovens, control computers for the automobile, security systems, etc.. All fields of electronics have similar examples of technological progress.

In this assignment you will identify several state-of-the-art developments from the electronic areas of:

- Communications
- Industrial Electronics
- Automation
- Instrumentation
- Computer Electronics
- Data Processing
- Therapeutic Electronics
- Bionics
- Military Electronics
- Space Technology
- Cryogenics

Select any eight of the areas listed above. Record your choices on the chart below, and in the spaces to the right of each selection list two current developments (products) that have been introduced or disclosed in that particular field.

AREA	DEVELOPMENTS
1. ____________	____________ ____________
2. ____________	____________ ____________
3. ____________	____________ ____________

Name: ____________________

Date: ____________________

Period: ____________________

4. ______________________________ { ______________________________
____

5. ______________________________ { ______________________________
____

6. ______________________________ { ______________________________
____

7. ______________________________ { ______________________________
____

8. ______________________________ { ______________________________
____

NOTE:

There are several "electronic" and "science" magazines which will serve as a resource for this assignment.

ANSWER KEY
UNIT 1

A. VOCABULARY - SCRAMBLED WORD PUZZLE

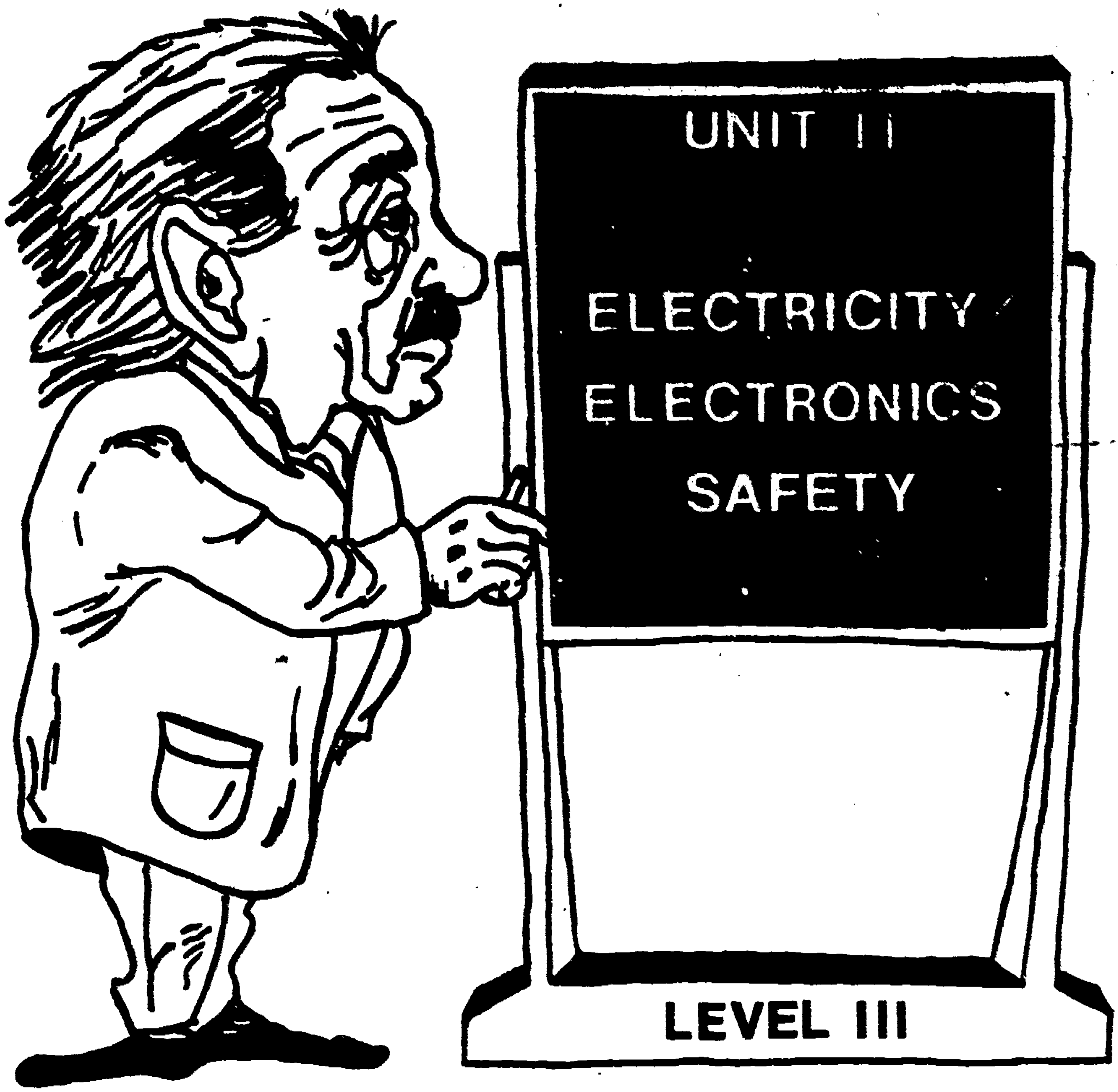
1. space
2. bionics
3. military
4. computer
5. industrial
6. cryogenics
7. therapeutic
8. automation
9. instrumentation
10. communications
11. data processing
12. fundamental principle

B. QUEST ACTIVITY

(subjective evaluation)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________

DATE STARTED________

DATE COMPLETED________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Electricity/Electronics Safety

Time Allocation: 1 week

Unit Goal:

To inform and instil student competence in safe guarding themselves and to apply this safety attitude to their daily life, whether in the classroom, on the job, or at home.

Unit Objectives:

The student will be able to:

1. define those vocabulary terms presented in the unit without error.
2. summarize and evaluate each shop rule of conduct and procedure as discussed.
3. identify the three classes or categories of fires, and indicate the proper method of extinguishing each.
4. distinguish between common safe laboratory practices and, hazardous conditions, and pass a safety test with 100% accuracy, based on the information discussed.
5. explain and apply the proper safety and first aid procedures when dealing with an electrical hazard or a serious shock.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria which utilizes a combination of written or oral testing procedures.

Instructor References:

Basic Electricity: Theory and Practice. Milton Kaufman and J.A. Wilson, McGraw-Hill Book Co., 1973. Appendix A.

Industrial Education Safety Guide. Published by the State of Californi 1978.

Making Safety Work. National Safety Council, McGraw-Hill Book Co., 1976.

Overview:

In Unit 2 the purpose is to provide an efficient guide or format for safety instruction and to establish the habit of students practicing the enclosed safety rules when applicable during ensuing units.

The unit should be introduced as a necessary, yet meaningful resource for all activities. In order to place "safety" in its proper perspective within the students' mind, stress that safety instruction should begin early in childhood and extend continuously throughout life! The idea thatan accident or electrical shock is unavoidable in this kind of class must be discouraged. In fact, the concept that accidents can generally be avoided by utilizing plain common sense should be encouraged.

The central safety theme of this unit is promoted by the discussion of rules which have been established to assist students in remembering the fundamentals of preventing accidents. Students should feel that for their well being and for the safety of their classmates, they should not ignore or violate any of the rules.

The next topic of emphasis deals with the nature of electrical shock and the first aid procedures to employ if necessary.

This unit concludes with a brief discription on fire prevention and fire classifications. This topic is vital in terms of the potential destructive force that fire represents. The student is also informed of proper extinguishing techniques to be used as dictated by the type of fire burning.

A variety of appropriate exercises and laboratory experiments should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. Students enjoy staging safety accidents, and if care is taken it is not only fun but extremely beneficial to the instructional program. If theatrical blood is liberally used in the accident simulations, slides can be taken and used for other classroom presentations.
2. This unit often is used as the most opportune time to introduce both school fire drills or civil defense drills. Try to impress students, during these kinds of activities, with the idea that disaster preparation is the only thing that really saves lives.
3. When presenting various rules to the class, call on different students to read each rule, then when those rules that need further explanation are read, stop and discuss. This technique may help eliminate the dryness of this portion of the lesson.
4. In the objectives of this unit it is stated that a safety examination must be passed with 100% accuracy, however, with some students this may be virtually impossible. Allow these few the opportunity to retake the test after a study session, but do not advertise this make up test at the beginning of the safety lesson. Sometimes certain disadvantaged students have a very difficult time to comprehending the vast amount of

Methodology continued:

written material handed out, hence they score lower than other students on the test, so a buddy study system can assist them greatly in achieving a successful score.

5. When describing dangerous current levels and their affect on the human body, remember that electrical terms and units of measurement may not be familiar to some students at this time, thus much of the impact will be lost if this is not considered and modified.

Supplemental Activities and Demonstrations:

1. Obtain and show a good safety film from regular film sources, local industries, National Safety Council, or any other company and/or institution which offers such a service.

2. When explaining the classification of fires, demonstrate the actual procedures necessary to activate the fire extinguisher. A blast from a chemical extinguisher while explaining operating techniques can stimulate a class instantaneously.

3. Invite a medical guest speaker to deliver a simple first aid presentation to the class. Prior to the class lesson explain to the guest specific areas of concentration that will help the overall safety program.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Crossword Puzzle
5. Quest Activities
6. Informational Handout (Shop Conduct and Procedure Rules)
7. Informational Handout (Classification of Fires and Extinguishing Techniques)
8. Informational Handout (Laboratory Safety Procedures)
9. Informational Handout (Electric Shock)
10. Unit Module Answer Keys

II. Electricity/Electronics Safety

A. Safety--Philosophy and Attitude

B. Electric Shock

C. Laboratory Conduct and Procedures

D. Safety Rules

E. First Aid Procedures

F. Fire Safety

G. Civil Defense Drills

Test Number _____

LIII-U2

UNIT EXAM

ELECTRICITY/ELECTRONICS SAFETY

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. "Horseplay", running, and throwing of objects are dangerous practices in the shop and are forbidden:
(A) when the teacher is looking, (B) only when students are working, (C) at all times, (D) occasionally.

2. When using machines or hand tools:
(A) give the job all your attention, (B) stand up straight, (C) watch your classmates, (D) watch the clock.

3. The floor, aisles, and passageways should be kept clear of stock, tools, and materials. Objects on the floor:
(A) may be left there if the operator of the machine is in a hurry, (B) may cause someone to slip or trip into a moving machine, (C) may be ignored, (D) are unsightly.

4. Students must not talk to or distract a person operating a machine because:
(A) the operator is likely to be injured, (B) conversation slows down the flow of work, (C) the operator is likely to make a mistake, (D) conversation is annoying to the operator.

5. Report to the teacher any:
(A) damaged tools and equipment,(B) missing guards, (C) equipment not working properly, (D) all of the above.

6. Never operate shop equipment when the teacher is:
(A) out of the shop, (B) in the shop, (C) both A and B, (D) none of the above.

7. Most tools are designed for a specific use or purpose. If they are used incorrectly, the result may be:
(A) damage to the student's project, (B) breakage of tools, (C) injury to the students, (D) damage to the bench tops.

8. Long hair is dangerous around shop equipment. If it is long enough to get caught in the machine, it must be:
(A) tied up and back, (B) burned off, (C) pulled out, (D) none of the above.

9. Loose clothing must be securely fastened or removed and long loose sleeves rolled up above the elbows:
(A) before operating any machine, (B) after operating any machine, (C) during the operation of a machine, (D) only when you are assisting the teacher.

10. All accidents and injuries, no matter how slight must be:
(A) ignored, (B) reported to the principal's secretary immediately, (C) reported to your teacher immediately, (D) reported to the shop foreman immediately.

11. Caution other students if you see a violation of shop:
(A) traffic rules, (B) good manners, (C) safety rules, (D) none of the above.

12. Only the operator and __________ are permitted within the working area around a machine.
(A) one other student, (B) the teacher, (C) a helper, (D) all of the above.

13. Gasoline, paints, kerosene, and other materials that will burn or produce fumes should be used:
(A) with another student, (B) in a well ventilated area, (C) at a workbench, (D) in an enclosed area.

14. Students are to operate only those machines or pieces of equipment for which they have received:
(A)instructions to operate, (B) permission to operate, (C) both A and B, (D) none of the above.

15. When touching electrical switches, plugs, or receptacles be sure your hands are dry because:
(A) a switch will not properly operate if your hands are wet, (B) a plug will easily slip from your fingers if your hands are wet, (C) if your hands are wet, you may receive a severe shock and serious burns, (D) none of the above.

16. Acid or chemicals on the hands or face should be immediately washed away with plenty of:
(A) water, (B) glycerine, (C) olive oil, (D) vaseline.

17. If you notice any breakage or damage to tools, instruments, or machinery, you should:
(A) repair the damage yourself, (B) be careful when using such equipment, (C) say nothing because you might get the blame, (D) none of the above.

18. Screws, nuts, and other nondigestible materials are never to be placed in your:
(A) hand, (B) pocket, (C) mouth, (D) all of the above.

19. If you are in doubt about the use of any tool or machine, or about any shop procedures:
(A) ask an advanced student for help, (B) proceed cautiously, (C) always ask your teacher, (D) none of the above.

20. Always sweep scraps from your workbench or table with a brush or whisk broom rather than your hand because:
(A) sharp or jagged particles may injure your hand, (B) less dust is stirred up, (C) this is the easiest way to clean up, (D) it will cause less work for the janitor.

21. Eye protection is used to:
(A) improve your vision, (B) prevent eyestrain, (C) prevent flying particles or corrosive substances from entering your eyes, (D) none of the above.

22. When tools are carried in the hands, keep the cutting edge or sharp points:
(A) directed toward the floor, (B) directed away from the body, (C) directed over the head, (D) directed toward the body to protect others.

23. NEVER direct compressed air:
(A) toward the floor, (B) toward the teacher, (C) toward another student, (D) all of the above.

24. Extension and power cords should always be checked and kept in good repair because:
(A) breaks and tears in the cord are unsightly, (B) breaks and tears in the cord can cause serious shocks or burns, (C) sparks may cause wood to burn, (D) a short may cause the machine to burn up.

25. Carbon dioxide (CO^2) fire extinguishers may be used to put out what types of fires?
(A) electrical fires only, (B) wood fires only, (C) oil fires only, (D) any kind of fire.

26. Water should never be used to put out what kind of fires?
(A) wood fires, (B) electrical and oil fires, (C) paper fires, (D) none of the above.

27. The proper procedure to fight a fire with a fire extinguisher is to:
(A) point the nozzle at the top of the flame, (B) point the nozzle at the middle of the flame, (C) cover the area around the fire and keep it from spreading, (D) point the nozzle at the source of the fire because that is where the fire is located.

28. In case of fire in the shop you should first:
(A) run out of the shop, (B) throw water on it, (C) sound the alarm, (D) none of the above.

29. Lifting any object that is too heavy for you:
(A) is all right if you do it slowly, (B) can be done if you know the right way to lift, (C) should never be done, because it may cause strain or rupture, (D) is a good way to show off you strength.

30. Before the power is turned on, the teacher must check:
(A) the hand tools, (B) the classroom, (C) all special setups, (D) none of the above.

31. The teacher MUST approve:
(A) all "horseplay", (B) all projects, (C) all fighting in the shop, (D) none of the above.

32. Deliberately shorting an electric circuit:
(A) is permissible if the voltage is low, (B) may damage the wires, (C) is an easy method to test whether the circuit is closed or open, (D) may cause an explosion or do bodily harm.

33. Cutting two or more "hot" wires with pliers:
(A) is safe practice if the handles of the pliers are insulated, (B) is permissible if the wires are 18 gage, (C) may be done safely if you are standing on a wooden floor, (D) none of the above.

34. Shop clean up is the responsibility of:
(A) the custodian, (B) all the students, (C) the teacher, (D) the principal.

35. When a machine makes an unusual sound, it should be:
(A) oiled immediately, (B) ignored, (C) reported to the teacher immediately, (D) adjusted.

36. Check a soldering iron for heat with:
(A) your face, (B) your hand, (C) a piece of solder, (D) your feet.

37. To remove excess solder from a soldering iron tip:
(A) wipe with a cloth, (B) flip it off, (C) wash it off, (D) use cleaning fluid.

38. When changing components in an electrical circuit:
(A) leave the plug in, (B) pull the plug out, (C) turn the circuit on its side, (D) turn off the power switch.

39. Make sure that the hand tools you are going to use are:
(A) sharp, (B) the proper tool for the job, (C) in good condition, (D) all of the above.

40. If a tool becomes defective while you are using it you should:
(A) hide it so that no one will know, (B) report the condition of the tool to the instructor, (C) place it back on the tool panel and not say anything, (D) repair the tool yourself.

41. Be sure your hands are as free as possible of __________ before using hand tools.
(A) dirt, (B) grease, (C) oil, (D) all of the above.

42. Repairs are to be made on shop equipment only with:
(A) the power on, (B) the machine running, (C) the teacher's permission, (D) none of the above.

43. Spilled oil or grease is dangerous. Always:
(A) clean it up, (B) leave it, (C) pour water on it, (D) none of the above.

44. The motion involved in striking or cutting must be done in a direction:
(A) towards you, (B) away from you, (C) towards other students, (D) all of the above.

45. A project is still dangerous even after the power is turned off because:
(A) it may still be plugged in, (B) some of the components may be hot, (C) the capacitors can store a charge which can shock you, (D) all of the above.

46. Never use a file:
(A) without a handle, (B) as a pry bar, (C) as a hammer, (D) all of the above.

47. Pass tools to classmates:
(A) with handles first, (B) with the points first, (C) by throwing them, (D) none of the above.

48. Before starting a machine, you must:
(A) check all adjustments, (B) make sure all guards work, (C) remove all tools/rags, (D) all of the above.

49. Before leaving a machine, you must make sure:
(A) the guards are off, (B) the power is off, (C) the machine has come to a complete stop, (D) both B and C.

50. I did well on this test.
(A) True, (B) False, (C) OK, (D) I blew it.

SAFETY

Name: ____________

Date: ____________

Period: ____________

TECHNICAL GLOSSARY

ACCIDENT: An unplanned or unexpected occurance usually resulting in injury. Most common shop accidents can be prevented by observing safety rules, working carefully, and using common sense.

ARTIFICIAL RESPIRATION: A life saving procedure used to revive a person who has stopped breathing. Artificial respiration may be required as a result of electric shock, drowning, strangling, etc.

CARDIAC ARREST: A loss of heartbeat caused by electrical shock, or high blood pressure. Closed cardiac massage is the recommended first aid procedure.

ELECTRIC SHOCK: The flow of an electric current through the body. Shock can cause such physical effect as muscle twitching or paralysis, burns, interruption of breathing, unconsciousness, ventricular fibrillation, cardiac arrest, or death.

FIRE: A combustion process characterized by heat, flame, and light. There are three general classes of fire: Class A fires involve wood, paper, rubbish, and fabrics; Class B fires involve oil, grease, gasoline, paints, and solvents; Class C fires involve insulation and other combustible materials in electrical and electronic equipment.

FIRE EXTINGUISHER: A portable, selfcontained device holding a liquid, or chemical which can be sprayed on a fire to extinguish it.

FIRST AID: Emergency treatment for injury, accidents, or sudden illness generally administered before regular medical care is available.

FLAMMABLE: A designation for types of materials which are easily ignited or set on fire. Other designations may be used to identify these materials, such as; combustible or inflammable.

GROUNDING: A safety precaution which calls for placing the metal housing or case of a device at ground potential to prevent possible operator shock. Most commonly, a third wire is added to the power cord. This wire is connected between the case and earth ground allowing an alternate path for current flow. Thus, if the metal housing of a device becomes electrally "hot", current will flow through the grounding wire to the earth, instead of through the operators body to earth.

HAND TOOLS:	This term refers to a wide variety of tools which require physical manipulation or primarily the use of your arms and hand muscles for their operation and use. Examples of typical hand tools would be; screwdrivers, wrenches, soldering irons, pliers, etc..
HAZARD:	The presence of a dangerous or potentially dangerous situation.
HORSEPLAY:	The undesired, potentially hazardous activity of clowning, or playing in the shop or laboratory.
INJURY:	Physical harm or damage to ones body.
LIVE CIRCUIT:	An electrical circuit which is energized, (power applied switch on) and capable of producing current flow.
MACHINE TOOLS:	Generally, power assisted tools utilized for "heavy" jobs which require work beyond that supplied by hand tools. Examples of machine tools; drill press, grinders, sheet metal shears, box and pan break, etc..
SAFETY GLASSES:	Protective eye glass with shatter proof lens and side shields. Safety glasses should be worn at all times when necessary while working in the shop. They provide invaluable protection by preventing foreign materials (pieces of wire, chips, broken glass, chemicals etc.) from entering or coming in contact with the eyes. Goggles and face shields can be utilized to provide additional eye protection while working in extremely hazardous areas.
SAFETY PRECAUTION:	An action taken, followed or observed to avoid a possible hazard or dangerous situation.
SAFETY RULES:	A specific list of rules designed to identify common accident causing situations and hazards. By observing the safety rules many accidents will be avoided or prevented.
SAFETY ZONE:	An identified area around a piece of equipment within which only the operator or instructor should stand. For safety, all other individuals are to remain outside of the safety zone.
VENTRICULAR FIBRILLATION:	A type of heart failure, caused by electric shock, in which the heart muscle no longer beats in a regular fashion but rather quivers erratically. If this condition is not corrected rapidly, death will result.

SCORE:

GRADE:

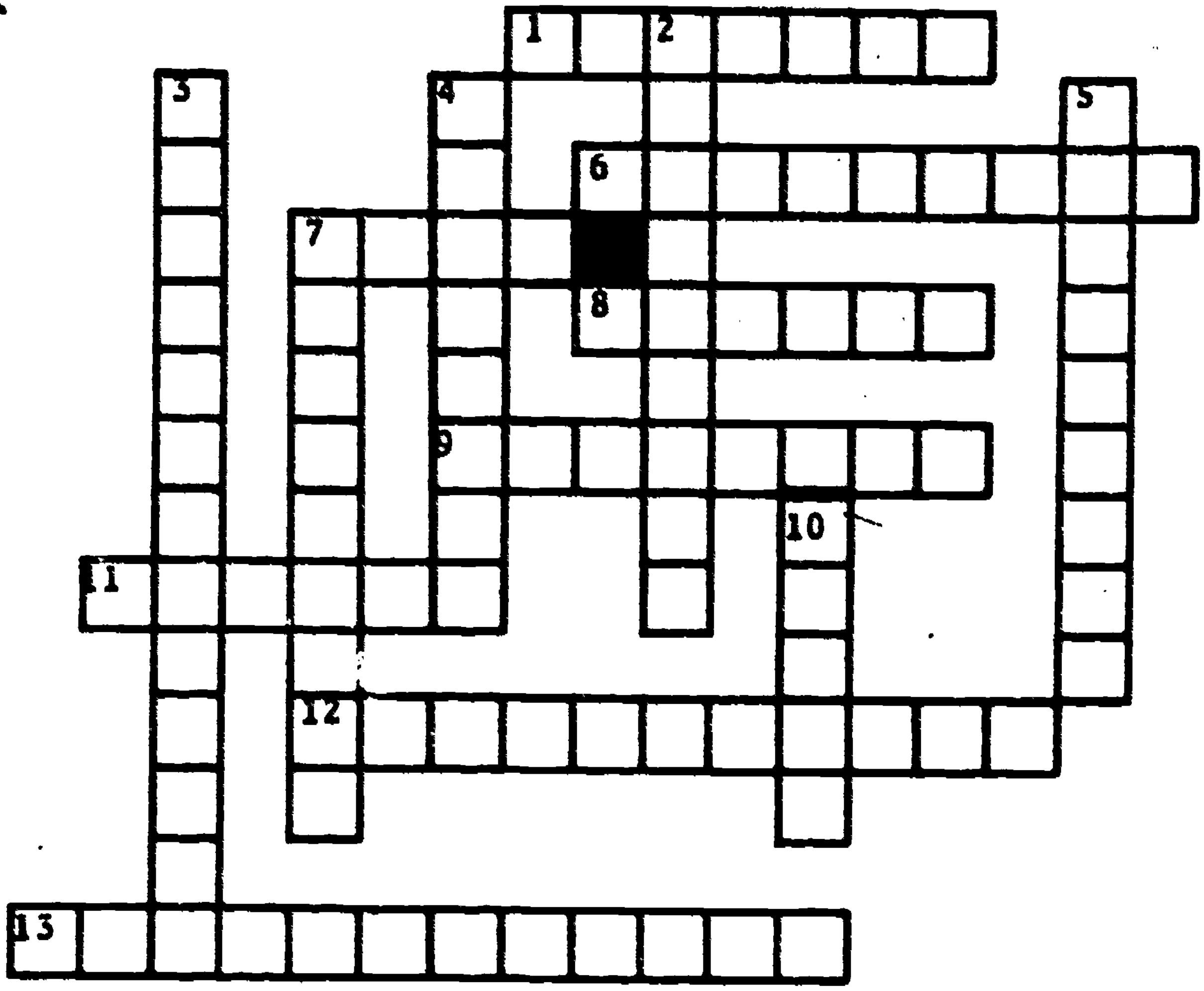
Name: ______________

Date: ______________

Period: ______________

WORKSHEET

VOCABULARY - CROSSWORD PUZZLE



ACROSS

1. Eye protection used in place of, or along with safety glasses.
6. Clowning or potentially dangerous play.
7. Combustion.
8. Damage to your body.
9. An unplanned or unexpected injury.
11. A potentially dangerous situation.
12. An energized circuit.
13. A device used to put out fires.

DOWN

2. An electrical safety precaution which places the devices metal housing at ground potential.
3. A loss of heartbeat.
4. Emergency treatment for injuries.
5. Tools that require primarily the use of your muscles for operation.
7. Materials which are easily ignited.
10. The flow of an electric current through the body.

SCORE:

GRADE:

SAFETY

WORKSHEET

QUEST ACTIVITY

"UNIT 2"

Name: ______________

Date: ______________

Period: ______________

Utilizing the safety techniques you have learned in this unit, analyze the shop area for possible hazards that may cause you or your classmates serious injury. After you have identified a possible hazard, prepare a safety poster, which can be placed in the area of the hazard, to help prevent accidents.

Suggestions: Use an 8 1/2" x 11" sheet of paper (white or colored), include the use of color, pictures, words, cartoon drawings, etc.. Be creative.

Name: ____________

Date: ____________

Period: ____________

<u>INFORMATIONAL HANDOUT</u>

SHOP CONDUCT AND PROCEDURE RULES

1. Students must be on time daily and each student must be in his/her assigned seat <u>before</u> the tardy bell rings.
2. You are required to have a notebook specifically for this subject at your desk each day. It will be collected and graded during the year.
3. You must also supply yourself with the necessary materials for classroom notes - paper and a writing tool.
4. All handouts and notes will be kept neatly in your notebook, not scattered in your locker.
5. Seats (and lab. station) will be assigned. Do not change your seat. without consulting your teacher.
6. Absolutely no horseplay in the shop. Many painful accidents occur by the careless and thoughtless antics of the so-called "clown." Walk in the shop at all times. Loud talk and unnecessary noise will not be tolerated.
7. No eating, drinking, or gum chewing is allowed in the shop or classroom.
8. Keep your desk (lab. station) and adjacent floor area clean.
9. Pencils should be sharpened before class. All trash (scratch paper etc.) shall be kept at your desk and thrown away after class only.
10. Throwing <u>anything</u> in the classroom is absolutely forbidden.
11. Turn in all assignments on time. Late assignments will be down graded.
12. If you finish your work before others, use the extra time constructively. Do not disturb your fellow students.
13. Poor attendance will hurt your grade, because it is difficult to make up missed work.
14. It is the students responsibility to make up any tests or assignments that were missed due to absence.
15. Feel free to ask questions anytime on subject matter which you do not understand.
16. If you must leave the room during class, clear it through the instructor first.

Name: ______________

Date: ______________

Period: ______________

17. Work safely and encourage other students to do the same by setting a good example each day.

18. Use only the machines and tools on which you have satisfactorily passed a safety test.

19. Report any injuries or damage to yourself or equipment to the teacher.

20. Malicious damage to equipment and parts will not be tolerated. You will be required to pay for any damage caused in this manner.

21. Do not remove any project, or material, from the shop without the instructors approval.

22. When the time for clean-up comes, cooperate with the foreman and do your fair share to keep the shop clean and attractive.

23. Students must return to their seats prior to class dismissal at the end of the period. Class will de dismissed only after the shop is clean, all tools are accounted for, and all students are quiet and in their assigned seats.

SHOP CONDUCT AND PROCEDURE RULES

The shop conduct and procedure rules have been read and explained to me. I agree to abide by these rules, and if I have any questions I will ask the instructor.

Students signature: ______________

Period: ______________

Date: ______________

Instructors initial: ______________

Name: ____________

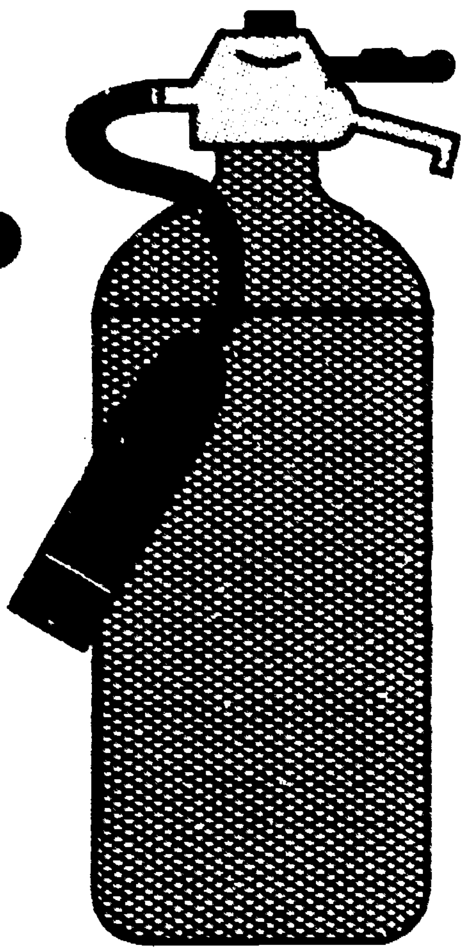
Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

CLASSIFICATION OF FIRES AND EXTINGUISHING TECHNIQUES

There are three classification categories for fire. Each type of fire requires special extinguishing techniques. Use the chart below to distinguish the extinguishing techniques.



Class "A"

Fires involving combustible material such as wood, paper or cloth: to extinguish, cool and quench with pump type extinguishers containing water, or soda-acid. CO^2 (carbon dioxide) extinguishers may also be used.

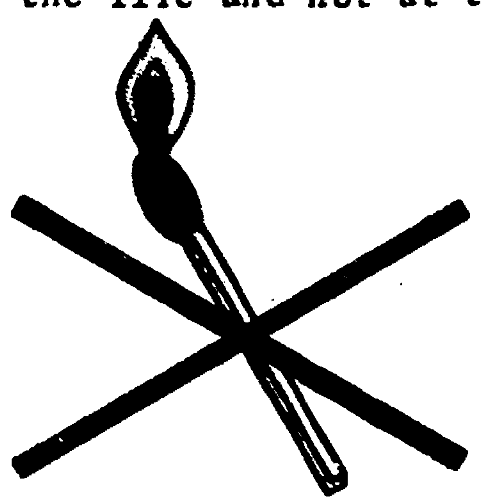
Class "B"

Fires involving flammable liquids such as gasoline, keresone, greases, thinners, and finishes: smother the burning fuel. Foam and CO^2 type extinguishers may be used.

Class "C"

Fires involving electrical equipment; use a nonconducting type extinguisher such as CO^2 or dry powder, and if possible disconnect the source of electrical energy.

NOTE: Always point the fire extinguisher nozzle at the source of the fire and not at the top of the flame



SAFETY

Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

LABORATORY SAFETY PROCEDURES

INTRODUCTION:

People working in industry know the importance of safe working habits. Safety training programs are sponsored by unions, management , public agencies, and insurance companies. Despite these good efforts, accidents annually cause lost job time, painful injuries, and needless deaths.

Good safety habits are learned daily. As you begin your laboratory work in electricity, resolve now to learn and practice safe working habits in the laboratory. The choice of your future safety and future laboratory work habits is up to you. Form safe habits now.

Name: ____________________

Date: ____________________

Period: ____________________

GENERAL SAFETY PROCEDURES:

Safe Attitudes. Laboratories are working areas for adults. Tricks, games, and horseplay should be left in the school yard.

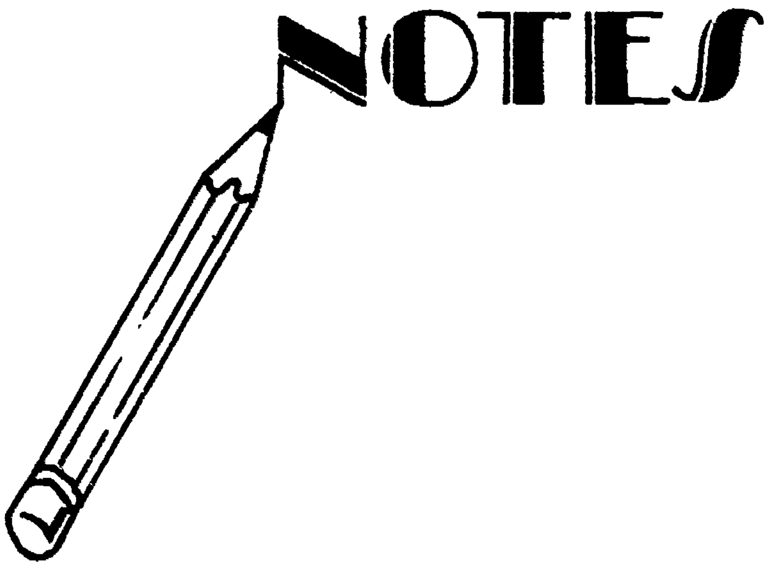
Safe Environment. Work areas must have proper power, ventilation, and light. Aisles should be open and clear. Storage areas are to be kept clean and secured. The use of temporary extension cords, fans, heaters, gas or water connections is discouraged. Maintain a neat and orderly work area.

First Aid Procedures. Even with good safety practices someone may be injured. Your instructor and/or the school nurse are trained in first aid procedures, but there are several general rules which you should follow.

Don't panic! Determine if there is any immediate danger to the injured person. Never move an unconscious person without cause. Lay such a person flat. Keep the person warm to prevent shock. Never try to force liquids on an unconscious person. If the victim is breathing normally, keep the person still and comfortable until medical aid arrives.

Severe electrical shock or other types of accidents may interrupt breathing. A procedure such as artificial respiration can be used to stimulate the breathing process. Check for a swallowed tongue before application of artificial respiration. This procedure should be administered by a trained person if possible, and continued until medical help arrives. The two common methods of artificial respiration are mouth-to-mouth and the Schaeffer method.

All injuries should be reported to the instructor. Even minor cuts can become infected, and the best first aid supplies, nurses, and doctors cannot help an unreported injury.



Name: ______________

Date: ______________

Period: ______________

GENERAL SAFETY RULES:

Shop Behavior and Safety Practices

1. Clowning, scuffling, pushing, running, and throwing objects are dangerous practices in any shop and are forbidden at all times.

2. Obey all warning signs--they are posted for your protection.

3. Caution any student you see violating a safety rule.

4. When using machines or hand tools, give the job at hand all of your attention.

5. Work at a speed consistent with safety. "Foolish hurry," such as rushing to complete a procedure, is dangerous.

6. Cooperate with your classmates in the shop cleanup program.

7. Machines must not be operated while instructor is out of the room.

8. If equipment is not working properly, shut it off and tell the instructor at once.

9. Report to the teacher all breakage or damage to tools, machinery, or equipment.

10. A student who sees a dangerous situation must report it at once to the teacher.

Eye Protection

11. Eye protection must be worn when working in an area where hazardous conditions exist.

12. Face shields or goggles shall be utilized where extra protection is required, such as while grinding or working with caustic substances.

13. Eye glasses must not be used in place of goggles or face shields.

14. When compressed air is used for cleaning, wear eye protection. Take care to direct chips, shavings, and dust away from other students. NEVER ALLOW THE STREAM OF AIR TO COME IN CONTACT WITH YOUR BODY.

Name: ____________

Date: ____________

Period: ____________

Clothing

15. Wear safe clothing when working in a shop. Fasten or remove loose clothing before you operate any machine. Roll long sleeves above the elbows. Apron fastening should be such that they will break if the apron becomes entangled in a machine.

16. Long, loose locks of hair can easily be caught in revolving machinery and ripped out causing serious scalp laceration. Have your hair cut short, tied back, or tightly covered.

17. Wearing gloves is forbidden when you are working with power driven machinery in the lab.

18. Remove jewelry--bracelets, rings, chains, and other accessories that are hazardous in shop work.

19. Sharp, pointed tools or materials are not to be carried in clothing. Hold sharp points and sharp edges down.

20. Always wear protective clothing when working with chemicals. Rubber gloves should be worn when handling chemicals or immersing your hands in chemical solutions.

21. Always wash hands with soap and water after working with materials that might be harmful to the skin.

Housekeeping

22. Keep your work area clean and orderly. Good housekeeping is part of safety.

23. Keep floors, aisles, and passageways clear of materials and equipment.

24. Keep tools in a safe place. Never leave them where they may cause injury. Put them in tool boxes, trays, cases, or on wall panels.

25. Store material neatly and securely and in a place where persons passing will not be injured.

26. If water, grease or oil is spilled on the floor, clean it up immediately to prevent slipping.

27. Extension cords shall always lie flat on the floor in such a way that students will not trip over them.

28. Always use a brush to clean off benches and machines. There may be sharp or jagged particles among the scraps, which could cause serious injury to the hands.

Name: ____________________

Date: ____________________

Period: ____________________

29. Always keep bench, cabinet drawers, and locker doors closed.

30. Keep tools and materials from projecting over the edge of benches or tables whenever possible.

Approval

31. Students are warned not to use machines until they have been given the proper safety instruction, and received permission from the teacher. The student must ask for further instructions if in doubt concerning any operation.

32. When in doubt, ask the instructor. Do not depend upon the advice of another student.

33. The shop safety test must be passed by students in order to operate any power driven machines.

34. Do not operate switches of machines and instruments unless given permission to use them by the instructor.

35. Ask your instructor to approve all projects you plan to do.

36. Repairs are to be made on shop equipment only when permission has been given. Do not tamper with shop equipment.

37. All special set-ups in the lab. must be approved before the power is turned on.

Injury

38. Report all accidents, however slight, to the instructor at once. Infection may result from uncared for cuts and scratches.

39. When lifting heavy objects, keep your arms and back as straight as possible, bend your knees, then lift with the powerful muscles in you legs.

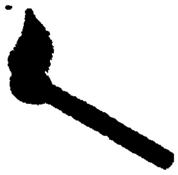
40. Do not attempt to lift heavy items alone. If there is any doubt in your mind about your ability to safely lift an object, ask for help.

41. Screws, nuts, and other nondigestible materials are never to be placed in one's mouth.

Name: ____________

Date: ____________

Period: ____________



Fire

42. The location of fire extinguishers, fire exits, and fire drill procedures shall be known by all students.

43. Nothing shall be hung on fire extinguishers. The area around them must be kept clear so that they may be reached without delay if a fire were to occur.

44. When pouring flammable liquids, be careful not to spill them.

45. Oily or paint-filled rags must be placed in a covered metal container.

46. Toxic chemicals, kerosene, paints, thinners, and other finishes or cleaning materials are to be used in a well ventilated room. They are never to be used near an open flame.

47. Never use water to put out an electrical or oil fire, it will cause the fire to spread.

48. In case of fire in the shop: Sound the alarm; FIRE!!, turn off all gas and electricity, put the fire out.

Hand Tools

49. Be sure your hands are as free as possible of dirt, grease, and oil when using tools.

50. Select the right tool for the job to be done. Use the proper type and size hand tool for the job.

51. Make sure when using a sharp-edged tool to point the edge away from yourself and classmates.

52. When carrying tools in the hands, keep the cutting edge or point directed toward the floor.

53. Clamp small work on a bench or in a vise when using a hacksaw, a screwdriver, or when performing delicate operations.

54. Never use a chisel, punch, or hammer with a "mushroomed" head. Chips may fly off and injure someone.

55. Never use a file without a handle. Be sure that the handle is properly secured to the file.

56. Pass tools to classmates with the handles first.

Name: ____________

Date: ____________

Period: ____________

57. Plastic handled screwdrivers should not be used near an open flame or near hot soldering irons.

58. Metal rules should be kept clear of electrical circuits. When in doubt use a plastic or wood rule.

59. All portable electric tools and equipment must be disconnected when not in use.

60. When disconnecting an electric tool or appliance from a circuit, remove the attachment plug from the receptacle by pulling on the plug handle instead of on the wire.

61. There is a right and a safe method to use all tools. Don't try to cut corners by using incorrect methods.

Soldering

62. Never test the heat of a soldering iron by feeling it with your hands. Check the heat of the iron with a piece of solder.

63. Always return the iron to its proper holder.

64. Always wipe off excessive molten solder. Never flip it off. Molten solder inflicts painful burns when it comes in contact with the skin.

65. When passing a soldering iron to another student, place it on the soldering iron rest. The other student can then pick up the iron by the handle.

66. Care must be taken not to let the soldering iron burn any electrical cord, or circuit wire.

Machine Tools

67. Only the operator may start and stop a machine, and after the machine is turned off, s/he should stand by until it has stopped running.

68. All adjustments must be securely fastened before the power is turned on.

69. All wrenches and other tools must be removed from the machine before the power is turned on.

70. Keep machine and safety guards in proper position at all times.

71. Overloading or forcing in any manner any hand operated or power driven machine is dangerous. Use only the material or stock furnished or approved by your teacher.

Name: ____________________

Date: ____________________

Period: ____________________

72. Keep rags away from machines that are in operation.

73. Make sure everyone is clear of the machine before starting it.

74. Have the instructor check all special set-ups and new operations before turning on the machine.

75. Think about your job while operating a machine. It is dangerous to talk when you are using power equipment.

76. Have machine at a dead stop, power off, before cleaning, oiling or repairing. Always turn the power off before leaving a machine.

77. Use only electric power tools that are grounded, or that have UL approved housings.

Safety Zones

78. Only the operator and teacher are permitted within the defined working area around any machine.

79. Do not lean on machines - stand clear.

80. Disturbing another student while he is working is a dangerous practice.

Electrical

81. Consider every electric circuit live until proved otherwise.

82. Make certain your hands are completely dry before touching electrical switches, plugs, or receptacles.

83. Remember even 110 volts can be fatal. Approach all jobs with caution, and analyze each job before you start.

84. The location of emergency power switches shall be known by all students.

85. Never allow anyone to turn power on and off for you while you are working with instruments.

86. Cutting two or more wires at the same time with pliers or other tools is extremely dangerous and may result in damage to the circuit and tools, and severe injury to the person if the power is not turned off.

87. Electricity has no respect for ignorance. Do not apply voltage or turn on any device until it has been properly checked by the instructor.

Name: ____________________

Date: ____________________

Period: ____________________

88. Always stand a safe distance from any project when it is turned on for the first time. Sparks and smoke can be dangerous.

89. Deliberately shorting any electric circuit or generating device may damage the equipment, cause an explosion, or do bodily harm.

90. Certain components such as resistors and vacuum tubes get hot while operating. Wait for them to cool before attempting to remove them.

91. Do not work around electri equipment if floors are damp or wet.

92. Do not work on an electrical circuit with the power turned on.

93. Be sure equipment is in proper working order before using. Frayed cords and plugs are a major source of accidents.

94. Ask for instructions before using any piece of electronic test equipment. One wrong connection can destroy an instrument and thus deprive you and others of its use until repaired. The repairs can be expensive.

95. Use proper instruments for testing circuits.

96. Before replacing a fuse in any electrical equipment, disconnect the power source.

97. When making temporary or permanent connections, carefully avoid leaving open splices or pieces of wire sticking out. Secure all wires properly. Tape or cover the connections.

LABORATORY SAFETY PROCEDURES

The laboratory safety procedures have been read and explained to me. I agree to abide by these rules, and if I have any questions I will ask the instructor.

Students Signature: ____________________

Period: ____________________

Date: ____________________

Instructors Initial: ____________________

Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

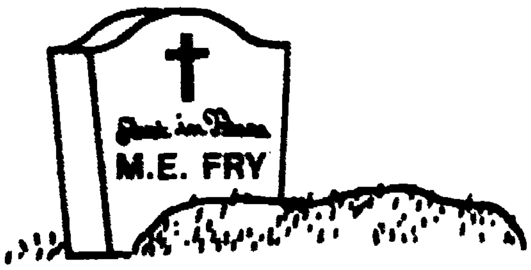
ELECTRICAL SHOCK

One of the major hazards in the electronics field is protection against electrical shock. Shock is caused by the passing of electric current through the body. Current flow is related to the voltage applied and therefore the higher the voltage the more serious the shock. Don't however get the idea that low voltages do not shock for they certainly do if the circumstances are right.

Let's see what can happen when an electric current passes through your body. A number of effects may occur depending upon the circumstances and magnitude of the shock.

Current Value	Effect
.001 ampere	Produces a shock than can be felt. (Mild "tingling" sensation).

Current Value	Effect
.01 ampere	Produces a severe shock, which is painfull, and can cause loss of muscular control. (Can't let go phenomenon).



Current Value	Effect
.1 ampere	Produces a potentially fatal shock which can cause death if current lasts for a second or more.

Name: ______________

Date: ______________

Period: ______________

As you can see, the body is sensitive to relatively small current flows. As a comparison, a common 100 watt light bulb draws a current flow of .85 amperes, far higher than the .1 ampere of current which can cause death.

OTHER EFFECTS OF ELECTRIC SHOCK:

Muscular paralysis-

Burns-

Cessation of breathing-

Unconsciousness-

Ventricular fibrillation-

Cardiac arrest-

All of these effects do not occur with every shock. As stated before, conditions vary. What happens to you depends upon several factors:

(1) The intensity of the current.
(2) The frequency of the current.
(3) The path the current follows through the body.
(4) How long the current passed through the body?
(5) Did you expect to be shocked?

Keep in mind, that the current flow through your body, not the amount of voltage applied is the determining factor in the severity of a shock you might receive. The higher the current, the more dangerous the shock.

CAUTION: Electric shock can be hazardous to your health.

SCORE:
GRADE:

Name: ______________________

Date: ______________________

Period: ______________________

ANSWER SHEET

EXAM LIII U2

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.			■		26.		■			51.					76.				
2.	■				27.				■	52.					77.				
3.		■			28.			■		53.					78.				
4.	■				29.			■		54.					79.				
5.				■	30.			■		55.					80.				
6.	■				31.		■			56.					81.				
7.			■		32.				■	57.					82.				
8.	■				33.				■	58.					83.				
9.	■				34.		■			59.					84.				
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11.			■		36.			■		61.					86.				
12.		■			37.	■				62.					87.				
13.		■			38.		■			63.					88.				
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16.	■				41.				■	66.					91.				
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18.			■		43.	■				68.					93.				
19.			■		44.		■			69.					94.				
20.	■				45.				■	70.					95.				
21.			■		46.				■	71.					96.				
22.	■				47.	■				72.					97.				
23.				■	48.				■	73.					98.				
24.		■			49.				■	74.					99.				
25.				■	50.					75.					100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 2

A. VOCABULARY - CROSSWORD PUZZLE

ACROSS

1. goggles
6. horseplay
7. fire
8. injury
9. accident
11. hazard
12. live circuit
13. extinguisher

DOWN

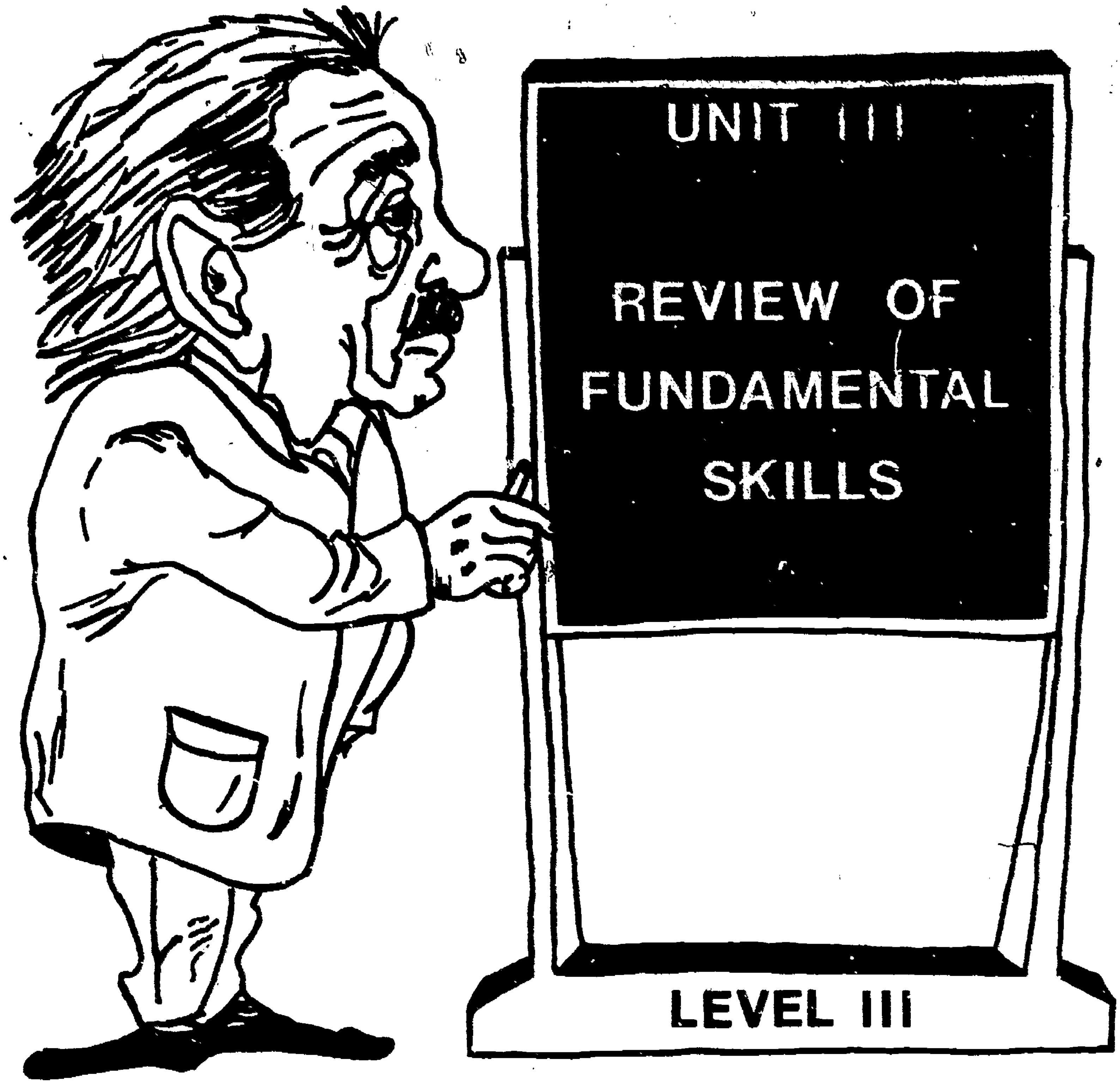
2. grounding
3. cardiac arrest
4. first aid
5. hand tools
7. flammable
10. shock

B. QUEST ACTIVITY

(subjective evaluation)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME____________________
DATE STARTED____________
DATE COMPLETED__________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Review of Fundamental Skills

Time Allocation: 3 weeks

Unit Goal:

To investigate and reappraise those competencies acquired in the previous course, and to utilize these fundamental skills as the foundation for future technical instruction.

Unit Objectives:

The student will be able to:

1. demonstrate comprehension of basic technical theory verbally and indicate corresponding written responses to all questions on three review worksheets.

2. describe common laboratory practices and indicate simple manipulative skills that are necessary in project construction or experimentation.

3. explain and display the proper safety and/or handling techniques in response to any review topic presented.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral and laboratory testing procedures.

Instructor References:

Basic Electricity. Marcus and Marcus, Prentice-Hall Inc., 1974. Chapters: 1-8, and 14.

Exploring Electricity Electronics. Thomas E. Kraus and Philip J. Rollain, Delmar Publishers, 1971. Units: 1-5, 7-14, and 20.

Introduction to Electricity. Kurt H. Schick, McGraw-Hill Ryérson Limited, 1975. Chapters: 1-7, 11-16, and 20.

Overview:

It was presupposed that this course was not the first Electricity/Electronics program that the student has been enrolled in, however, if in fact this course does stand alone, then some slight curriculum modifications will be necessary by the instructor.

This unit was designed into Level III for a variety of reasons. First, to act as a solid foundation for this level of technical instruction. Next, to serve as a skill review for material previously taught. Finally, to provide flexibility as a buffer or calendar adjustment unit during the first few weeks of school. The time length allocation has purposely been increased to allow for change, hence, most modification then will not really disturb the sequence of overall instruction.

The main thrust of this unit is obvious, but important, and to omit a review of this nature would be a serious mistake. A majority of students will forget a lot of key information over a vacation period and a short informative review will quickly re-establish those technical competencies necessary for a successful course experience.

The instructor should refer to the Level II outlines of the State Electricity/Electronics Curriculum Guide for additional topics or further breakdown of topic titles utilized in this review unit.

This unit concludes with a review of fundamental mathematics which is not only informative for many students but very practical, especially in solving electronic problems within this level.

A variety of appropriate exercises, laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. Take some extra class time on the following concepts: basic electrical quantities, units of measurement, meters, and simple circuits. All too often, these areas are hazy in the minds of the student and some additional review instruction will pay off during this course.
2. Remind students to utilize their old Electricity/Electronics notebook as a valuable resource center. This notebook can serve as a study guide, and of course be very important in assisting students in completing the review worksheets in this unit.
3. The school district may have available a central Audio Visual Center which might carry filmstrips, slides, and/or film loops pertaining to this area of instruction. Get aquainted with this service or any local agency that can provide these kinds of material on loan, and then coordinate their showing with the unit topic under discussion.
4. Do not overlook the review of laboratory materials or equipment during this unit. This activity will also break up the monotony of a review by focusing on "hands on" learning activities.

Methodology continued:

5. During the unit presentation do not allow yourself to be intellectually stagnated because this unit is just a review. Instead be as excited and interested as humanly possible, the pay off will be a class that is motivated.

Supplemental Activities and Demonstrations:

1. This unit has eight major topics which can be further enhanced by a variety of demonstrations. Whatever demonstrations are selected be cognizant of visibility, otherwise the demonstrations become inconsequential. If a VTR system is available this would probable be a nice time to introduce its use.

2. If the laboratory has some past built kits or projects available, bring them out and describe their function. This will allow a transition into a discussion on their possible choice of a future project. Whatever is displayed, however, should be of top quality both electrically and aesthetically.

3. Many short story booklets on Electricity/Electronics are available from major companies. A letter written on school letterhead indicating a need for a classroom set will usually bring results.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Worksheet - Vocabulary Review
4. Worksheet - Review of Fundamental Skills #1
5. Worksheet - Review of Fundamental Skills #2
6. Worksheet - Review of Fundamental Skills #3
7. Quest Activities
8. Unit Module Answer Keys

III. Review of Fundamental Skills

A. Nature of Electricity

B. Methods of Producing Electricity

C. Conductors, Insulators, Semi-conductors

D. Electrical Team

E. Language and Symbols of Electricity

F. Component, Switches, and Circuits

G. Resistance and Resistors

H. DC and AC Electricity

I. Electronic Mathematics Fundamentals

LIII-U3

UNIT EXAM

REVIEW OF FUNDAMENTAL SKILLS

IMPORTANT

Indicate your response on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. Anything that takes up space, and has weight or mass is called energy. (T-F)

2. The atomic particle which orbits around the nucleus of the atom, and has a negative charge, is called an electron. (T-F)

3. Electricity is the orderly movement of free electrons. (T-F)

4. Atomic ions are produced when an atom either gains or loses electrons. (T-F)

5. The nucleus of the atom has no charge. (T-F)

6. Semiconductors have 5 electrons in their valence band. (T-F)

7. Insulators are good conductors of electricity. (T-F)

8. Conductors do not allow electron flow. (T-F)

9. I is the letter symbol for amperes. (T-F)

10. SPDT is the abbreviation for a type of switch. (T-F)

11. In order to have a current flow, you must also have a voltage applied to the circuit. (T-F)

12. A battery converts chemical energy into electrical energy. (T-F)

13. In a parallel circuit the voltage is the same across all the components. (T-F)

14. A series circuit contains several paths for current flow. (T-F)

15. Direct current flows first in one direction through a circuit, stops, and then flows in the opposite direction. (T-F)

16. Identify the basic particles that make up an atom.
(A) positive, negative, neutral, (B) molecules, and elements, (C) electrons, protons, neutrons, (D) pions and protons.

17. The basic law of electrical charges states:
(A) electrons flow from negative to positive, (B) unlike charges are either positive or negative in polarity, (C) all charges are either positive or negative in polarity, (D) like charges repell, unlike charges attract.

18. Which of the following statements is true?
(A) the electron has a positive charge; the proton has a negative charge; and the neutron has no charge, (B) the electron has a negative charge; the proton has a positive charge; and the neutron has no charge, (C) the electron has a negative charge; the proton has no charge; and the neutron has a positive charge, (D) the electron has a positive charge; the proton has no charge; and the neutron has a negative charge.

19. A complete electric circuit must have:
(A) just a switch and a DC source, (B) an AC source and a load, (C) an AC or DC source, a load, a complete circuit, and a control, (D) just a load and a complete path for current.

20. In an electric circuit, a switch is:
(A) used to control current flow, (B) always used, (C) used in place of a load, (D) the source of energy.

21. Two sources of electricity are:
(A) chemical action and water, (B) heat and thermocouple, (C) light and H_2SO_4, (D) chemical action and piezoelectricity.

22. Static electricity is electricity:
(A) in motion, (B) utilized commonly in industry, (C) at rest, (D) produced by light.

23. Piezoelectricity is electricity produced from:
(A) heat, (B) chemicals, (C) pressure, (D) magnetism.

24. An example of magnetoelectricity is a:
(A) battery, (B) phonograph cartridge, (C) solar cell, (D) generator.

25. A conductor, like copper, is a material that will:
(A) support current flow, (B) act as a dielectric, (C) not allow electrons to flow, (D) have many bound electrons.

26. Which of the following is a semiconductor material?
(A) water, (B) glass, (C) silver, (D) silicon.

27. In an electric circuit, electromotive force is measured in:
(A) amperes, (B) volts, (C) microamperes, (D) coulombs.

28. Electric current flow is considered to be the movement of electrons:
(A) from a negative point to a positive point, (B) in orbit around a nucleus, (C) in a random fashion, (D) from left to right.

29. The basic unit of measurement for electric current is:
(A) the volt, (B) the milliampere, (C) the ampere, (D) the coulomb.

30. Electrical resistance is measured in:
(A) coulombs, (B) amperes, (C) volts, (D) ohms.

31. A voltmeter measures:
(A) power, (B) electricity, (C) static voltage, (D) electromotive force.

32. A DC ammeter is connected:
(A) across the circuit, (B) so electrons flow out of the - terminal, (C) in series with a circuit, (D) in parallel with a circuit.

33. A DC voltmeter is connected:
(A) across or in parallel with the points where the voltage appears, (B) just like an ammeter, (C) so electrons flow out of the - terminal (D) so electrons flow in to + terminal.

34. When connecting an ohmmeter to measure the resistance of a circuit or device:
(A) power should be removed from the circuit, (B) the ohmmeter is connected in combination (series-parallel) with the circuit, (C) power should be applied to the circuit, (D) make sure that only AC current is flowing in the circuit.

35. The letter abbreviation for current is:
(A) E, (B) C, (C) I, (D) A.

36. The letter abbreviation for voltage is:
(A) E, (B) C, (C) I, (D) V.

37. A schematic diagram:
(A) shows the electric connections of the components in a circuit, (B) shows the physical positions of the components in a circuit, (C) is used only when the source voltage is AC, (D) is used only when the source voltage is DC.

38. The total voltage of three 1.5 volt dry cells connected in series is:
(A) 1.5V, (B) 4.0V, (C) 9.0V, (D) 4.5V.

39. The total voltage of three 1.5 volt dry cells connected in parallel is
(A) 1.5V, (B) 4.0V, (C) 9.0V, (D) 4.5V.

40. In a series circuit, the current is __________ throughout the circuit:
(A) the same, (B) different at all points, (C) high, (D) low.

41. Two things that effect the resistance of a given wire are:
(A) length and height, (B) temperature and diameter, (C) kind and color, (D) insulation and gauge.

42. A resistor coded brown, green, red has a value of:
(A) 16,000 ohms, (B) 152 ohms, (C) 1.5k ohms, (D) 250 ohms.

43. Alternating current is used as:
(A) a source of electrical power and as a means of carrying information or intelligence, (B) a source of power only, (C) a means of carrying information only, (D) an AC signal only.

44. When the AC signal produced by a single loop generator is drawn, the pattern or waveform produced is referred to as a:
(A) sawtooth wave, (B) triangular wave, (C) sine wave, (D) square wave.

45. The number of complete AC cycles occuring in one second is called:
(A) an alternation, (B) the sine curve, (C) the frequency, (D) an alternating current.

46. In scientific notation, .0022 ampere equals:
(A) 2.2×10^{-3} amperes, (B) 2.2×10^{3} amperes, (C) 22×10^{-3} amperes, (D) $.22 \times 10^{-1}$ ampere.

47. The number 3.7×10^{4} equals:
(A) 370, (B) 370,000, (C) 37,000, (D) 37.

48. A megohm is equal to:
(A) 1,000 ohms, (B) 1,000,000 ohms, (C) .001 ohms, (D) .000001 ohms.

49. Convert 750mV to volts.
(A) .750V, (B) 750000V, (C) 75.0V, (D) 750V.

50. Convert .0019h to µh.
(A) 1.9µh, (B) .0000019µh, (C) .0000000019µh, (D) 1900µh.

SCORE:

GRADE:

Name: ____________

Date: ____________

WORKSHEET

Period: ____________

VOCABULARY REVIEW

MATCHING

1. Proton	A. Device which produces electricity/by rotating a coil of wire in a magnetic field.	1.	
2. Atom	B. Basic unit of measurement for voltage.	2.	
3. Ion	C. A positively charged particle in the atom.	3.	
4. Battery	D. Instrument used to measure current flow.	4.	
5. Generator	E. An expression such as 5 x 10^3.	5.	
6. Static Electricity	F. An atom that has either gained or lost an electron.	6.	
7. Photoelectricity	G. An electrical unit equivalent to one, one thousandths, or .001.	7.	
8. Semiconductor	H. A material that can act as either a conductor or an insulator.	8.	
9. Volt	I. A device that can step-up or step-down AC voltages.	9.	
10. Ampere	J. The origin or supply of electric energy for a circuit.	10.	
11. Ohm	K. A device which produces electricity through chemical reactions.	11.	
12. Source	L. The basic unit of measurement for resistance.	12.	
13. Load	M. Electric charges produced by friction.	13.	
14. Graphic Symbol		14.	
15. Ammeter		15.	
16. Ohmmeter		16.	
17. Voltmeter		17.	
18. Switch		18.	
19. Resistor		19.	
20. Transformer		20.	
21. Kilo		21.	
22. Scientific Notation		22.	
23. Milli		23.	

Name: ____________________

Date: ____________________

Period: ____________________

24. Micro	N. A device used to control the flow of electrons by opening or closing a circuit.	24.	
25. Pico		25.	

O. A particle which contains a nucleus and electron shells.

P. A symbolic representation (drawing) of a component.

Q. An electrical unit equivalent to one, one millionths, or .000001.

R. The production of electricity caused by light striking certain materials.

S. An instrument utilized to measure resistance.

T. The device or component which a circuit is designed to operate.

U. A device which opposes current flow.

V. The basic unit of measurement for current flow.

W. An electrical unit equivalent to one thousand, or 1000.

X. An instrument used to measure potential difference or electromotive force.

Y. An electrical unit equivalent to one, one trillionths, or .000000000001.

DEFINITIONS

Write out a clear, factual definition for the following terms.

26. Electron:

Name: ____________

Date: ____________

Period: ____________

27. Chemical Electricity:

28. Magnetoelectricity:

29. Conductor:

30. Insulator:

31. Voltage:

32. Current:

Name: ________

Date: ________

Period: ________

33. Resistance:

34. Schematic Diagram:

35. Series Circuit:

36. Parallel Circuit:

37. Short:

38. Open:

39. Direct Current:

40. Alternating Current:

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

REVIEW OF FUNDAMENTAL SKILLS #1

MATCHING

1. Atom
2. Electron
3. Proton
4. Nucleus
5. Valence electrons
6. Ion
7. Compound
8. Element

A. Two or more elements, chemically bound together.
B. Outermost electron shell.
C. Center of the atom.
D. Contains protons, neutrons, and electrons.
E. Basic building block of matter.
F. Negative charged, atomic particle.
G. Atom with an electrical charge.
H. Positively charged atomic particle.

1. [ ]
2. [ ]
3. [ ]
4. [ ]
5. [ ]
6. [ ]
7. [ ]
8. [ ]

9. The small particles which revolve around the nucleus of an atom are called: ____________ 9. [ ]

10. The atom consists of three basic particles. List these and indicate their charge.

10A. [ ] [ ]
10B. [ ] [ ]
10C. [ ] [ ]

11. The nucleus of an atom consist of a certain number of A) ____________ and B) ____________ bound tightly together.

11A. [ ]
11B. [ ]

12. All matter may be grouped into three categories, what are they?

12A. [ ]
12B. [ ]
12C. [ ]

13. If a particular kind of matter cannot be further broken down into any other kind, but retains its unique features in spite of being ever so finely divided, it is called an ____________. 13. [ ]

Name: ______________

Date: ______________

Period: ______________

14. In their "natural" state, atoms have the same number of A) __________ and B) __________. In this state, the atom is said to be C) __________. 14A. 14B. 14C.

15. If a neutral atom loses electrons, it becomes negatively charged. (T-F) 15.

16. An electron that has been removed from an atom and **has not** become a part of another atom is called a __________ electron. 16.

17. Make a sketch of the Boron atom.

$_5B^{11}$

18. Describe (define) electricity.

19. A positively charged particle will attract a __________ charged particle. 19.

20. An electric circuit is a combination of components connected together to form a complete path through which __________ can move. 20.

21. That part of a circuit which converts the energy of moving electrons into some other form of useful energy is called the: __________ 21.

22. An electrical circuit consists of four basic parts, name them. 22A. 22B. 22C. 22D.

Name: ________________

Date: ________________

Period: ________________

23. State the basic law of charges.

24. Draw a schematic of a simple electrical circuit, and label its four basic parts.

MATCHING

25.	Solar Cell	A.	Static Electricity	25.	
26.	Generator	B.	Photoelectricity	26.	
27.	Battery	C.	Piezoelectricity	27.	
28.	Lightning	D.	Chemical Electricity	28.	
29.	Thermocouple	E.	Thermoelectricity	29.	
30.	Piezo Crystal	F.	Magnetoelectricity	30.	

----

31. A generator is an example of magnetoelectricity. What things are needed to generate electricity? A) ________, B) ________, C) ________. 31A. 31B. 31C.

32. What things are needed to make a battery? A) ________, B) ________ 32A. 32B.

33. Why is the battery an important source of power? A) ________, B) ________. 33A. 33B.

34. Static electricity is produced by ________. 34.

35. The output of a generator is affected by: A) ________, B) ________, C) ________. 35A. 35B. 35C.

Name: ______________

Date: ______________

Period: ______________

36. Draw a schematic for four 2V cells connected in series. What is the total output voltage?

Total Voltage ______________

37. Draw a schematic for two 12V batteries connected in parallel. What is the total output voltage?

Total Voltage ______________

38. The wire used to interconnect components in an electric circuit provides an easy path for current flow. (T-F) 38. [ ]

39. Air is a good insulator. (T-F) 39. [ ]

40. Stranded wire has the advantage of being very flexible. (T-F) 40. [ ]

41. All insulating materials will break down and conduct current if a high enough voltage is applied across them. (T-F) 41. [ ]

42. A semiconductor has four electrons in its valence band. (T-F) 42. [ ]

43. Electrons move through a conductor at the speed of light. (T-F) 43. [ ]

44. Conductors contain many __________ electrons. 44. [ ]

45. Name two semiconductor materials. 45A. [ ]

45B. [ ]

46. The best conductor is __________. 46. [ ]

47. A materials ability to act as an insulator is measured in terms of its __________ strength. 47. [ ]

Name: ____________

Date: ____________

Period: ____________

48. A conductor is a material that will:

49. What is an insulator?

50. Name a few insulators.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

REVIEW OF FUNDAMENTAL SKILLS #2

MATCHING

1.	Electrical Pressure	A.	Voltage	1.	
2.	I	B.	V	2.	
3.	Orderly Flow of Electrons	C.	Resistance	3.	
		D.	Ω		
4.	E	E.	Current	4.	
5.	Opposition to Current Flow	F.	I	5.	
6.	R	G.	A	6.	
7.	Volt			7.	
8.	Ohm			8.	
9.	Ampere			9.	
10.	Electromotive Force			10.	

----

11. Electric current flows from the A) __________ of the source to the B) __________. 11A. 11B.

12. The basic unit of resistance is the __________. 12.

13. The force, or pressure, that causes electrons to flow in a circuit is called __________. 13.

14. What is the basic unit of measure for voltage? 14.

15. Current strength or magnitude is measured in the basic unit of __________. 15.

16. The shop meter is able to measure what electrical quantities?

Name: ____________________

Date: ____________________

Period: ____________________

17. Draw a sketch showing how a meter should be connected into a circuit to measure voltage.

18. Explain how to zero a meter for measuring voltage.

19. Explain how to zero a meter for measuring resistance.

20. Give the schematic symbol for the following components.

A. Fixed Resistor — 20A.

B. Fixed Capacitor — 20B.

C. Inductor (air core) — 20C.

D. Transformer (iron core) — 20D.

E. Variable Resistor — 20E.

F. PNP Transistor — 20F.

G. Semiconductor Diode — 20G.

Name: ______________

Date: ______________

Period: ______________

H. Electrolytic Capacitor 20H. [ ]

I. Lamp 20I. [ ]

21. Give the letter symbol for the following electrical terms:

A. Direct Current __________ 21A. [ ]

B. Alternating Current __________ 21B. [ ]

C. Volt __________ 21C. [ ]

D. Voltage __________ 21D. [ ]

E. Resistance __________ 21E. [ ]

F. Current __________ 21F. [ ]

G. Ampere __________ 21G. [ ]

H. Lamp __________ 21H. [ ]

I. Capacitor __________ 21I. [ ]

J. Resistor __________ 21J. [ ]

K. Farad __________ 21K. [ ]

L. Ohm __________ 21L. [ ]

M. Inductor __________ 21M. [ ]

N. Transformer __________ 21N. [ ]

22. Draw the symbols for A) a single cell and B) a battery. Label the polarity of each.

A) [ ] B) [ ]

23. Draw the schematic diagram for a series circuit consisting of a source, a control, and three load devices.

[ ]

Name: ______________

Date: ______________

Period: ______________

24. A switch is seldom connected in series with a circuit. (T-F) 24. [ ]

25. A series circuit provides only one path through which current can flow. (T-F) 25. [ ]

26. When a series circuit is opened at any point the entire circuit is de-energized. (T-F) 26. [ ]

27. A parallel circuit provides one common path for current flow. (T-F) 27. [ ]

28. When one of the loads in a parallel circuit is removed, all the remaining loads stop operating. (T-F) 28. [ ]

29. Devices connected in parallel must be designed to operate at the same voltage. (T-F) 29. [ ]

30. Voltaic cells are often connected together in series to obtain a higher total voltage than is possible from a single cell. (T-F) 30. [ ]

31. Cells (or batteries) are connected in parallel to obtain more current than is available from a single unit. (T-F) 31. [ ]

32. When similar batteries are connected in parallel, the total voltage of the circuit is equal to the voltage of a single battery. (T-F) 32. [ ]

33. A source of energy must be able to supply the A) __________ and B) __________ required by its circuits load. 33A. [ ] 33B. [ ]

34. The same amount of __________ is present at all points in a series circuit. 34. [ ]

35. The same __________ is present across all of the loads in a parallel circuit. 35. [ ]

36. The different current paths of a parallel circuit are called __________. 36. [ ]

37. When cells are connected in series, the total voltage is equal to the __________ of the individual cell voltages. 37. [ ]

Name: ____________

Date: ____________

Period: ____________

38. Explain what is meant by the expression "abnormal circuit."

39. Draw a circuit consisting of 3 resistors connected in series.

40. Draw a circuit containing 4 pilot lamps connected in parallel.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

REVIEW OF FUNDAMENTAL SKILLS #3

1. Resistors are commonly used to limit current. (T-F) 1. [ ]

2. The resistance of common wire increases as its length decreases. (T-F) 2. [ ]

3. In general, as the temperature of a metal increases, its resistance increases. (T-F) 3. [ ]

4. A wire with a large cross-sectional area has less resistance than a smaller diameter wire of the same length. (T-F) 4. [ ]

5. In a heating circuit, resistance is necessary to change electric energy into heat energy. 5. [ ]

6. Carbon-composition resistors generally have a maximum power rating of 1/2 watt. (T-F) 6. [ ]

7. The tolerance of a resistor indicates the amount by which the actual resistance may vary from its labeled value. (T-F) 7. [ ]

8. A resistor can become defective as a result of excessive current. (T-F) 8. [ ]

9. Composition resistors are read by decoding color dots painted on the body of the resistor. (T-F) 9. [ ]

10. Wirewound resistors have their resistance value and tolerance printed on the body of the resistor. (T-F) 10. [ ]

11. __________ is a property of all materials which limits the flow of current. 11. [ ]

12. Conductors have a A) __________ resistance, while insulators have a B) __________ resistance. 12A. [ ] 12B. [ ]

13. The basic unit of resistance is the __________. 13. [ ]

14. The resistance of a resistor can be measured with an instrument called an __________. 14. [ ]

Name: ______________

Date: ______________

Period: ______________

15. What four things affect or determine the resistance of a wire?

16. What two effects can a resistor cause in an electric circuit?

17. Name three types of fixed resistors.

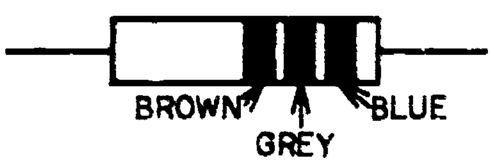
18. What is the color coded value of the resistors below?

18A.

18B.

A.

B.



Indicate the ohm value of the following color coded resistors.

19. Red-Violet-Brown-Silver — 19.

20. Brown-Green-Black — 20.

21. White-Brown-Brown-Gold — 21.

22. Yellow-Violet-Red-Silver — 22.

23. Green-Blue-Orange — 23.

Name: ______________

Date: ______________

Period: ______________

24. Brown-Gray-Yellow-Silver 24. [ ]

25. Brown-Black-Green-Gold 25. [ ]

Determine the color code for the following resistor values.

	VALUE	BAND A	BAND B	BAND C	BAND D
26.	120Ω ± 20%				
27.	3900Ω ± 10%				
28.	47000Ω ± 20%				
29.	68Ω ± 5%				
30.	1800Ω ± 10%				
31.	56kΩ ± 20%				

32. Between what two values (maximum and minimum) should the actual resistance of the resistor shown below be? 32. [ ] to [ ]

33. Define direct current:

34. Define alternating current:

35. List three distinct advantages of alternating current versus direct current.

Name: ____________

Date: ____________

Period: ____________

36. Draw a sine wave and label the two maximum points and three minimum points.

37. Define the term frequency.

38. In the United States, the frequency of AC power supplied to the home is __________. 38. [ ]

39. The voltage at the wall receptacles in most homes is __________ volts AC. 39. [ ]

40. There are two __________ in an AC cycle. 40. [ ]

41. Audio frequencies range from A)__________ hertz to B)__________ hertz. 41A. [ ] 41B. [ ]

42. The standard radio broadcast band (AM) uses which band of frequencies? 42. [ ] to [ ]

43. An inverter is used to change A) __________ to B) __________. 43A. [ ] 43B. [ ]

44. What is the name of the electronic device used to generate a high-frequency AC voltage using transistors, coils, capacitors, resistors and a DC power supply? 44. [ ]

45. Convert the following numbers to scientific notation expressions.

A. 2000 __________ 45A. [ ]

B. 4500000000 __________ 45B. [ ]

Name: ____________

Date: ____________

Period: ____________

C. .00034 ________ 45C. [ ]

D. 7.25 ________ 45D. [ ]

46. Convert the following scientific notation expressions to real numbers.

A. 7×10^3 46A. [ ]

B. 1.45×10^2 46B. [ ]

C. 16×10^{-3} 46C. [ ]

D. 3.4×10^{-2} 46D. [ ]

47. Convert the following:

A. .004A to mA ________ 47A. [ ]

B. 25000V to kV ________ 47B. [ ]

C. 2000000W to MW ________ 47C. [ ]

D. .000009A to μA ________ 47D. [ ]

E. .000000005S to nS ________ 47E. [ ]

F. .000000000076F to pF ________ 47F. [ ]

48. List the five common electrical units, and their power of ten equivalent.

EXAMPLE: NANO – 10^{-9}

A. ________ – ____

B. ________ – ____

C. ________ – ____

D. ________ – ____

E. ________ – ____

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 3"

Utilize the component puppets provided on page three to construct the circuits described below. You will cut out and arrange the puppets to form series, parallel, and combination circuits. You must draw in interconnecting lines to represent conductors. Be sure that each problem fulfills the four requirements for a complete electric circuit --i.e. supply, control, load, and conductor.

1. Construct a low voltage DC series circuit consisting of two different load devices and a circuit protection element. Each device should operate simultaneously when the switch is closed.

2. Design a parallel AC circuit consisting of three branches, each branch will contain a different load device. The circuit should be protected against excessive <u>total</u> current, and each load shall be individually controlled.

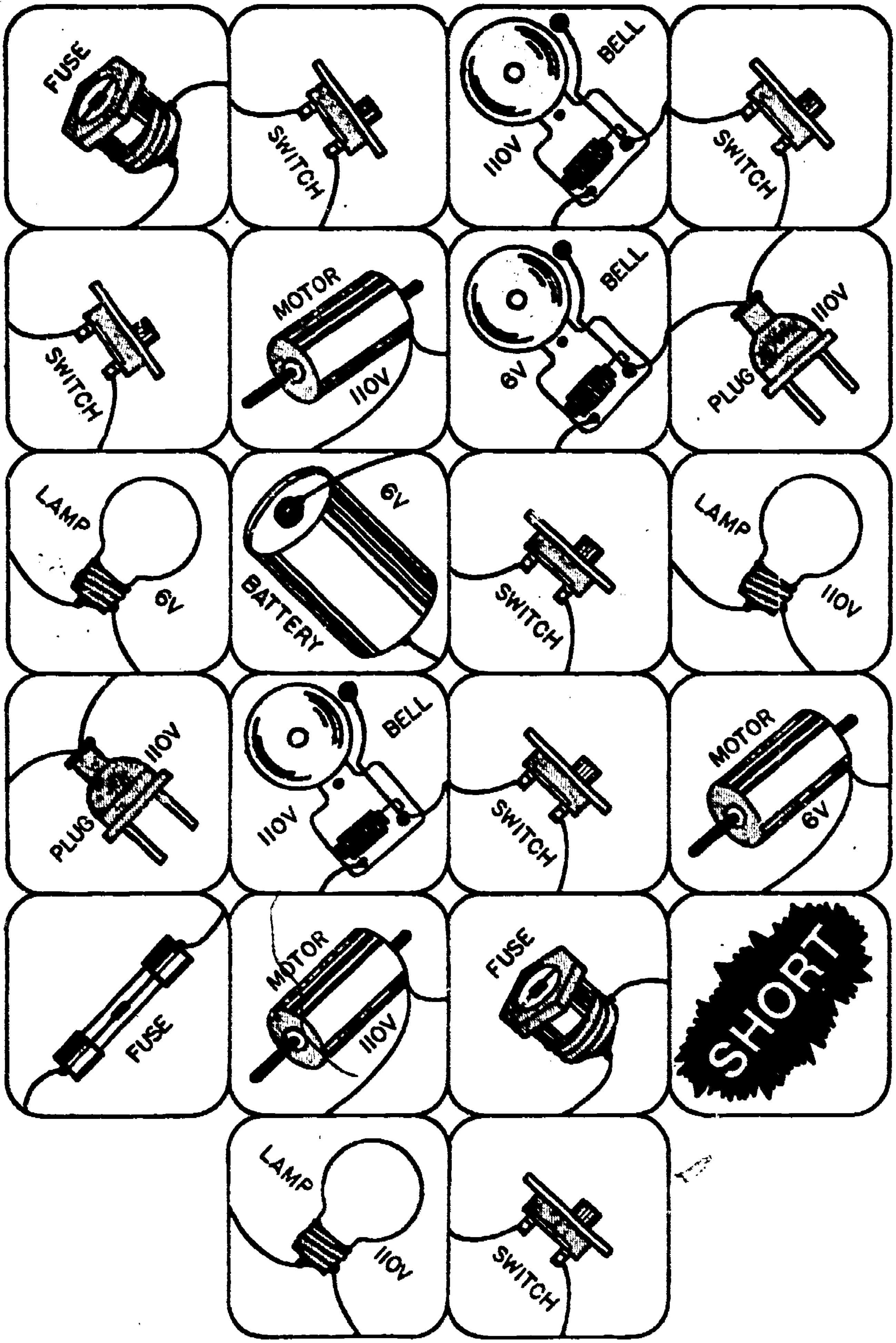
Name: ______________

Date: ______________

Period: ______________

3. Assemble a combination circuit consisting of one series load, and two parallel loads. The circuit will be protected against excessive AC current, and will require that two switches be wired into the circuit. One switch will properly energize the circuit, while closing the second switch will cause an abnormal circuit condition or short. Mark the short condition with the appropriate puppet.

PUPPET COMPONENTS



SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

ANSWER SHEET

EXAM LIII U3

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.		■			26.				■	51.					76.				
2.	■				27.		■			52.					77.				
3.	■				28.	■				53.					78.				
4.	■				29.			■		54.					79.				
5.		■			30.				■	55.					80.				
6.		■			31.				■	56.					81.				
7.		■			32.			■		57.					82.				
8.		■			33.	■				58.					83.				
9.		■			34.	■				59.					84.				
10.	■				35.			■		60.					85.				
11.	■				36.	■				61.					86.				
12.	■				37.	■				62.					87.				
13.	■				38.				■	63.					88.				
14.		■			39.	■				64.					89.				
15.		■			40.	■				65.					90.				
16.			■		41.		■			66.					91.				
17.				■	42.			■		67.					92.				
18.		■			43.	■				68.					93.				
19.			■		44.			■		69.					94.				
20.	■				45.			■		70.					95.				
21.				■	46.	■				71.					96.				
22.			■		47.			■		72.					97.				
23.			■		48.		■			73.					98.				
24.				■	49.	■				74.					99.				
25.	■				50.				■	75.					100.				

*Show work for problems on back of answer sheet.

LIII-U3-32

ANSWER KEY
UNIT 3

A. VOCABULARY REVIEW

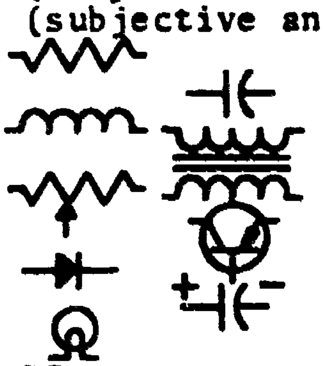
1. C
2. O
3. F
4. K
5. A
6. M
7. R
8. H
9. B
10. V
11. L
12. J
13. T
14. P
15. D
16. S
17. X
18. N
19. U
20. I
21. W
22. E
23. G
24. Q
25. Y
26. - 40. (subjective answers)

B. REVIEW OF FUNDAMENTAL SKILLS #1

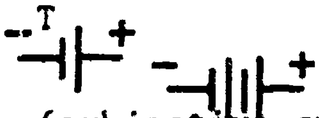
1. D
2. F
3. H
4. C
5. B
6. G
7. A
8. E
9. electrons
10A. protons +
10B. electrons -
10C. neutrons +-
11A. protons
11B. neutrons
12A. solids
12B. liquids
12C. gases
13. element
14A. protons
14B. electrons
14C. balanced (neutral)
15. False
16. free
17. (subjective answer)
18. (subjective answer)
19. negatively
20. electrons
21. load
22A. source
22B. conductor
22C. load
22D. control
23. (subjective answer)
24. (subjective answer)
25. B
26. F
27. D
28. A
29. E
30. C
31A. magnetic field
31B. conductor
31C. motion
32A. two dissimilar metals
32B. electrolyte
33A. portable
33B. self contained
34. friction
35A. strencth of field
35B. number of turns
35C. speed of rotation
36. 8 volts
37. 12 volts
38. True
39. True
40. True
41. True
42. True
43. True
44. free
45A. silicon
45B. germanium
46. silver
47. dielectric
48. allow electron movement
49. block electron movement
50. rubber
plastic
glass

C. REVIEW OF FUNDAMENTAL SKILLS #2

1. A
2. E
3. E
4. A
5. C
6. C
7. B
8. D
9. G
10. A
11A. negative
11B. positive
12. ohm
13. voltage
14. volt
15. ampere
16. (subjective answer)
17. (subjective answer)
18. (subjective answer)
19. (subjective answer)
20A.
20B.
20C.
20D.
20E.
20F.
20G.
20H.
20I.



21A. DC
21B. AC
21C. V
21D. E
21E. R
21F. I
21G. A
21H. LP
21I. C
21J. R
21K. F
21L. Ω
21M. L
21N. T
22A.
22B.



23. (subjective answer)
24. False
25. True
26. True
27. False
28. False
29. True
30. True
31. True
32. True
33A. voltage
33B. current
34. current
35. voltage
36. branches
37. sum
38. (subjective answer)
39. (subjective answer)
40. (subjective answer)

D. REVIEW OF FUNDAMENTAL SKILLS #3

1. True
2. False
3. True
4. True
5. True
6. False
7. True
8. True
9. False
10. True
11. resistance
12A. low
12B. high
13. ohm
14. ohmmeter
15. length
cross section
material
temperature
16. limit current
drop voltage
17. carbon composition
film
wire wound
18A. 27000 ohms
18B. 18000000 ohms
19. 270 ohms 10%
20. 15 ohms 20%
21. 910 ohms 5%
22. 4700 ohms 10%
23. 56000 ohms 20%
24. 180000 ohms 10%
25. 1,000,000 ohms 5%
26. brown, red, brown
27. orange, white, red, silver

ANSWER KEY UNIT 3
(continued)

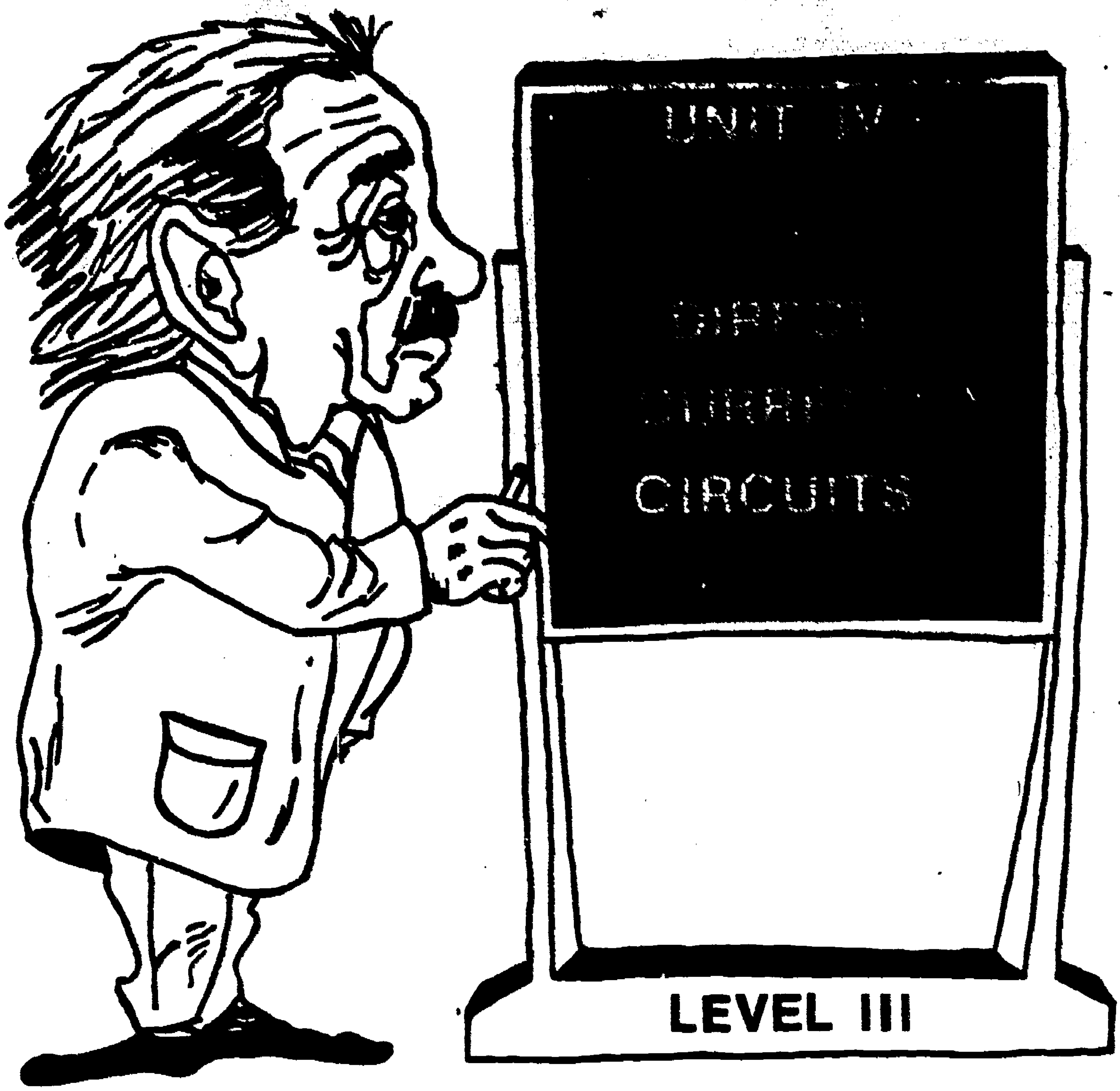
28. yellow, violet, orange
29. blue, grey, black, gold
30. brown, grey, red, silver
31. green, blue orange,
32. 3630 to 2970 ohms
33. (subjective answer)
34. (subjective answer)
35. (subjective answer)
36. (subjective answer)
37. (subjective answer)
38. 60 Hz
39. 120 volts
40. alternations
41A. 20 Hz
41B. 20,000 Hz
42. 535kc-1605kc
43A. DC
43B. AC
44. oscillator
45A. 2×10^{3}
45B. 4.5×10^{9}
45C. 3.4×10^{-4}
45D. $7.25 \times 10^{[illegible]}$
46A. 7000
46B. 145
46C. .016
46D. .034
47A. 4 mA
47B. 25 kV
47C. 2 mW
47D. 9 micro Amps
47E. 5 nano Sec.
48A. mega-10^{6}
48B. kilo-10^{3}
48C. milli-10^{-3}
48D. micro-10^{-6}
48E. pico-10^{-12}

E. QUEST ACTIVITY

(subjective evaluation)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________

DATE STARTED________________

DATE COMPLETED________________

BY
R. E. LILLO
N. S. SOFFIOTTO

STATE ELECTRICITY/ELECTRONICS CURRICULUM GUIDE
INSTRUCTOR'S GUIDE TO ACCOMPANY LEVEL III UNIT # 4

Title of Unit: Direct Current Circuits

Time Allocation: 4 weeks

Unit Goal:

To impart fundamental competencies related to basic circuit construction, meter usage, and OHM'S Law problem solving techniques.

Unit Objectives:

The student will be able to:

1. describe safety precautions to be observed to prevent electrical shock when wiring and testing circuits and equipment.

2. differentiate and identify the basic circuit parts of an electrical circuit.

3. demonstrate the ability to connect components either in a series or parallel configuration.

4. compare and contrast the proper operation and application of meters used in measuring voltage, current, and resistance.

5. demonstrate how the ammeter, voltmeter, and ohmmeter should be connected to a circuit under test.

6. state Ohm's Law and utilize it to solve for voltage, current or resistance when two of the values have been identified.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Electricity One-seven. Harry Mileaf, Hayden Book Company, Inc., 1976. Chapters: Electricity Two and Electricity Five.

Elements of Electronics. Henry V. Hickey and William M. Villines, McGraw-Hill Book Co., 1970. Chapters: 3,5,8,9,12, and 13.

Understanding Electricity and Electronics. Peter Buban and Marshall L. Schmitt, McGraw-Hill Book Co., 1975. Units: 2,9,10, and 11.

Overview:

In this first technical unit of Level III, several basic competencies are presented as a foundation for succeeding units throughout the level. In depth technical topic coverage which may not be presented in this unit are dedicated for presentation at a more appropriate time conceptionally.

The unit should be introduced by a careful analysis of D.C. Circuit Elements with teacher emphasis on simple circuit operation and basic component function, however, troubleshooting techniques utilizing logical test procedures can be easily adapted as the concluding portion of this topic section.

The next topic dealing with laboratory measuring instruments was introduced at this point to accompany a thorough presentation of the relationship of voltage, current, and resistance in electrical circuits. It will also facilitate a more meaningful grasp of the principle of OHM'S Law.

This unit concludes with an emphasis on OHM'S Law which is fundamental to the student's understanding of the entire field of electronics. A variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. Be mindful when explaining circuit operation and terminology that very often first exposure to technical expressions can be misunderstood for example "current flow", "potential difference", and "voltage". Spend a significant amount of time with these kinds of terms in order to facilitate your students basic comprehension.
2. A more meaningful way to present basic circuit analysis is by showing students what electrical parts of components comprise a system, when they are wired together to perform a desired result or function. This system can consist of a simple or complex circuit which has at its foundation a source, control, conductor and load.
3. Meters and measurement are vital instructional concepts especially for future laboratory work so it is worthwhile to re-emphasize major instructional points periodically, illustrate (dry lab. techniques) methods of meter connections, utilize managers or advance students to assist in supervision and instruction, and coordinate measurement activities so that electrical quantities are not measured in succession - E, I, and R. Careful presentation of this topic will enable both instructor/student an opportunity to maintain a positive laboratory attitude. Caution - since time allocation is always so critical in the classroom, focus

Methodology continued:

your attention on meters common to your laboratory.

4. After the class has mastered basic principles, accompanied by appropriate laboratory meter exercises, it is a perfect opportunity to learn the relationship between electrical quantities as expressed in OHM'S Law. Impress on the students the idea of basic units for each quantity and ease into formulas by using simple numbers. A successful program of constant formula repetition and problem solving will pay off for both student and instructor.

Supplemental Activities and Demonstrations:

1. Class physically examines a box containing basic parts such as switches, wires, lamps, cells, batteries, bells etc., and categories their functions on the blackboard in terms of circuit use; source, control, conductor, or load.
2. Instructor assembles several simple circuits to dramatize circuit operation, and by utilizing duplicate load devices can easily manipulate configuration into a series, parallel, or combination circuit. Circuit failures can be introduced along with troubleshooting and repair techniques.
3. An overhead projector can be adapted as an inexpensive demonstration device. A unique way in assisting student familiarity with their laboratory meter is simply to dismantle one meter panel, xerox it, burn a transparency, and use a string to simulate needle operation.
4. Game simulation strategy - students simulate various types of meters, plug themselves into chalkboard circuits, describe polarity considerations, and verbally indicate meter reading.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Spelling Puzzle
5. Worksheet (vocabulary) - Know Your Definitions
6. Worksheet - D.C. Circuit Elements
7. Worksheet - Electrical Instruments and Measurements
8. Worksheet - OHM'S Law
9. Quest Activities
10. Informational Handouts (Meters and Ohm's Law)
11. Unit Module Answer Keys

IV. Direct Current Circuits

A. D.C. Circuit Elements

1. Definition of an Electrical Circuit

2. Basic Circuit-Source, Control, Conductor and Load

3. Identify E, I, and R in a D.C. Circuit

4. Types of Circuits-Series, Parallel and Combination

5. Common Circuit Failures

B. Electrical Instruments and Measurements

1. Meters as an Indicating Device

2. Meter Care and Accuracy

3. Reading the Meter

4. Types of Meters

5. Operational Procedures and Applications

C. OHM's Law

D. Conductance

UNIT EXAM

DIRECT CURRENT CIRCUITS

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. The letter symbol for voltage is I. (T-F)

2. Electromotive force and voltage mean the same thing. (T-F)

3. Electrons move through a circuit from the negative terminal to the positive terminal of the source. (T-F)

4. A switch is never connected in series with a circuit. (T-F)

5. The load supplies the voltage necessary for circuit operation. (T-F)

6. A series circuit provides only one path through which the current can flow. (T-F)

7. If the current path through one of a group of parallel units is interrupted, all others will continue to function. (T-F)

8. Parallel connections are sometimes called branch connections or shunt connections. (T-F)

9. Troubleshooting an electronic circuit usually begins with a visual inspection of all circuitry. (T-F)

10. A continuity test is made to indicate whether or not a conducting path exists between two points of a circuit or a device. (T-F)

11. A typical ammeter is connected in series with a circuit or that part of a circuit under test. (T-F)

12. The symbol ∞, which appears on some ohmmeter scales, means infancy. (T-F)

13. Ohm's law expresses the relationship between the voltage, current, and power in a circuit. (T-F)

14. When the voltage applied to a circuit having a constant resistance is increased, it will cause the current in the circuit to decrease. (T-F)

15. According to Ohm's law, the value of current in a circuit is directly proportional to the applied voltage. (T-F)

16. Conductance is a measurement to indicate the ease of current flow in a circuit. (T-F)

17. An ohmmeter has a linear scale. (T-F)

18. When connecting an ammeter into a circuit to measure current the circuit must be broken, the meter placed in series, and polarity observed. (T-F)

19. A combination circuit is made up of two or more series circuits. (T-F)

20. Zeroing a meter is necessary to achieve accurate measurements. (T-F)

21. A schematic diagram
(A) shows the electric connections of the components in a circuit. (B) shows the physical positions of the components in a circuit. (C) is used only when the source voltage is ac. (D) is used only when the source voltage is dc.

22. The base unit of measurement of electric CURRENT is (A) the volt. (B) the milliampere. (C) the ampere. (D) the coulomb.

23. All complete electric systems must have (A) just a switch and a dc source. (B) an ac source and a load. (C) an ac or dc source, a load, conductor, and a control. (D) just a load and a complete path for current.

24. Electric current is the movement of electrons (A) from a negative point to a positive point. (B) in orbit around a nucleus. (C) in a random fashion. (D) from left to right.

25. In electric circuits, the Potential Difference is measured in (A) amperes. (B) volts. (C) microamperes. (D) coulombs.

26. In an electric circuit, when the voltage and resistance are known, which form of the Ohm's Law equation is used to find the current? (A) $E = IR$ (B) $R = \frac{E}{I}$ (C) $I = \frac{E}{R}$ (D) $R = IR$

27. Resistance and current are (A) measured in the same units. (B) directly proportional. (C) inversely proportional. (D) always smaller than the voltage.

28. Voltage and current are (A) measured in the same units. (B) inversely proportional. (C) directly proportional. (D) always larger than the resistance.

29. When using any form of Ohm's Law, how many values must be known? (A) Three. (B) None. (C) One. (D) Two

30. In an electric circuit, if the current is 20 amperes and the source voltage is 400 volts, the circuit resistance is (A) 8000 ohms. (B) 20 ohms. (C) 420 ohms. (D) 380 ohms.

31. In an electric circuit, if the current is 25 milliamperes (.025 ampere) and the resistance is 5000 ohms, the source voltage is (A) 125 volts. (B) 200 volts. (C) 1250 volts. (D) 5 volts.

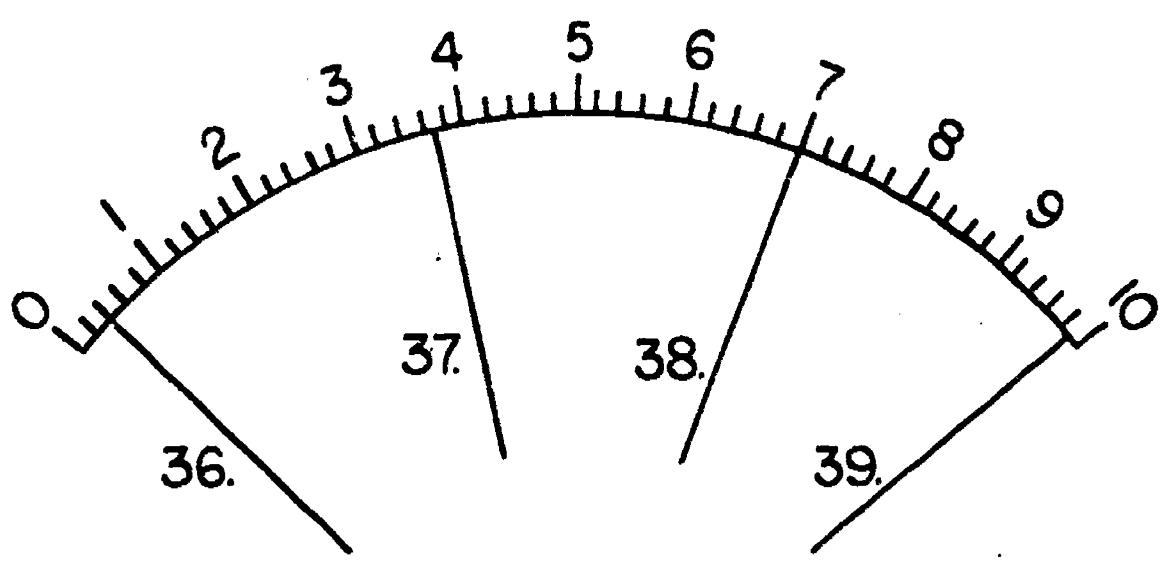
32. Direct current (A) flows from positive to negative in each circuit. (B) flows in alternate directions in each circuit. (C) has a different unit of measure than alternating current. (D) flows in one direction in a particular circuit.

33. Which of the following is not another name for the force which we call voltage? (A) electromotive force (B) potential difference (C) EMF (D) current

34. The term "short circuit" means most nearly a : (A) connection between two points where ordinarily no connection is intended (B) length of wire that has been cut to short (C) load connected to a circuit for only short intervals (D) light load connected to a circuit

35. The term "spst" means (A) single part slowly thrown (B) slowly placed single terminal (C) slow-pole slow-pole (D) single-pole single-throw

For questions 36 to 39 refer to the meter scale below.



36. What value is indicated by the pointer? Assume the meter is being used as a voltmeter. (A) 2V (B) .2V (C) 4V (D) .4V

37. What value is indicated by the pointer? Assume the meter is being used as an ammeter. (A) 3.65A (B) 3.7A (C) 3.35A (D) 37A

38. What value is indicated by the pointer? Assume the meter is being used as an ammeter. (A) 7A (B) 7V (C) .7V (D) .7A

39. What value is indicated by the pointer? Assume the meter is being used as a voltmeter. (A) 9.45V (B) 9.85V (C) 9.9V (D) 10.5V

Solve the following problems using Ohm's Law.

40. Find "E" when I = 4A, and R = 100Ω. (A) 25V (B) 400V (C) .004V (D) 250V

41. Find "R" when E = 20V, and I = 2A. (A) 40Ω (B) .1Ω (C) 100Ω (D) 10Ω

42. Find "I" when E = 6V, and R = 30Ω. (A) 180A (B) 5A (C) 2A (D) .2A

43. Find "E" when I = .05A, and R = 560Ω. (A) 2800V (B) 28V (C) 28A (D) 2800A

44. Find "I" when R = 1200Ω and E = 18V. (A) 21600A (B) 66 2/3A (C) .015A (D) 1.5A

45. Find R when E = 26V and I = .4A. (A) 65Ω (B) 6.5Ω (C) 104Ω (D) 10.4Ω

Name: ____________

Date: ____________

Period: ____________

TECHNICAL GLOSSARY

AMMETER:	An instrument designed to measure current flow. —A—
AMPERE:	The basic unit of measurement for current flow. Symbol: A
BASIC UNITS:	The fundamental values of a formula or equation. For OHM'S Law the basic units are: Volts, Amperes, and Ohms. If any of these terms are in any other form (kV-Kilovolt, mA-Milliampere, μA-Microampere, etc.) they must be converted to the basic unit in order to obtain correct and meaningful answers.
CALIBRATION:	The process of comparing and/or adjusting a measuring device to a known standard.
CIRCUIT:	A complete electrical system which provides the electron path between the source and load.
CLOSED CIRCUIT:	A circuit which has a complete path from the negative of the source through the circuit, and back to the positive of the source.
COMBINATION CIRCUITS:	A circuit consisting of one or more series and parallel paths.
COMPONENT:	An electrical or electronics part such as a switch, resistor, lamp, etc. used in a circuit.
COMMON:	A point in a circuit where a number of connections are made. In some circuits the earth or metal chassis in an electronic system is also used for a common connection. Symbol: ⏚ or ▽
CONDUCTANCE:	The ability of a circuit or component to conduct electricity. Its unit of measurement is the mho. Symbol: G
CONDUCTOR:	Any material through which electric current can easily flow, such as a copper wire.
CURRENT:	The flow of electrons through a circuit. Current is measured in the basic unit Amperes, however, Milliamperes and Microamperes are also used as units of measurement. Symbol: I
D'ARSONVAL MOVEMENT:	A moving coil movement found in meters in which the coil is deflected in a stationary magnetic field in an amount proportional to the current through it.

Name: ______________

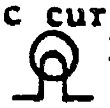
DEFLECTION: The movement of the meter pointer from the zero position.

DIRECT CURRENT: An electric current which flows in one direction through a circuit - from negative to positive. Symbol: DC

ELECTROMOTIVE FORCE: The pressure that causes electrons to move through a circuit and frequently referred to as voltage. Symbol: E Abbreviation: EMF

FULL SCALE: The maximum deflection of the meter pointer. The maximum value a meter can indicate on a given scale.

FUNCTION SWITCH: A meter control used to select the electrical quantity (voltage, current, or resistance) to be measured.

INCANDESCENT LAMP: An electrical lamp which emits light when an electric current flows through its filament. Symbol:  Letter symbol: LP

INFINITY: An extremely large value that continues indefinitely. Symbol: ∞

JACK: A receptacle that receives a plug and provides an electrical contact which may be easily connected and disconnected. Symbol  Letter symbol: J

KILO: A prefix meaning 1,000 (thousand). Abbreviated k. Example: 15k means 15,000.

LEADS: A connecting wire used to attach one device to another, such as power supply leads, test leads, etc. Many times special lead sets are required for proper equipment operation.

LINEAR SCALE: A meter scale whose divisions or increments have an equal value between the minimum and maximum marks.

LOAD: The device that is operated by the circuit. Load also refers to the amount of current drawn by a circuit.

MECHANICAL ZERO: An adjustment to the meter movement which mechanically sets the meter pointer on zero. This adjustment is necessary for accurate measurement.

MEGA: A prefix meaning 1,000,000 (million). Abbreviated M. Example 5M means 5,000,000.

METER: A device to measure electrical quantities; such as voltage, resistance, frequency, etc. Symbol: 

Letter symbol: M.

Name: ____________________

MHO: The basic unit for measurement of conductance. The siemens has been adopted as a replacement for this unit. Symbol: ℧ or Siemen S.

MICRO: A prefix meaning .000001 (millionths). Abbreviated μ. Example: 6μ means .000006.

MILLI: A prefix meaning .001 (thousandths). Abbreviated m. Example: 3m means .003.

MULTIMETER: A meter designed to measure more than one electrical quantity. Most multimeters can measure AC and DC voltage, AC and DC current, and resistance.

MULTIPLIER: A control on an instrument which determines the maximum range of values that can be measured or generated. This control is sometimes referred to as the range switch.

NEEDLE: The indicating device on a meter, sometimes called the pointer. The needle and scale are used in conjunction to read the indicated value.

NONLINEAR: A meter scale whose divisions or increments vary in value as you move from the minimum to maximum marks. The ohm's scale is usually nonlinear.

OHM: The basic unit of measurement for resistance. Symbol: Ω

OHMMETER: An instrument used to measure electrical resistance in OHMS. Symbol: Ω

OHM'S LAW: A law that expresses the relationship between voltage, current, and resistance. It states that the voltage (in volts) is equal to the current (in amperes) multiplied by the resistance (in ohms). Mathematically this is expressed, $E = I \times R$.

OPEN CIRCUIT: A circuit with an incomplete path, making current flow impossible.

PARALLAX: The error introduced in meter reading as the result of not viewing the meter from directly in front.

PARALLEL CIRCUIT: A circuit which provides two or more paths for current flow, sometimes referred to as a shunt or branch circuit.

PICO: A prefix meaning .000000000001 (millionths of a millionth). Abbreviated p. Example: 4p means .000000000004.

Name: ______________

PLUG: The mating connector for a jack, which together, provides an electrical contact which may be easily connected and disconnected. Symbol: 
Letter symbol: P

POLARITY: The property of a device or circuit determining the direction in which current flows. The quality of having two opposite charges, one positive (+) and the other negative (-). Polarity can also refer to the quality of having two opposite magnetic poles, one north and one south.

POTENTIAL DIFFERENCE: See Electromotive Force.

POWER SUPPLY: An electronic circuit designed to provide various DC and/or AC voltages.

RESISTANCE: A measure of the opposition that a component or circuit offers to the flow of an electric current. Resistance is measured in the basic unit Ohms, however Kilohm, and Megohms are also used as units of measurement. Symbol: R

RESISTOR: A component used to offer a specific resistance or opposition to current. Symbol:  Letter symbol: R

SCALE: Line or arc found on an instrument face with graduations or increments that have an assigned value.

SCHEMATIC DIAGRAM: A circuit drawing using symbols to represent the components or parts.

SENSITIVITY (METER): The loading effect upon a meter measured in Ohms per volt. It is equal to the reciprocal of the current flowing through the meter movement for a full-scale deflection.

SERIES CIRCUIT: A circuit which allows only one path for current flow. Series circuit components are connected in a line, one after the other.

SHORT CIRCUIT: A low resistance path between two points of a circuit (power supply terminals, line, etc.) usually accidental, which causes excessively high current flow and possible circuit damage.

SHUNT (AMMETER): A precision low-value resistance placed across the terminals of an ammeter to increase its range.

Name: ______________

SOURCE: The part of an electrical system which provides the energy (voltage and current) for circuit operation.

SWITCH: A control device used to open or close a circuit. Symbol: (single pole single throw) Letter symbol: S

SYMBOL: A representation of an electrical device or quantity.

TERMINAL: A place or point of electrical connections.

TEST PROBE: A pointed metal end of a lead, to contact specific points in a circuit to be tested or measured.

VOLT: The basic unit of measure of electromotive force or voltage. Symbol: V

VOLTAGE: Another term for difference of potential or electromotive . Symbol: E

VOLTAGE DROP: The voltage across a component that results when a current flows through it. The voltage drop across a resistor in a circuit is equal to the current times the resistance (I x R), and also may referred to as the IR drop.

VOLTMETER: An instrument used for measuring voltage or electromotive force. Symbol: V

VOM: Volt-Ohm-Milliammeter is a test instrument that can measure voltage, current, and resistance.

ZERO ADJUST: An adjustment on the meter to electrically balance the needle on zero.

SCORE:
GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

VOCABULARY - SPELLING PUZZLE

Copy the correctly spelled word in the box at the right. As indicated in the example below.

A.	(ampmeter)	(ammeter)	(ameter)	A.	ammeter
1.	(simbole)	(symbal)	(symbol)	1.	
2.	(voltmeater)	(voltmeter)	(voltsmeter)	2.	
3.	(shunt)	(schunt)	(shuant)	3.	
4.	(defection)	(deflextion)	(deflection)	4.	
5.	(conductor)	(cunductor)	(conducter)	5.	
6.	(parallel)	(pairallel)	(pearallel)	6.	
7.	(searies)	(series)	(ceries)	7.	
8.	(resister)	(resitor)	(resistor)	8.	
9.	(calibration)	(calebration)	(calabration)	9.	
10.	(current)	(currant)	(kurrent)	10.	
11.	(kelo)	(killo)	(kilo)	11.	
12.	(leeds)	(leades)	(leads)	12.	
13.	(enfinity)	(infinity)	(infenity)	13.	
14.	(MHO)	(MOH)	(MOWE)	14.	
15.	(needle)	(kneedle)	(needull)	15.	
16.	(commom)	(common)	(cammon)	16.	
17.	(termenol)	(terminol)	(terminal)	17.	
18.	(switch)	(sawitch)	(schitch)	18.	
19.	(sinsativity)	(sensativity)	(sensitivity)	19.	
20.	(poleairity)	(polarity)	(palarity)	20.	

SCORE:	Name:
GRADE:	Date:
	Period:

WORKSHEET

VOCABULARY - KNOW YOUR DEFINITIONS

Below you will find short definitions for a number of electrical terms. Your job is to find the term that best fits the definition. If you're imaginative you might refer to your technical glossary.

DEFINITION	TERM
EXAMPLE:	
A. The basic unit for measuring current.	ampere
YOUR TURN:	
1. An electrical part used in a circuit.	1.
2. A prefix meaning thousand.	2.
3. The maximum value a meter can indicate.	3.
4. A circuit drawing using symbols to represent components.	4.
5. The part of an electric system which provides the energy for circuit operation.	5.
6. The fundamental values of a formula or equation.	6.
7. A meter control used to electrically set the reading to zero.	7.
8. A circuit having only one path for current flow.	8.
9. A material which allows electrons to flow through it.	9.
10. The movement of the meter pointer.	10.
11. A prefix meaning millionths.	11.
12. An electrical lamp which produces light by heating a filament.	12.

Name: ____________

Date: ____________

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13.	An instrument control or switch used to select the maximum range.	13.	
14.	The mating connector for a jack.	14.	
15.	E=I x R	15.	
16.	An accidental low resistance path in an electric circuit which causes excess current flow.	16.	
17.	Special set of wires used to connect one device to another.	17.	
18.	The voltage produced across a resistor as current flows through the circuit.	18.	
19.	A point in a circuit where a number of connections are made.	19.	
20.	A control on a multimeter used to select the electrical quantity to be measured.	20.	
21.	The process of adjusting a measuring device to a known standard.	21.	
22.	A meter designed specifically to measure electromotive force, or voltage.	22.	
23.	A circuit which allows electrons to flow through a complete path, from the negative to the positive of the source, without interruption.	23.	
24.	The designation of a positive or negative charge within a circuit or component.	24.	
25.	An electrical component which acts as the control, in an electric circuit, by either opening or closing the circuit.	25.	

SCORE:

GRADE:

Name: ______________

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WORKSHEET

D.C. CIRCUIT ELEMENTS

EXAMPLE:

A. The letter symbol for voltage is ______. A. E

1. What is necessary besides a supply, switch, and a load to produce a flow of electrons? 1.

2. The source provides the electromotive ________ which causes electrons to move through the circuit. 2.

3. Electron flow, in a DC circuit, is always from (+) to (-). True or False? 3.

4. An electrical diagram which uses special symbols to represent circuit components and connections is called a ________. 4.

5. The ________ is that part of an electric circuit which uses the energy of moving electrons to do some type of work. 5.

6. The basic unit of measurement for voltage is the ________. 6.

7. Series circuits have how many paths for current flow? 7.

8. The letter symbol for current is ______, and its basic unit of measurement is the ampere. 8.

9. A buzzer, a bell, a lamp, and a speaker are all examples of a ________ which can be used in an electric circuit. 9.

10. ________ has the effect of opposing or decreasing current flow. 10.

11. When a switch is positioned so that it breaks the circuit, and allows no current flow, the switch is said to be ________. 11.

12. The basic unit of measurement for resistance is the ________. 12.

Name: ____________

Date: ____________

Period: ____________

13. A ____________ provides an easy path through which a current can flow. — 13. [ ]

14. A cell, a power supply, a generator, and a battery, are all examples of devices which can be used as a ________ in an electric circuit. — 14. [ ]

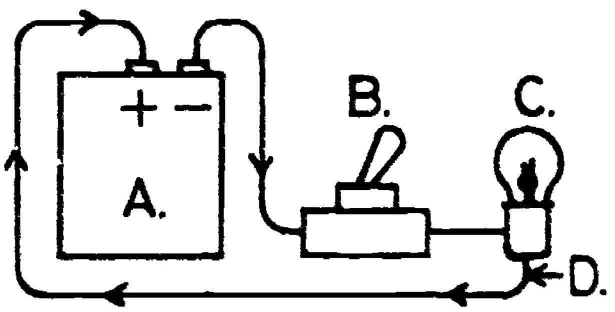
15. A source for a circuit must be able to supply the voltage and the __________ required to operate the load. — 15. [ ]

16. Troubleshooting usually should begin with a thorough ____________ inspection. — 16. [ ]

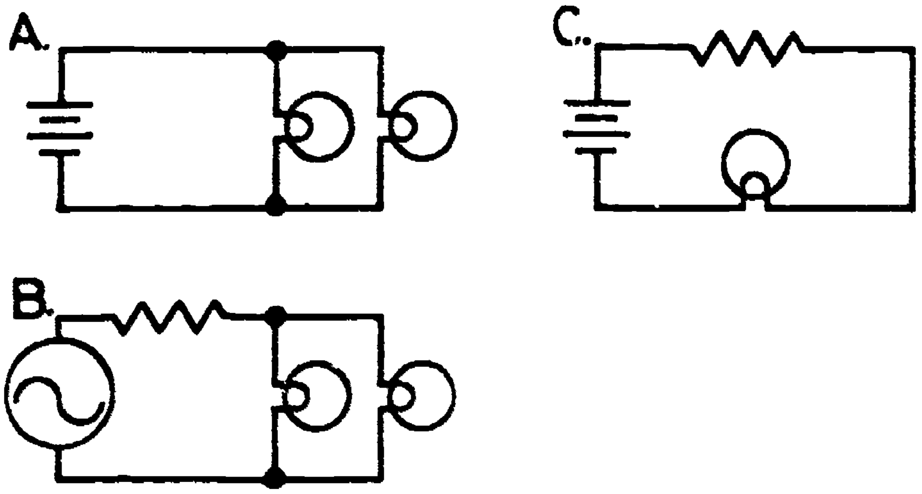
17. Overheated resistors, transformers, and motor windings can often be detected by their ________ or appearance. — 17. [ ]

18. Switches are connected in ________ with the circuit, so that they will be able to control current flow. — 18. [ ]

19. Identify the parts of this basic circuit. (Load, control, conductor, source) — 19A. [ ] 19B. [ ] 19C. [ ] 19D. [ ]



20. Identify the following circuits as either series, parallel, or combination. — 20A. [ ] 20B. [ ] 20C. [ ]



SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

ELECTRICAL INSTRUMENTS AND MEASUREMENTS

MATCHING

Match the term with the appropriate statement.
NOTE: Column 2 terms may be used more than once.

Column 1 (Question)

1. Ammeter
2. Voltmeter
3. Ohmmeter
4. Multimeter
5. Must be connected in series with the circuit.
6. Must be connected across the component.
7. All power must be off in circuit.
8. Can be used to check continuity.
9. Selects mode of operation-what is to be measured.
10. Sets maximum value that can be measured.

Column 2 (Answer)

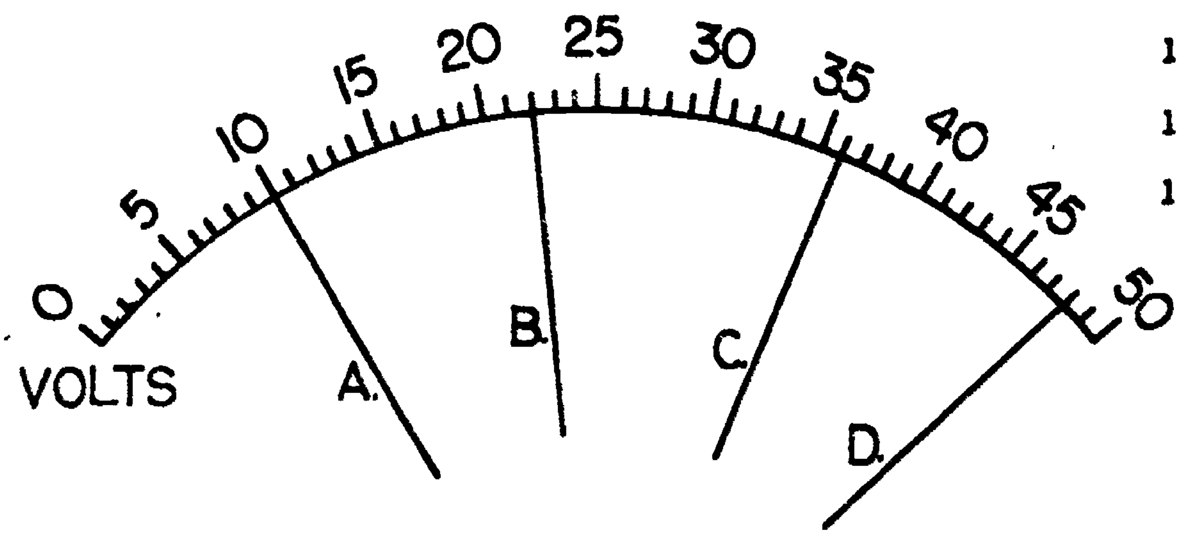
A. Measures resistance in ohms.
B. Function switch
C. Measures voltage in volts.
D. Voltmeter
E. Ammeter
F. Ohmmeter
G. Wattmeter
H. Measures current in amps.
I. Measures voltage in volts, current in amps, and resistance in ohms.
J. Range switch

Letter chosen from column 2

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____
10. ____

In Problems 11 - 14 use the scale and range switch to read the value indicated by the meter pointers.

11.



11A. ____

11B. ____

11C. ____

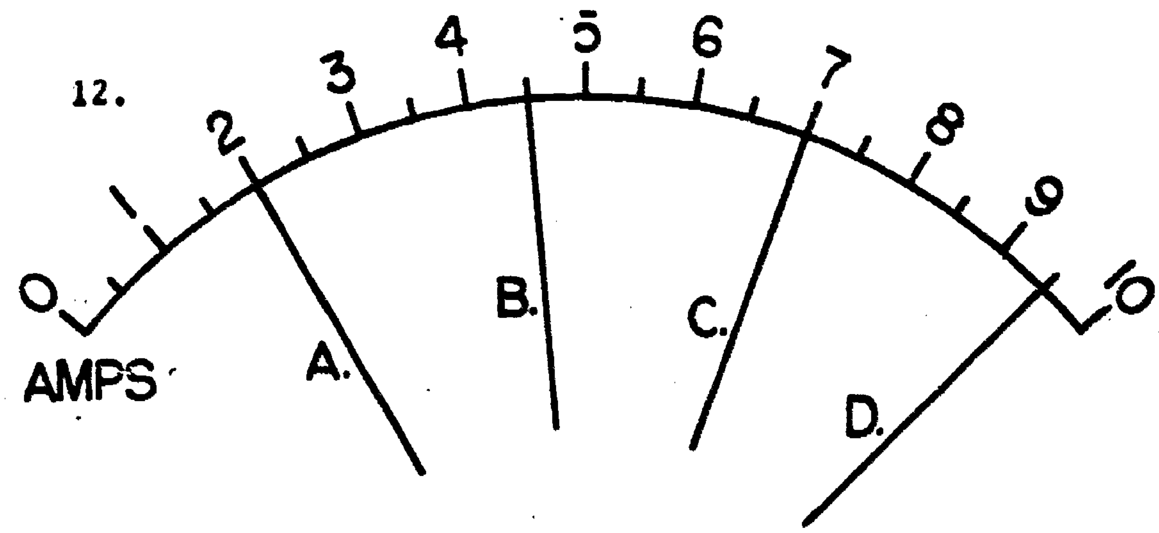
11D. ____

Name: ____________________

Date: ____________________

Period: ____________________

12.

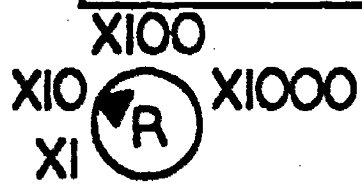


12A. [ ]

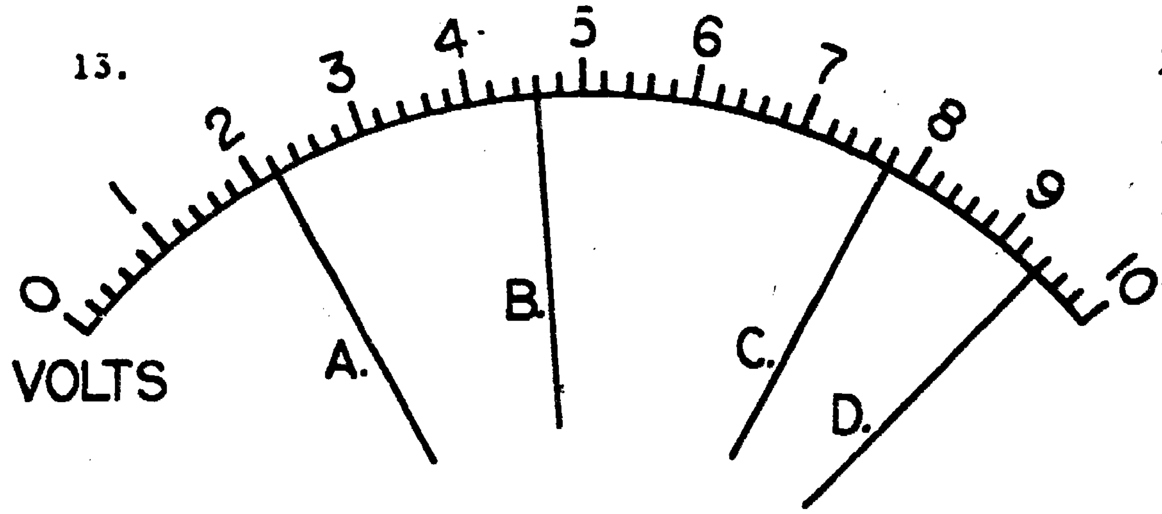
12B. [ ]

12C. [ ]

12D. [ ]



13.

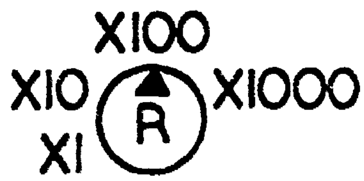


13A. [ ]

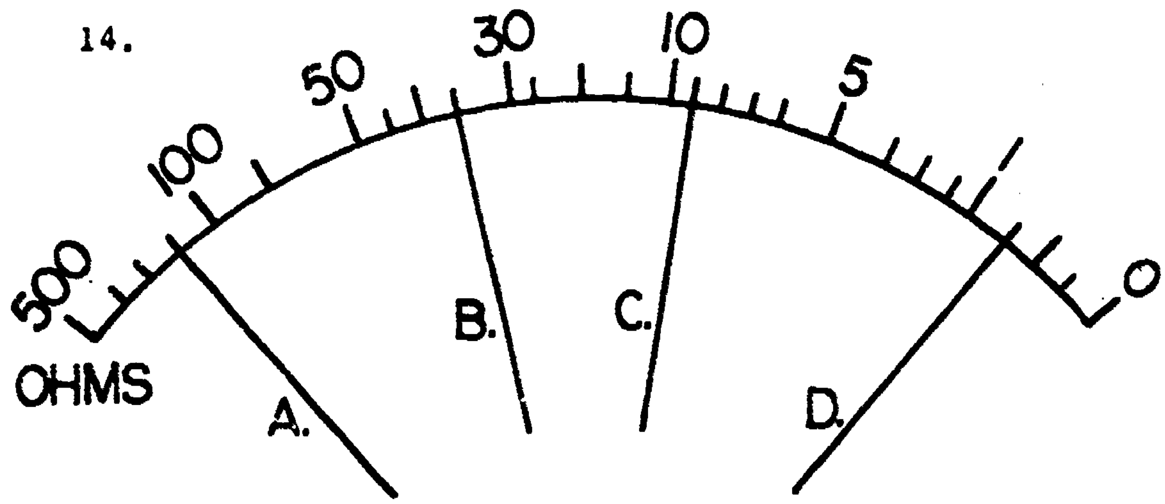
13B. [ ]

13C. [ ]

13D. [ ]



14.



14A. [ ]

14B. [ ]

14C. [ ]

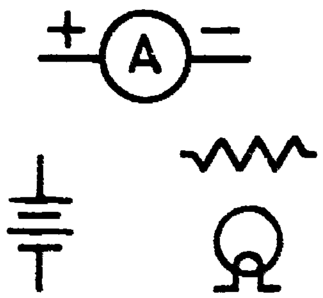
14D. [ ]

Name: ______________

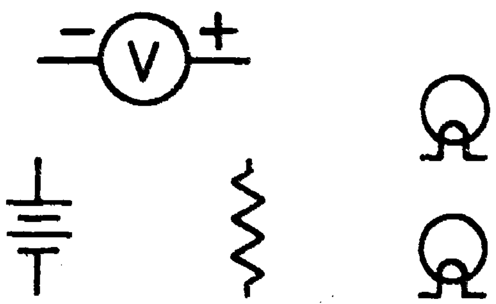
Date: ______________

Period: ______________

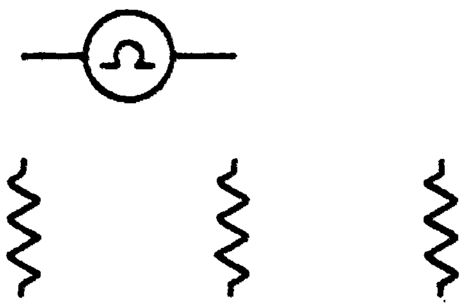
15. Connect the components below into a series circuit. The meter is to be connected to measure total circuit current.



16. Connect the components below into a parallel circuit. The meter is to be connected to measure the voltage across the resistor.



17. Connect the components into a series circuit. The meter is to be connected to measure total resistance.

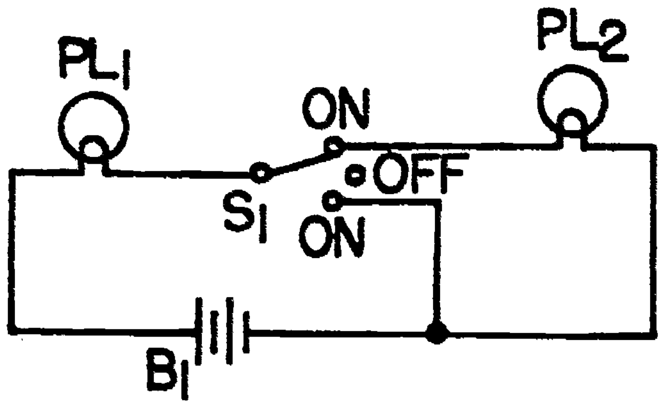


NOTE: When using the Ohmmeter, all power must be removed from the circuit.

Name: ______________

Date: ______________

Period: ______________



18. The above circuit is not functioning normally. You suspect that one of the pilot lamps is burnt out or the battery is dead. Describe how you would use a multimeter to troubleshoot the circuit.

Prodecure

#1:

Procedure

#2.

Procedure

#3:

SCORE:

GRADE:

Name: ____________

Date: ____________

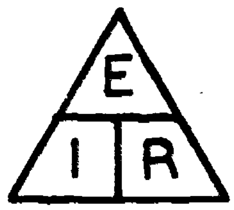
Period: ____________

WORKSHEET

OHM'S LAW

1. OHM'S law states that current is directly proportional to a)________ and inversely proportional to b)________. 1A. [ ] 1B. [ ]

2. Using the OHM'S law triangle below, write the 3 OHM'S law formulas.

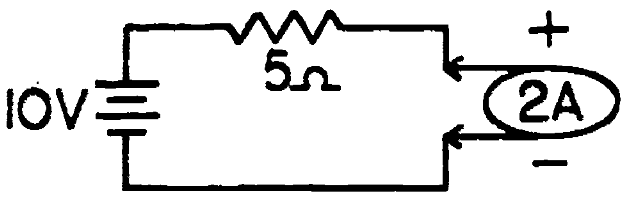


2A. E =
2B. I =
2C. R =

MATCHING

3.	Current is measured in:	a. resistance	3.
4.	E is the letter symbol for:	b. volts	4.
5.	R is the letter symbol for:	c. voltage	5.
6.	Voltage is measured in:	d. amperes	6.
7.	Resistance is measured in:	e. current	7.
8.	I is the letter symbol for:	f. OHMS	8.
9.	Conductance is measured in:	g. seimens	9.

10. Using the circuit below:



a. Identify the "R" (resistance) value in the circuit. 10A.

b. Identify the "E" (voltage) value in the circuit. 10B.

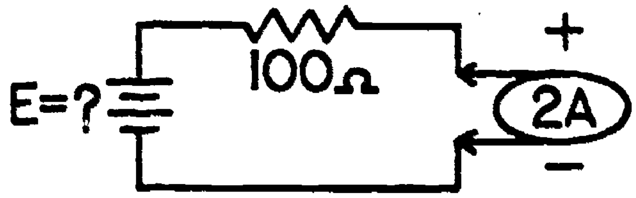
c. Identify the "I" (current) value in the circuit. 10C.

Name: ______________

Date: ______________

Period: ______________

11. Solve for voltage "E" in the circuit below:



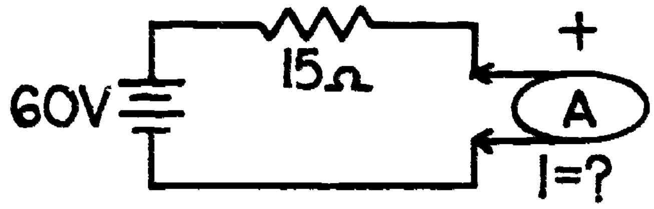
Formula: E = I x R

Enter values: E = ____x____

Solution: E = ______ ____

unit

12. Solve for current "I" in the circuit below:



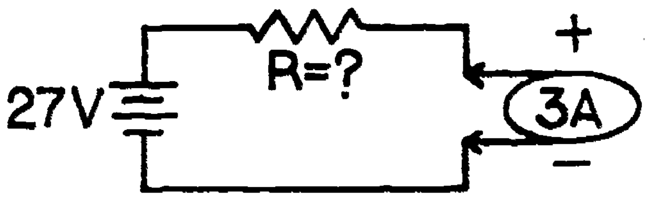
Formula: I =

Enter values: I =

Solution: I = ______ ____

unit

13. Solve for resistance "R" in the circuit below:



Formula: R =

Enter values: R =

Solution: R = ______ ____

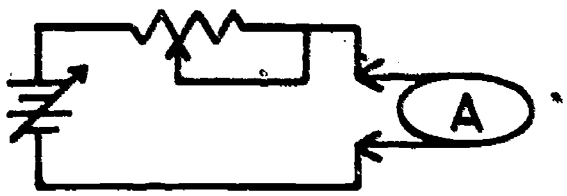
unit

Name: ______________

Date: ______________

Period: ______________

14. Refering to the schematic below, answer the following questions:



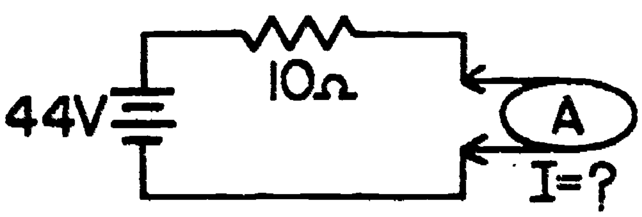
a. If the voltage is increased, and resistance held constant, what happens to the circuit current? (increases-decreases)

14a. [ ]

b. If the resistance is increased, and voltage held constant, what happens to the circuit current? (increases-decreases)

14b. [ ]

15.



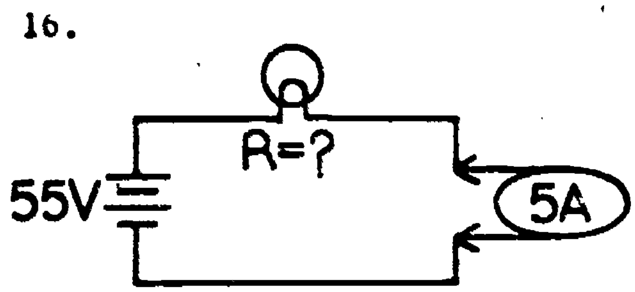
Solve for I.

Formula I =

Enter values I =

Solution I = ______ ___

16.



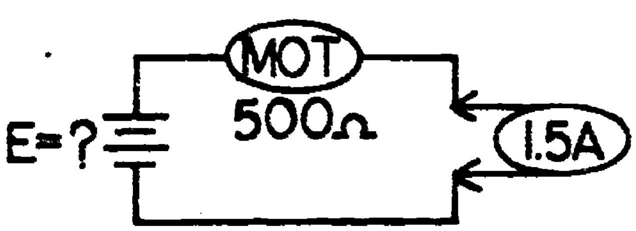
Solve for R.

Formula R =

Enter values R =

Solution R = ______ ___

17.



Solve for E.

Formula E =

Enter values E =

Solution E = ______ ___

Name: ____________

Date: ____________

Period: ____________

OHM'S LAW MATCHING:

18. E = 52V, R = 4Ω, I = ______	a. .15A	18.	
19. R = 1,000Ω, I = .2A, E = ______	b. 13A	19.	
20. I = .5A, E = 15V, R = ______	c. 2280Ω	20.	
21. I = .01A, R = 4,700Ω, E = ______	d. 47V	21.	
22. E = 15V, R = 100Ω, I = ______	e. 200V	22.	
23. I = 2A, E = 4,560V, R = ______	f. 30Ω	23.	

Work for Prob. 18

Work for Prob. 21

Work for Prob. 19

Work for Prob. 22

Work for Prob. 20

Work for Prob. 23

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 4"

WORD SEARCH:

Locate the electronic terms in the matrix below, and record your findings in the spaces provided. The first letter of each term is given to you.

H O A G M I I T E Z Y I M S C

I M M E T F R I X O L Y D A D

S O B M O C B E N A M P E R E

V E H B O M C E S B O L F T F

O S U M V L Q F E I C B V X L

L P K D E N D S N A S G J H E

T C I R C U I T F C O T T J C

M R L Z D L E S H M Z U O F T

E L O A D R V E X C F G W R I

T A T A O H M O Q A D I P L O

E N V E S A R A E N I L N O N

R E D R T E R M I N A L E R Y

Y L B I M F A G O Q H Y H C N

R D C T L Z N B J P X M U I W

E A S K Z E R O A D J U S T V

1. O ______________
2. M ______________
3. R ______________
4. P ______________
5. C ______________
6. A ______________
7. D ______________
8. K ______________
9. L ______________
10. N ______________
11. S ______________
12. T ______________
13. V ______________
14. Z ______________

Name: ____________

Date: ____________

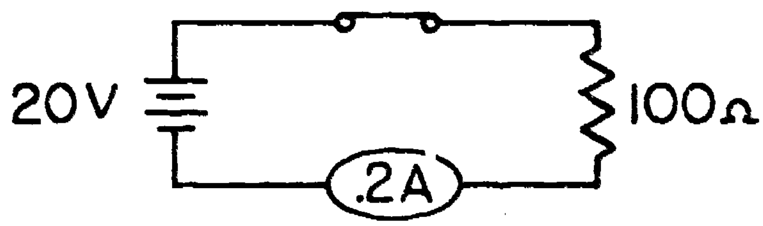
Period: ____________

15. What are the requirements for a complete electric circuit?

_________ _________ _________ ________

16. Draw a complete electric circuit that contains 3 series resistors and 2 parallel pilot lamps.

17. What is the value of E, I, and R in the circuit below.

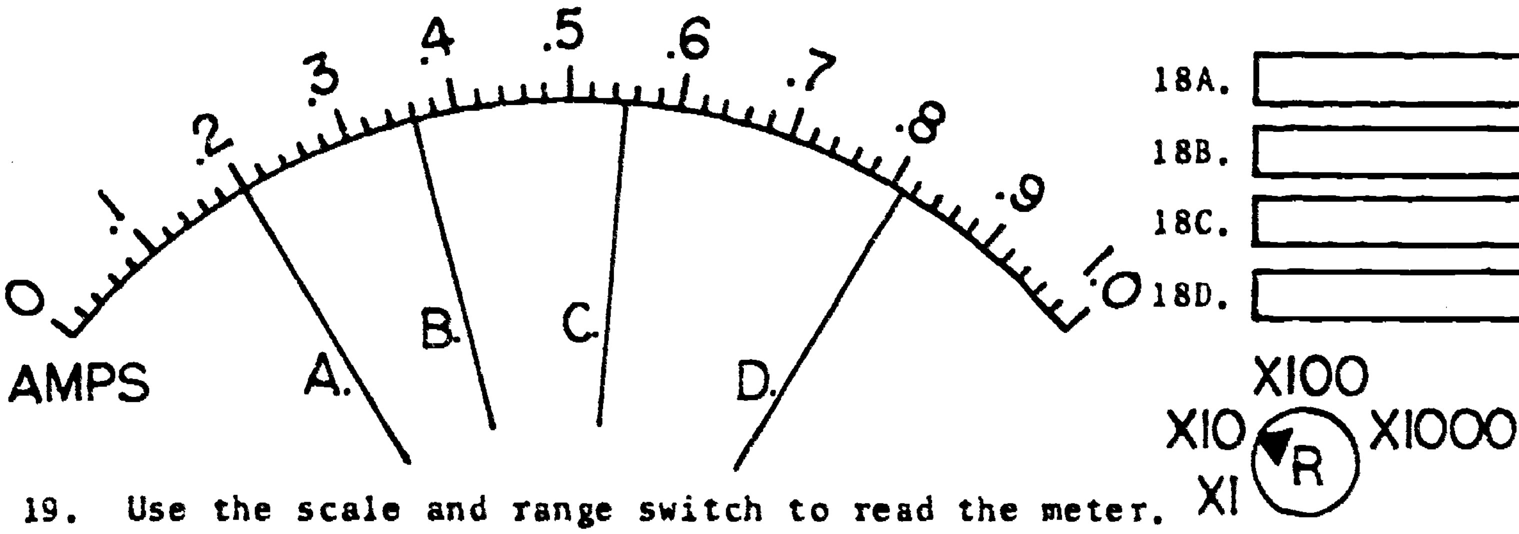


E = ________

I = ________

R = ________

18. Use the scale and range switch to read the meter.



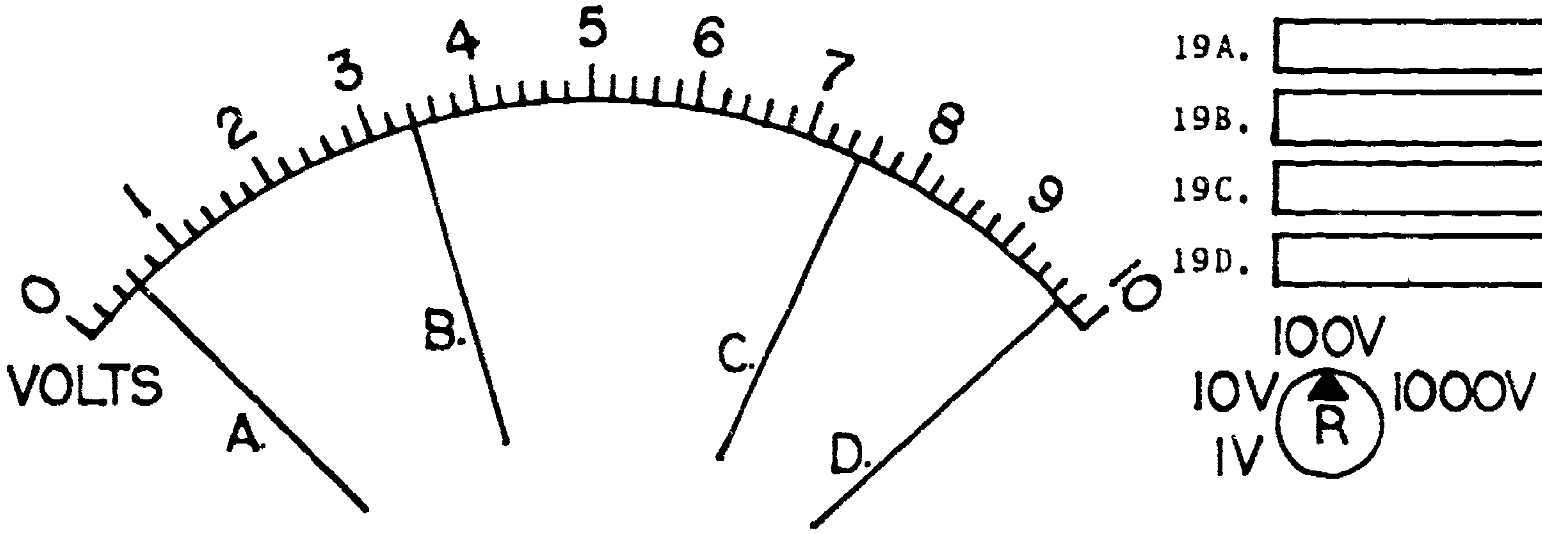
18A. [ ]

18B. [ ]

18C. [ ]

18D. [ ]

19. Use the scale and range switch to read the meter.



19A. [ ]

19B. [ ]

19C. [ ]

19D. [ ]

Name: ____________

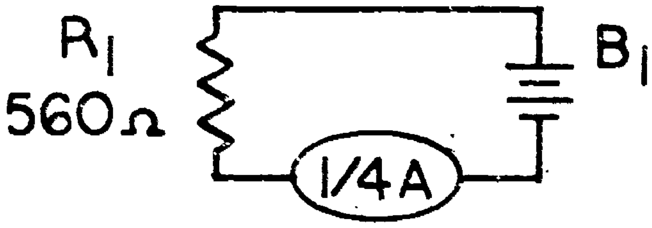
Date: ____________

Period: ____________

20. Write the three OHM'S Law formulas.

____________ ____________ ____________

21. Solve the following problem for "E".



Formula:

Enter values:

Solution:

22. If the voltage in a circuit is 50V, and the current is 2A, then the resistance must be ________ __.

Show Work

23. If the voltage in a circuit is 12V, and the resistance is 50Ω, then the current must be ________ __.

Show Work

24. If current flow in a circuit is 1.5A, and resistance is 270Ω, then the voltage must be ________ __.

Show Work

25. If resistance is 18,000Ω, and voltage is 220V, then the circuit current must be ________ __.

Show Work

Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

PROCEDURES IN READING A METER

The sequence below should be utilized as a reference guide when reading a meter.

1. CHECK THE FUNCTION SWITCH.

   Determine what quantity is being measured.

2. LOCATE THE METER SCALE.

   Find the scale that matches the quantity set on the function switch.

3. READ THE SCALE.

   Read the value where the pointer comes to rest across the scale divisions. Be sure you are looking directly at the scale to avoid parallax problems.

4. CHECK THE RANGE SWITCH.

   Identify the range position, then determine the multiplier.

5. MULTIPLY THE SCALE READING.

   Multiply the reading on the scale by the multiplier indicated by the range switch.

6. THAT'S ALL THERE IS TO IT - YOU HAVE READ THE METER.

   When you record the value you have read, be sure to also record the quantity measured - volts, ohms, or amperes.

Name: ______________

Date: ______________

INFORMATIONAL HANDOUT Period: ______________

STEPS IN USING A METER.

1. SET THE FUNCTION SWITCH

Adjust the function switch for the electrical quantity you want to measure.

Identify the quantity being measured - DC voltage, AC voltage, resistance, DC current, AC current, and select the one proper function switch position.

2. SET THE RANGE SWITCH

Caution must be used when setting the range switch. When using the voltage or current functions be sure the range switch is set in a high enough position so you will not peg the meter.

*** If measuring an unknown value of voltage, or current set the range switch in the highest position.

In the ohms function, the range position is not critical. Select the position that will move the pointer closest to mid-scale.

3. ZERO THE METER

Be sure to zero the meter. This will insure an accurate measurement.

ZEROING PROCEDURE:

a. If available, adjust the "mechanical zero" so that the meter indicates zero. This adjustment is made when the meter is off.

b. Zeroing for voltage and current. Turn the meter on, and allow enough time for stabilization. Connect the test leads together, and use the zero adjust control to set the indicator to zero.

c. Zeroing for resistance. Turn the meter on, and allow enough time for stabilization. Connect the test leads together, and use the zero adjust to set the indicator to zero. Hold the test leads apart, and use the Ohms adjust to set the indicator to the last marking on the scale - (infinity). The last two steps may have to be repeated to achieve an accurate zeroing.

4. CONNECT THE METER INTO THE CIRCUIT

A. Voltage connection

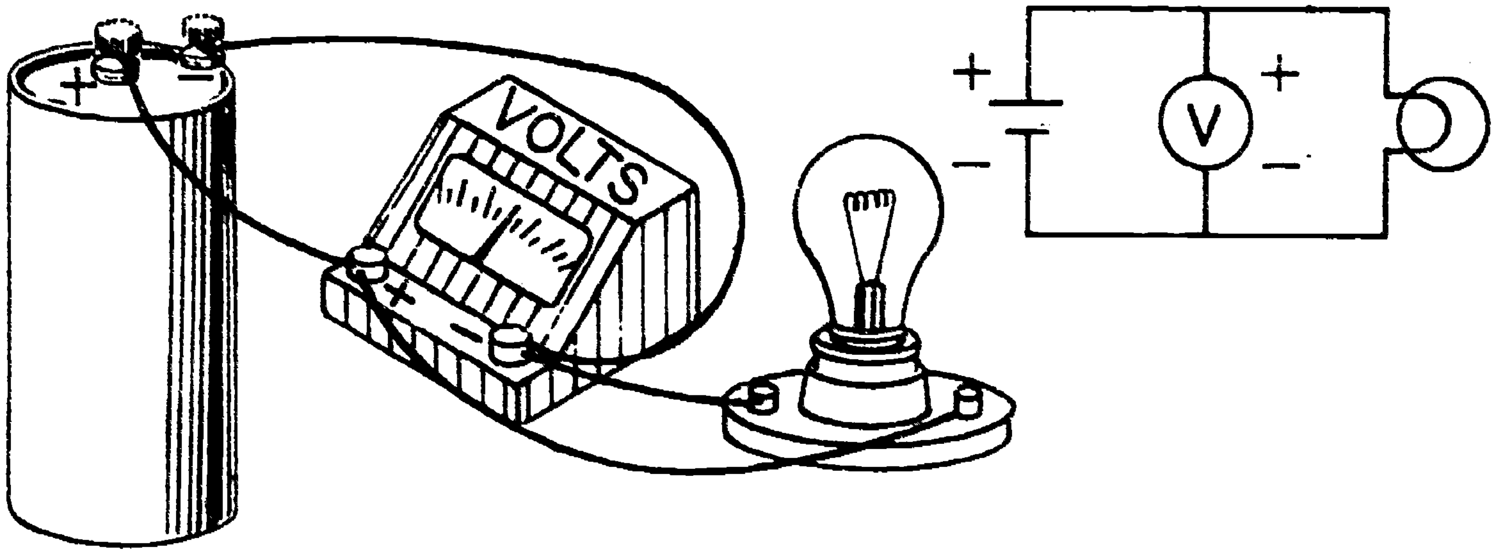
When measuring voltages (AC or DC) the meter must be connected in parallel with the circuit.

Name: ______________

Date: ______________

Period: ______________

Also, be sure to observe polarity - the positive lead of the meter must be connected to the positive side of the circuit. The negative lead must be connected to the negative side of circuit.



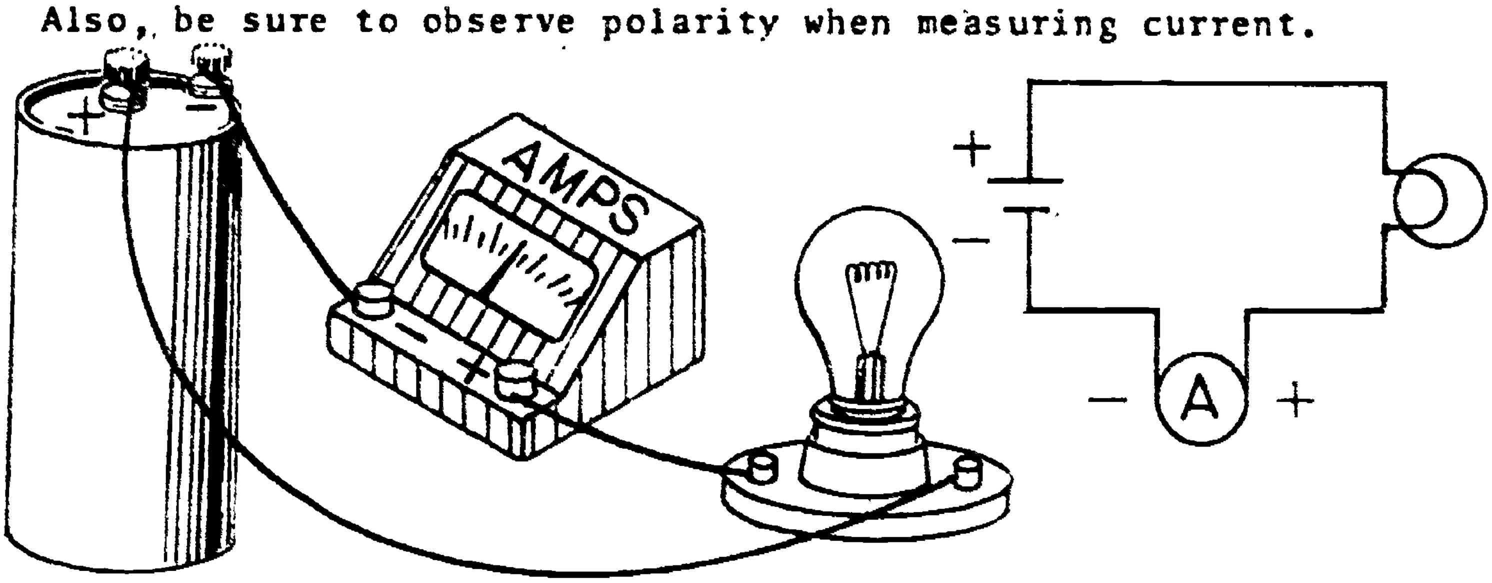
NOTE:

If the reading is below the usable portion on the voltage scale the range switch may be stepped down one position for a more accurate reading.

B. Current connection

When measuring current, the meter must be connected in series with the circuit.

Also, be sure to observe polarity when measuring current.



NOTE:

If the reading on the scale is below the usable portion the range switch may be stepped down one position for a more accurate reading.

Name: ____________

Date: ____________

Period: ____________

C. Resistance connection

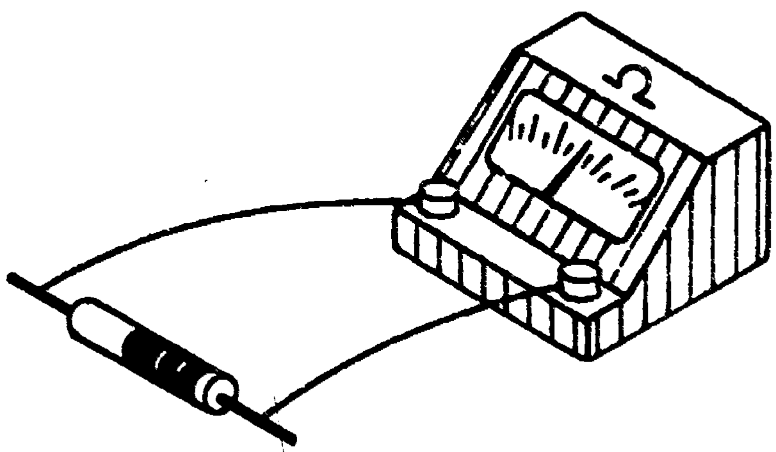
When measuring resistance the meter must be connected in series with the resistance being measured.

*Be sure that there is no power applied to the circuit when measuring resistance.

The best way to accurately measure the resistance of a resistor is to remove it from the circuit.

The ohm meter is a valuable instrument for checking continuity of both components and circuits.

Polarity need not be observed in this kind of measurement.



NOTE:

An accurate reading can be achieved if the needle is close to the middle of the scale. Vary the range switch to locate the position where the pointer moves closest to center scale.

5. READ THE METER

Read the value indicated on the meter. Refer to your handout - "Steps in Reading a Meter" for step by step procedure.

6. TROUBLESHOOTING HINTS

a. Common causes of meter malfunctions.
   1) open or damaged test leads
   2) weak or dead batteries
   3) blown fuse or reset
   4) damaged meter circuit
   5) improper meter connection

Name: ______________

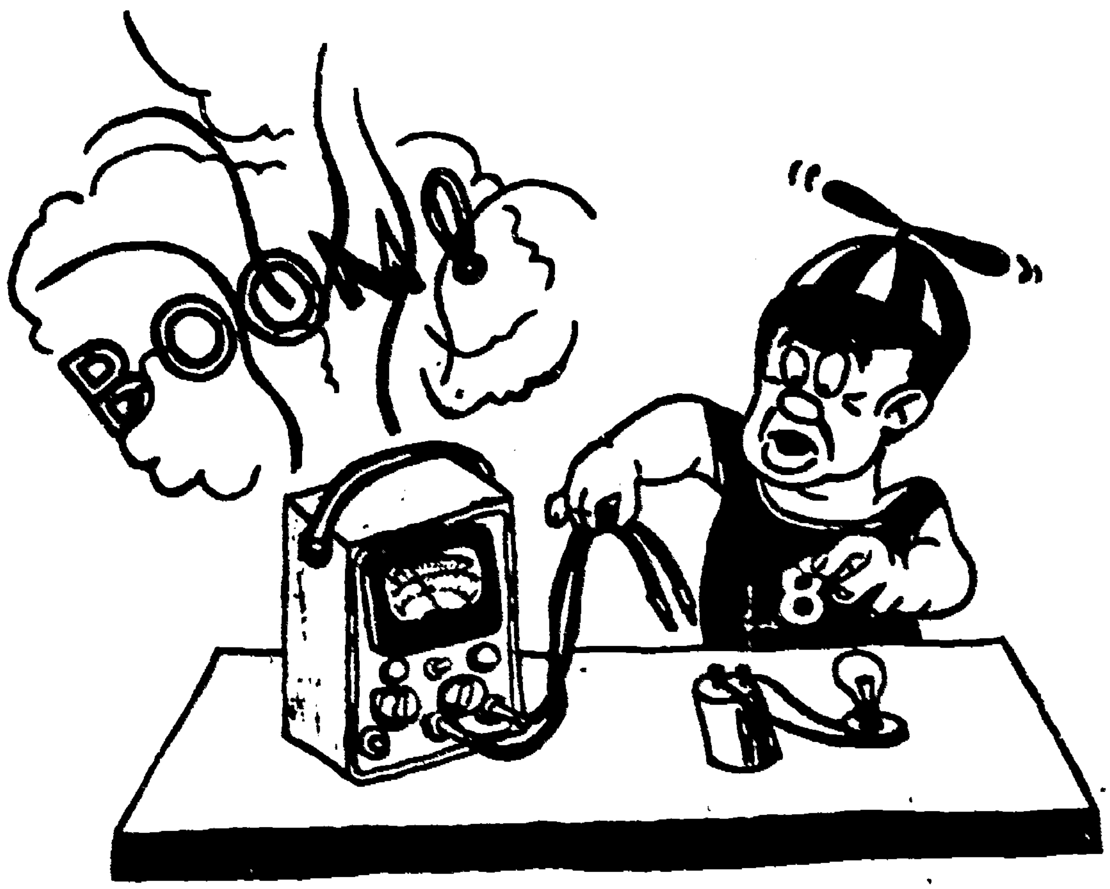
Date: ______________

Period: ______________

b. Be sure to recheck your zero adjustments if you have changed the function or range switch.

c. CAUTION - do not touch the metal tips on the test leads when making measurements.

d. Double check all connections before turning on power or taking measurements.



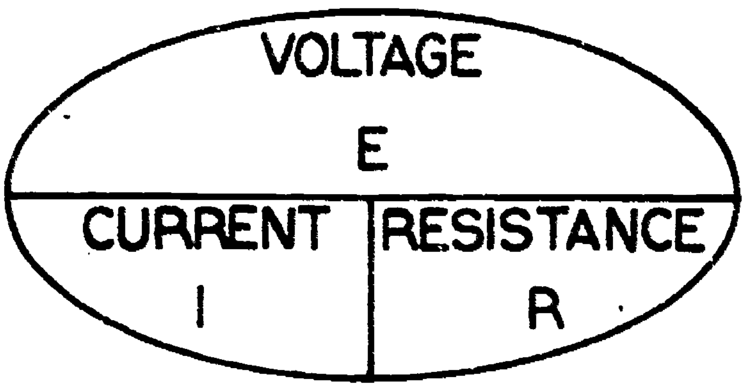
Name: ______________

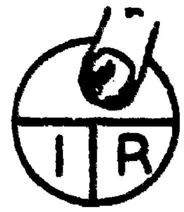
Date: ______________

INFORMATIONAL HANDOUT Period: ______________

OHM'S LAW

Generating the Ohm's Law Formulas:





VOLTAGE
$E = I \times R$

RESISTANCE
$R = \frac{E}{I}$

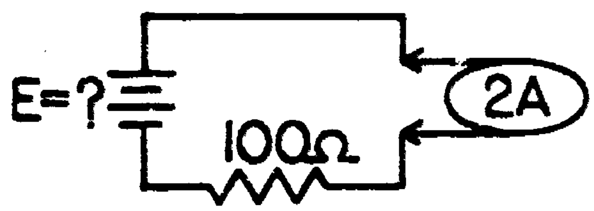
CURRENT
$I = \frac{E}{R}$

Terms - Symbols - and Units:

1. The term voltage (E) is measured in the unit volts (V).
2. The term resistance (R) is measured in the unit Ohms (Ω).
3. The term current (I) is measured in the unit amperes (A).

SAMPLE PROBLEMS:

Solving for voltage

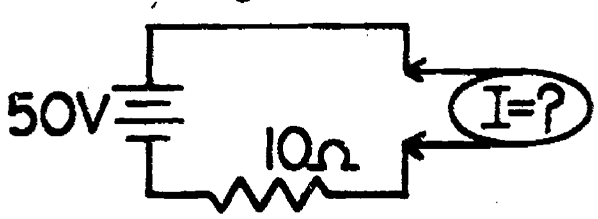


I = 2A
R = 10

Formula: $E = I \times R$
Enter values: $E = 2 \times 100$
Multiply: $E = 200$
Enter unit: $E = 200V$

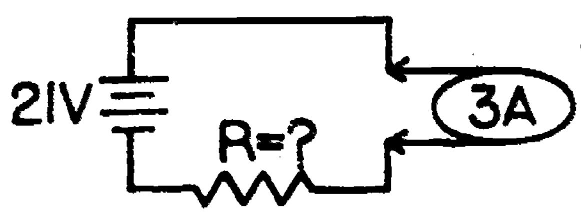
Solving for current

E = 50V
R = 10



Formula: $I = \frac{E}{R}$
Enter values: $I = \frac{50}{10}$
Divide: $I = 5$
Enter unit: $I = 5A$

Solving for resistance



E = 21V
I = 3A

Formula: $R = \frac{E}{I}$
Enter values: $R = \frac{21}{3}$
Divide: $R = 7$
Enter unit: $R = 7\Omega$

SCORE:

GRADE:

Name: KEY

Date:

Period:

ANSWER SHEET

EXAM LIII-U4

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.		■			26.			■		51.					76.				
2.	■				27.			■		52.					77.				
3.	■				28.			■		53.					78.				
4.		■			29.				■	54.					79.				
5.		■			30.		■			55.					80.				
6.	■				31.	■				56.					81.				
7.	■				32.				■	57.					82.				
8.	■				33.				■	58.					83.				
9.	■				34.	■				59.					84.				
10.	■				35.				■	60.					85.				
11.	■				36.				■	61.					86.				
12.		■			37.		■			62.					87.				
13.		■			38.	■				63.					88.				
14.		■			39.			■		64.					89.				
15.	■				40.		■			65.					90.				
16.	■				41.				■	66.					91.				
17.		■			42.				■	67.					92.				
18.	■				43.		■			68.					93.				
19.		■			44.			■		69.					94.				
20.	■				45.	■				70.					95.				
21.	■				46.					71.					96.				
22.			■		47.					72.					97.				
23.			■		48.					73.					98.				
24.	■				49.					74.					99.				
25.		■			50.					75.					100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 4

A. SPELLING PUZZLE

1. symbol
2. voltmeter
3. shunt
4. deflection
5. conductor
6. parallel
7. series
8. resistor
9. calibration
10. current
11. kilo
12. leads
13. infinity
14. MHO
15. needle
16. common
17. terminal
18. switch
19. sensitivity
20. polarity

B. KNOW YOUR DEFINITIONS

1. component
2. kilo
3. full scale
4. schematic
5. source
6. basic units
7. zero adjust
8. series circuit
9. conductor
10. deflection
11. micro
12. incandescent lamp
13. multiplier
14. plug
15. OHM'S LAW
16. short circuit
17. leads
18. voltage drop
19. common
20. function switch
21. calibration
22. voltmeter
23. closed circuit
24. polarity
25. switch

C. D.C. CIRCUIT ELEMENTS

1. conductor
2. force
3. false
4. schematic
5. load
6. volt
7. one
8. I
9. load
10. resistance
11. open
12. OHM
13. conductor
14. source
15. current
16. visual
17. smell
18. series

19A. source
19B. control
19C. load
19D. conductor
20A. parallel
20B. combination
20C. series

D. ELECTRICAL INSTRUMENTS AND MEASUREMENTS

1. H
2. C
3. A
4. I
5. E
6. D
7. F
8. F
9. B
10. J

11A. 10V
11B. 22V
11C. 36V
11D. 48V
12A. 20A
12B. 45A
12C. 70A
12D. 95A
13A. 220V

13B. 460V
13C. 780V
13D. 940V
14A. 2000 ohms
14B. 350 ohms
14C. 90 ohms
14D. 7.5 ohms
15.
16.
17.
18. Procedure 1. Move S_1 to lower on position. If PL_1 lights then fault is with PL_2.

Procedure 2. If PL_1 did not light then fault is with PL_1 or B_1. Switch S_1 to off use meter to test continuity of PL_1.

Prodecure 3. Use ~~meter~~ to test voltage of B_1.

E. OHM'S LAW

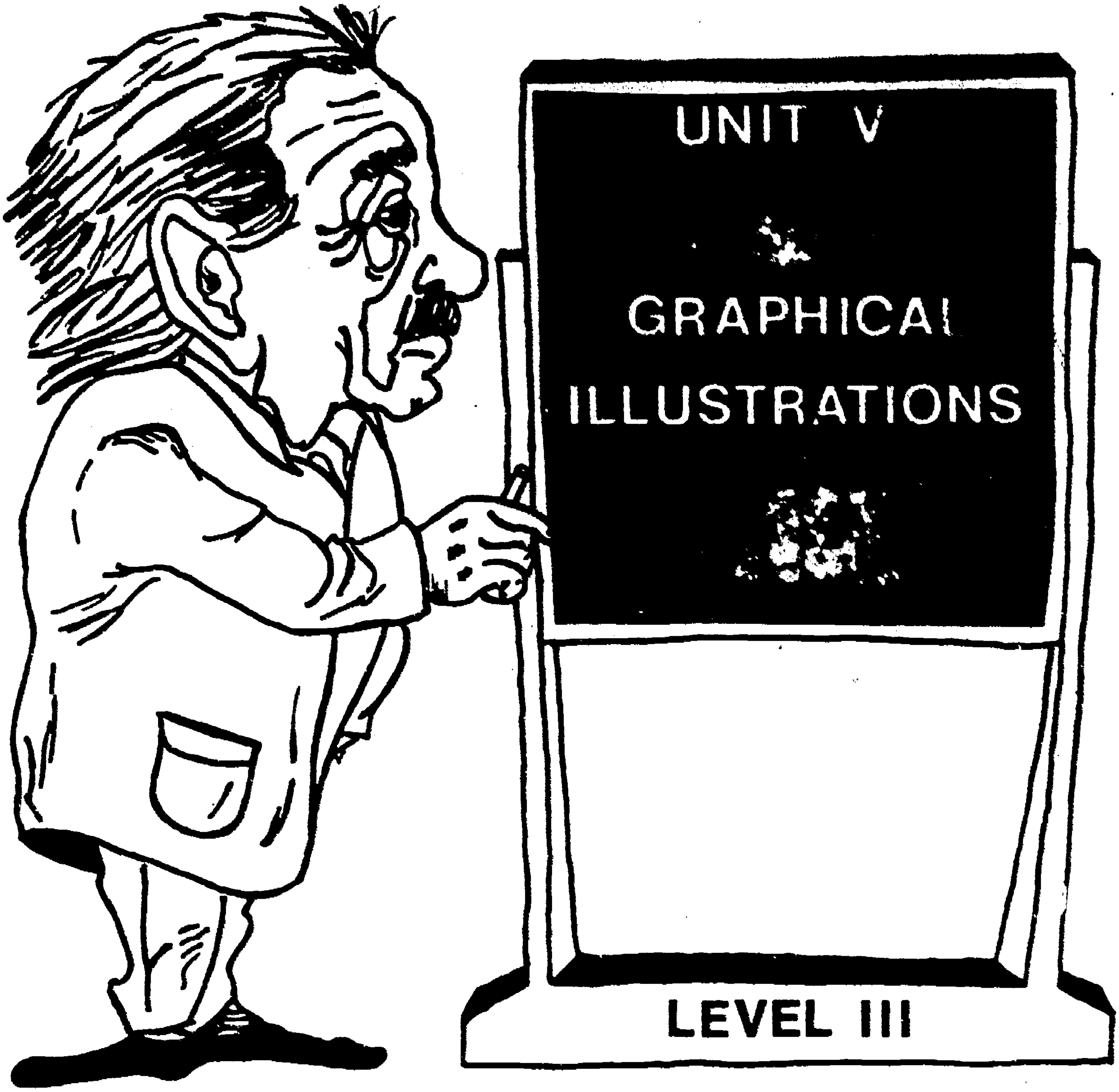
1a. voltage
1b. resistance
2a. E = I x R
2b. I = E/R
2c. R = E/I
3. D
4. C
5. A
6. B
7. F
8. E
9. G
10a. 5 ohms
10b. 10V
10c. 2A
11. Enter values: E = 2 x 100
Solution: E = 200 V
12. Formula: I = E/R
Enter values: I = 60/15
Solution: I = 4 A
13. Formula: R = E/I
Enter values: R = 27/3
Solution: R = 9 ohms
14a. increases
14b. decreases
15. Formula: I = E/R
Enter values: I = 44/10
Solution: I = 4.4 A
16. Formula: R = E/I
Enter values: R = 55/5
Solution: R = 11 ohms
17. Formula: E = I x R
Enter values: E = 1.5 x 500
Solution: E = 750 V
18. B
19. E
20. F
21. D
22. A
23. C

F. QUEST ACTIVITY

1. Ohm
2. Meter
3. Resistor
4. Pointer
5. Circuit
6. Ampere
7. Deflection
8. Kilo
9. Load
10. Nonlinear
11. Schematic
12. Terminal
13. Voltmeter
14. Zero adjust
15. source, load, conductor, control
16.
17. E = 20V
I = .2A
R = 100 ohms
18A. 2 A
18B. 3.6A
18C. 5.5A
18D. 8.1A
19A. 60V
19B. 340V
19C. 750V
19D. 970V
20. E = I x R
I = E/R
R = E/I
21. Formula: E = I x R
Enter values: E = 560 x 1/4
Solution: 140V
22. 25 ohms
23. .24 A
24. 405 V
25. .0122 A

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________________

DATE STARTED______________

DATE COMPLETED____________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Graphical Illustrations

Time Allocation: 2 weeks

Unit Goal:

To integrate with existing competencies those competencies neccessary to perceive a circuit and translate it into a functional graphical representation prior to the construction process.

Unit Objectives:

The student will be able to:

1. read and draw a number of technical symbols that represent components commonly utilized in basic circuits.

2. identify the various kinds of data which accompanies a circuit symbol but are not themselves a part of the symbol.

3. distinguish and interpret the four major types of diagrams generally encountered by electronics personnel.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Electronics Assembly and Fabrication Methods. Duarte and Duarte, McGraw-Hill Book Co., 1973. Chapters: 2,3, and 4.

Technical Electricity and Electronics. Peter Buban and Marshall L. Schmitt, McGraw-Hill Book Co., 1977. Units 29 and 30.

Understanding Electricity and Electronics. Peter Buban and Marshall L. Schmitt, McGraw-Hill Book Co., 1975. Unit 3.

Overview:

The underlining theme of this unit is that communication is a vital means for transferring knowledge from one individual to another. Specifically, in the electronics occupational families or clusters there are two essential systems for conveying information or instructions to the employee. The first system and most obvious means is through the prevailing language and the second means usually conveys a more technical intelligence which is imparted through a language of symbols and diagrams.

The unit should be initially introduced by indicating the logical reasons that led to the development of graphical illustrations and its relative importance in industry.

Upon this foundation the next topics should then deal with specific fundamental symbols, organization of symbols to provoke circuit intelligence, and a presentation about several common kinds of diagrams encountered in electronics.

The instructor should emphasize continually that all graphical communication should strive for clarity, conciseness, and simplicity in order to provide maximum impact.

This unit concludes with the student realizing that further explanation of new symbols and complex circuitry will continue throughout this Level. A variety of appropriate exercises and laboratory experiments and or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. When practicable, students should write out answers to safety questions, glossary terms, worksheets, quest activities, and unit text assignments. Student writing allows the instructor clues to their misconceptions and also an opportunity to evaluate their needs and adjust the lesson accordingly. The cryptic or picture puzzle was included as another device to stimulate students while assisting the instructor in locating certain learning difficulties.
2. Teachers often do not instruct formally in terms of a unit on graphic representation yet it has been included here so that it will serve as a vehicle to enhance student technical comprehension. Try to physically associate parts with their symbols in an effort to assist students immediately in familiarity with electronic components. At this point the student may become aware of various marking on the body of components and these identifications or designations can be discussed.
3. Have student respond to symbol exercises, if possible, with color pencils, markers, or felt pens. Illustrations seem to be of higher quality when generated in this format. Templates may also be utilized and many companies sponsor free courses to teachers on template usage.
4. Frequently, symbols are discussed by instructors without

Methodology continued:

mention of standards, recommended drawing practices, application of symbols, and diagram types. These topics are areas which contain essential competencies in terms of the industrial world and should be emphasized. An inexpensive teacher resource for samples of many graphic representation would be a television repair photofact folder.

5. After the class has digested those proper techniques used in reading a diagram, with the first requirement symbol recognition, a laboratory exercise would be in order. One kind would be a student investigation of a wired chassis, appliance, or circuit and then conversion to an appropriate diagram this will provide a quick means to appraise overall unit performance.

Supplemental Activities and Demonstrations:

1. A handy training device for teaching symbol recognition can be easily made with a minimum of cost or time. The idea is basically to have a column of symbols, and a column of corresponding component pictures mounted on a prewired frame. When the proper match occurs a bell will ring indicating proper student response.
2. A useful blackboard activity to impress remedial students with schematic symbols is for the instructor to pick out an assortment of components for the class to view. Out of this selection have the class name those that actually look like the symbols they represent. Use the black board to list the results and verbally emphasize that indeed many schematic symbols are definitely symbolic pictures.
3. An activity which teaches several concepts yet enjoyable is to have students send away for a free parts catalog. Once the student has a catalog the activities are bountiful for example; cut pictures of parts then summarize functions, list letter designations, and draw circuit symbols.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Glossary Cryptics
5. Worksheet - Electronic Graphics
6. Quest Activity
7. Informational Handouts - (Electronic Symbols and Designations)
8. Informational Handout - (Diagram Types)
9. Unit Module Answer Keys

V. Graphical Illustrations

A. Symbols

B. Application of symbols to a circuit diagram

C. Reference designations

D. Numerical values of components

E. Pictorial diagrams

F. Schematic diagrams

G. Block diagrams

H. Wiring diagrams

Test Number ____

LIII-U5

UNIT EXAM

GRAPHICAL ILLUSTRATIONS

IMPORTANT-
Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. Pictorial diagrams are difficult to read. (T-F)

2. Schematic diagrams are usually drawn to read from left to right. (T-F)

3. A schematic diagram shows the location of the components used in a circuit. (T-F)

4. A schematic diagram shows auxiliary devices such as terminals and sockets. (T-F)

5. The connecting lines on a schematic diagram should be drawn either horizontally or vertically, whenever possible. (T-F)

6. A typical reference designation uses a number/letter code such as 3_R to designate resistor 3. (T-F)

7. A pictorial diagram shows circuit components as graphic symbols and the location of the components on the chassis. (T-F)

8. A schematic diagram makes it impossible to trace the current flow through a circuit from beginning to end. (T-F)

9. On a schematic diagram, the components are represented by means of graphic sketches. (T-F)

10. The dot symbol on a schematic diagram is used to show that wires are electrically connected at that point. (T-F)

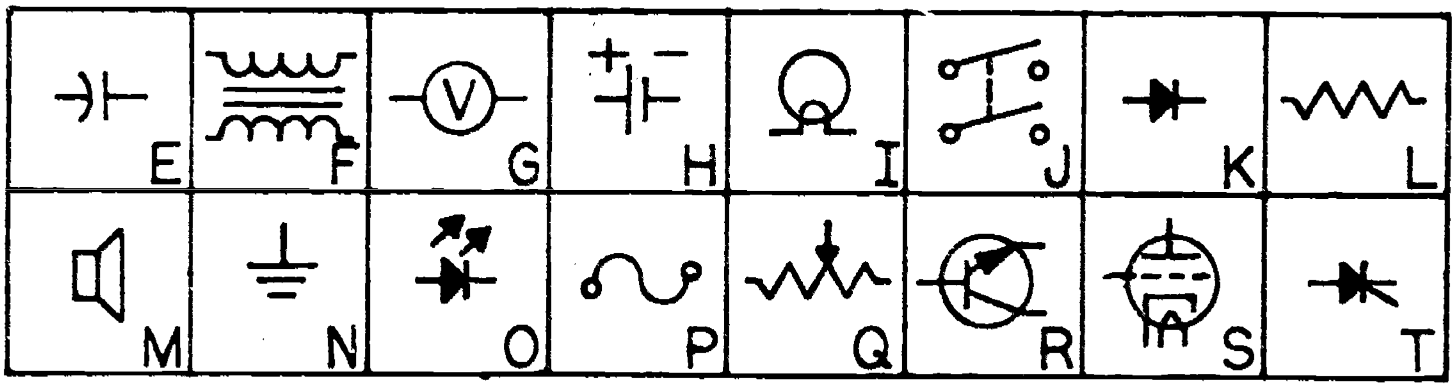
11. The wires represented on a wiring diagram are often color coded for the purpose of making it easier to lose them in the actual circuit assembly. (T-F)

12. Unlike a pictorial diagram, a schematic diagram does not show the location of components or the wires which connect the components. (T-F)

13. Block diagrams use simple shapes, and lines to show the signal flow between stages in a system. (T-F)

14. Abbreviations and letter designations are assigned to components in a diagram for ease of identification. (T-F)

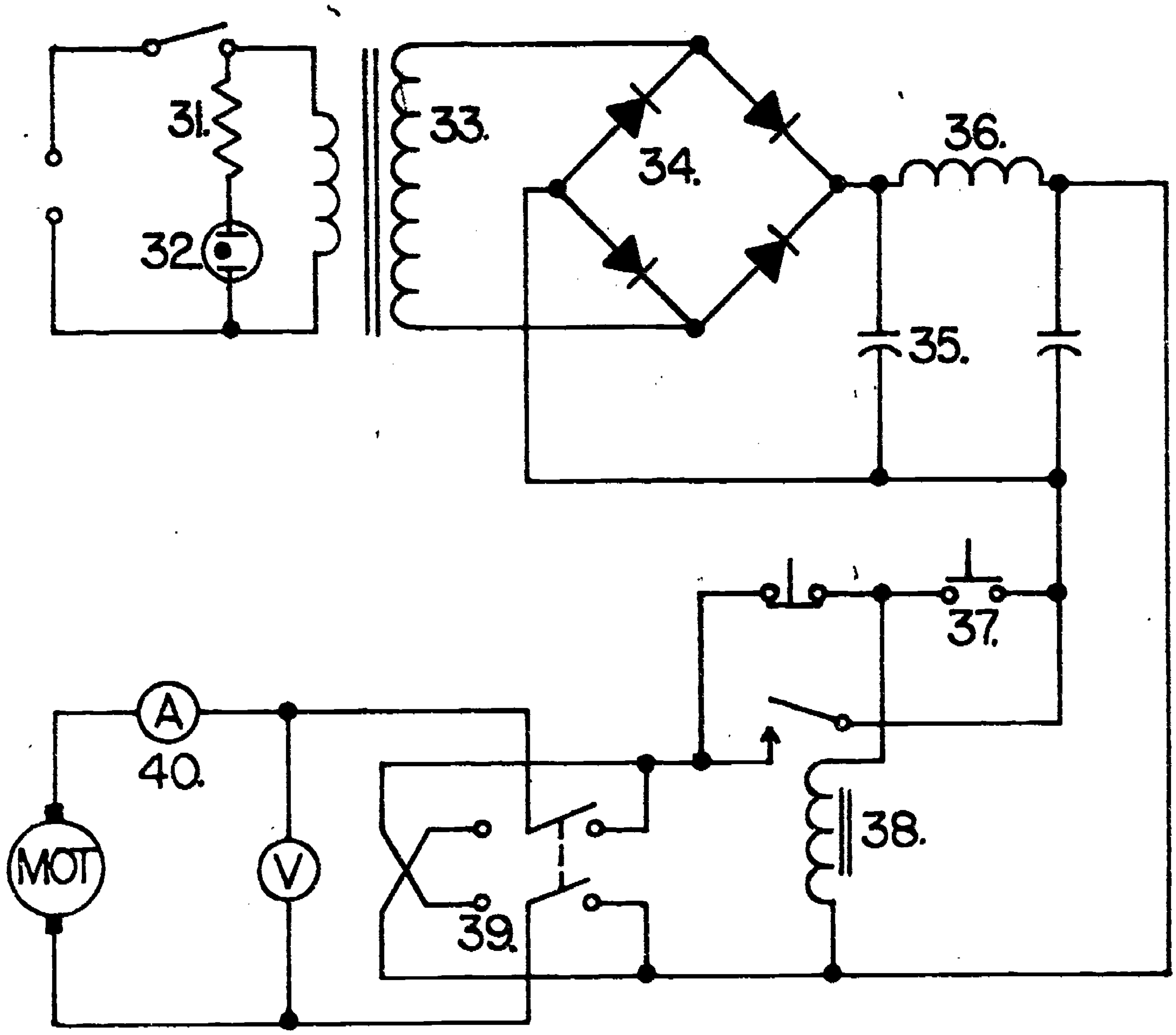
15. The block diagram of an amplifier might also include a portion of the schematic diagram to assist in connecting the various stages together. (T-F)



Identify the graphic symbol for the components listed below. Record the schematic letter which corresponds to the listed component.
EXAMPLE: 100. Silicon controlled rectifier - 100. T

COMPONENT		COMPONENT	
16.	resistor	24.	ground
17.	triode tube	25.	cell
18.	DPST switch	26.	transistor
19.	speaker	27.	transformer
20.	incandescant lamp	28.	light emitting diode
21.	capacitor	29.	voltmeter
22.	diode	30.	variable resistor
23.	fuse		

Indicate the reference designation for the components marked in the schematic.



31. ____________

32. ____________

33. ____________

34. ____________

35. ____________

36. ____________

37. ____________

38. ____________

39. ____________

40. ____________

Name: ______________

Date: ______________

Period: ______________

TECHNICAL GLOSSARY

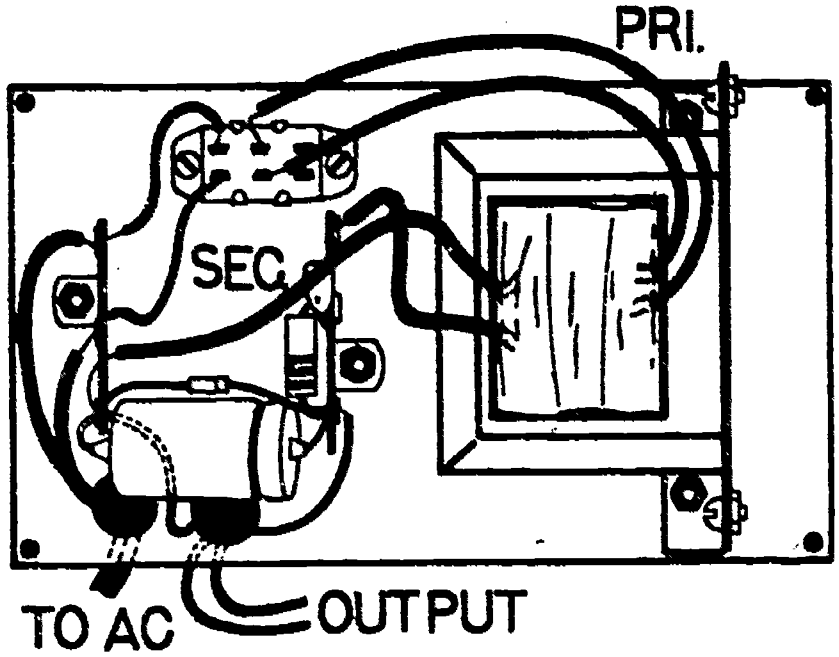
ABBREVIATION:	The expression of a word, or term in shortened form, usually by using representative letters. Example: The term resistance is abbreviated with the letter R.
BLOCK DIAGRAM:	A drawing in which complete circuits, or components of a circuit are represented as "functional" blocks.
COMPONENT:	An electronic part.
CONNECTION:	The junction of several conductors or components in an electrical circuit.
GRAPHIC SYMBOL:	A symbolic representation used to depict an electronic component and often referred to as a schematic symbol.
LETTER IDENTIFICATION:	A letter used to designate a particular type of electronic component. Example: The letter identification for a capacitor is C.
NUMERICAL VALUE:	The rating or value of a component expressed in its unit of measurement. The numerical value of a one thousand ohm resistor for example can be expressed as 1000 or 1k.
PICTORIAL DIAGRAM:	A drawing showing the components of a circuit, their location upon the chassis, and how they are connected together. The diagram is usually drawn to scale.
REFERENCE DESIGNATION:	The symbol used to represent components in a circuit diagram. The reference designation combines a letter identification and a subscript, to identify one particular component. The designation for resistor three on a schematic diagram would be R_3.
SCHEMATIC DIAGRAM:	A special type of drawing used in electronics to represent circuit components and connections. This type of diagram uses simplified symbols to show electric connections, but does not show the physical layout or part structure.
STAGE:	A unit which is composed of an electronic circuit or circuits which performs a function and operates as a interacting portion of a complete system.
SUBSCRIPTS:	Small identifying numbers or letters written slightly to the right of and below the quantity being identified.

Name: ________________

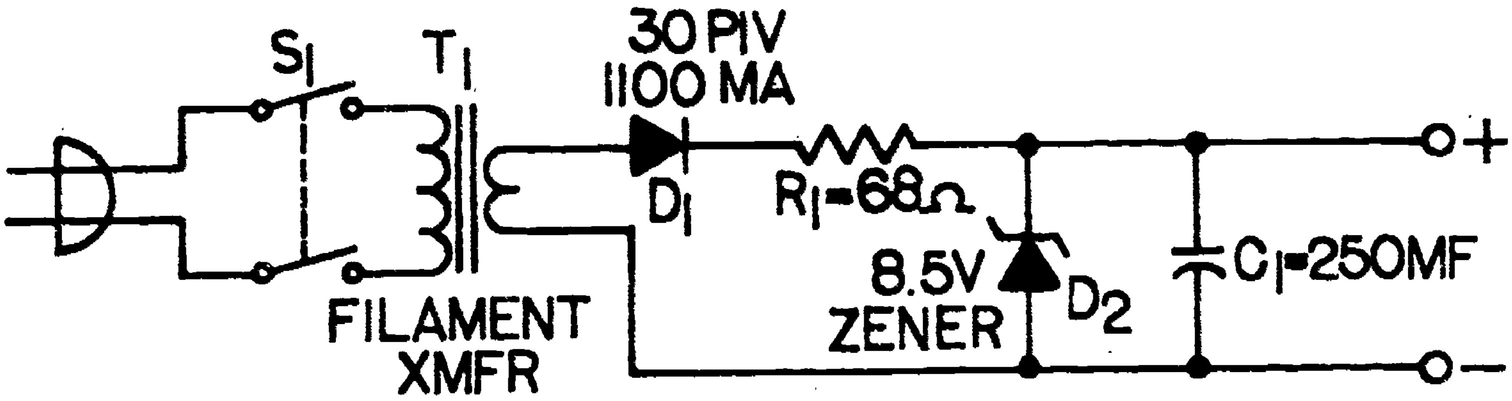
SYSTEM: A total electronic unit comprised of interacting stages.

WIRING DIAGRAM: A drawing used to show wiring connections in a simplified, easy - to - understand manner.

WIRING DIAGRAM



EQUIVALENT SCHEMATIC DIAGRAM



REGULATED 9V POWER SUPPLY

SCORE:

GRADE:

Name: ____________

Date: ____________

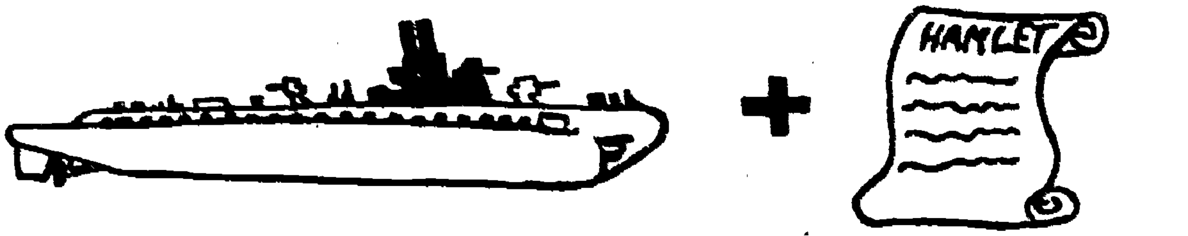
Period: ____________

WORKSHEET

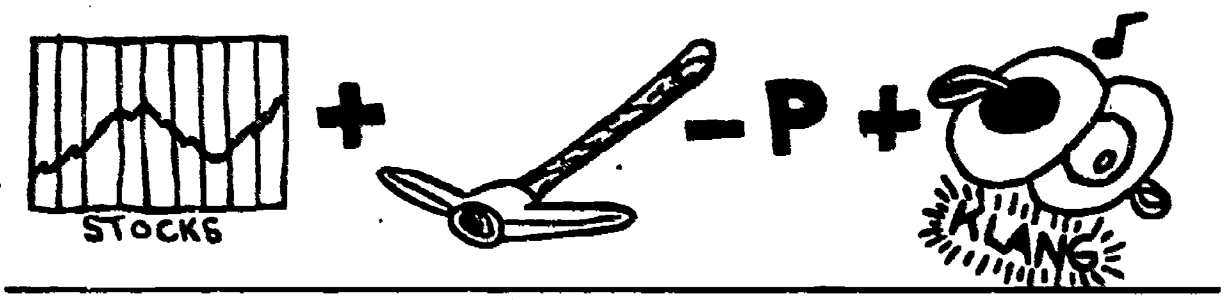
GLOSSARY CRYPTICS

Decode the cryptic messages below to identify the electronic term.

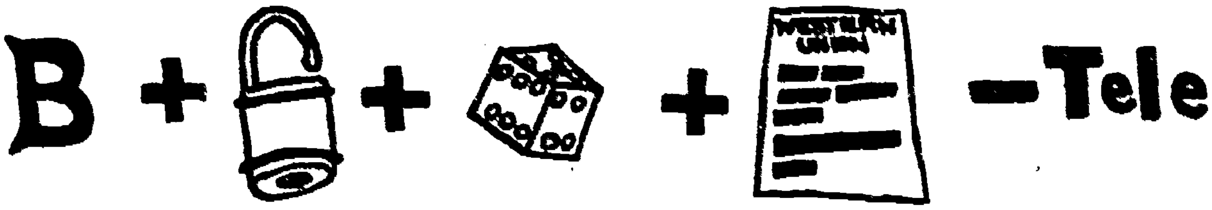
EXAMPLE:

A. 

A. subscript

1. 

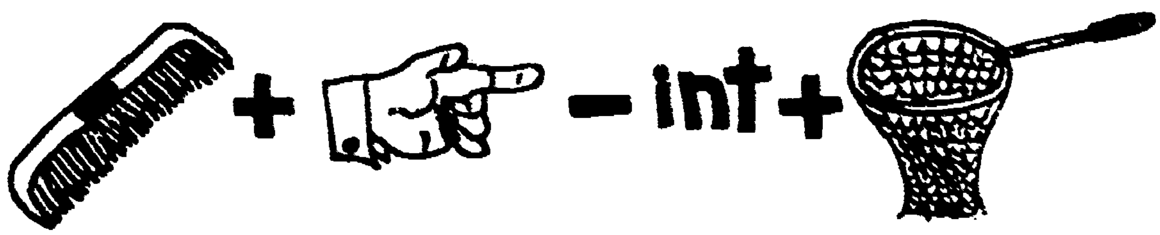
1. ____________

2. 

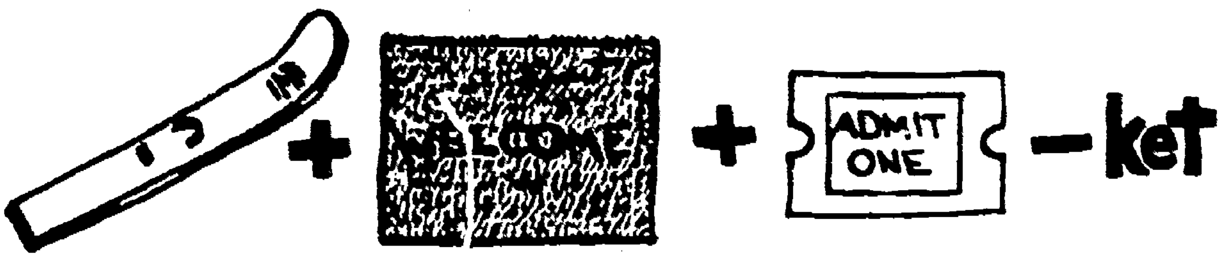
2. ____________

3. 

3. ____________

4. 

4. ____________

5. 

5. ____________

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

ELECTRONIC GRAPHICS

A. Draw in the correct graphic symbol for the following electronic components.

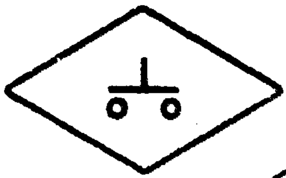
1. Incandescent lamp: ____
2. Fuse: ____
3. Fixed value capacitor: ____
4. Potentiometer : (variable resistor) ____
5. Cell: ____
6. Electrolytic capacitor: ____
7. Air core inductor: ____
8. Iron core transformer: ____
9. Chassis ground: ____
10. Center tapped transformer: ____
11. PBNO switch: ____
12. Ammeter: ____
13. Triode tube: ____
14. SCR: ____
15. AC generator: ____

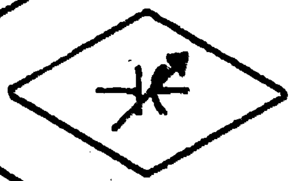
Name: ______________________

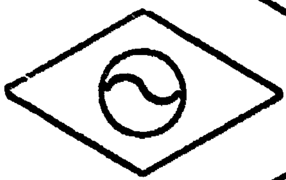
Date: ______________________

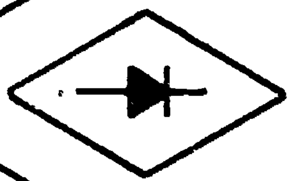
Period: ______________________

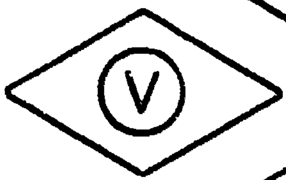
B. Identify the following graphic symbols:

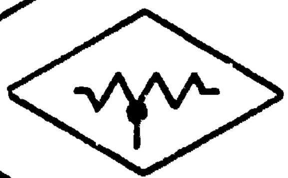
16.  . . . . ______________________

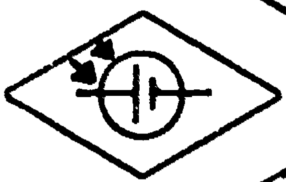
17.  . . . . . . ______________________

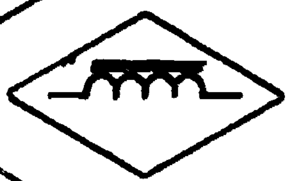
18.  . . . . ______________________

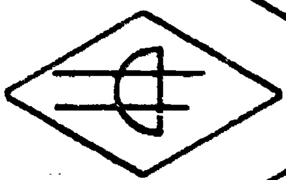
19.  . . . . . . ______________________

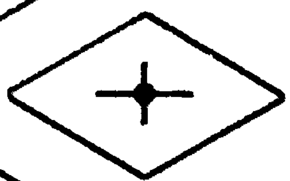
20.  . . . . ______________________

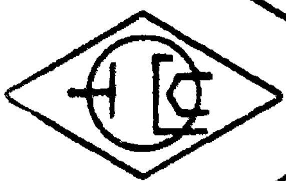
21.  . . . . . . ______________________

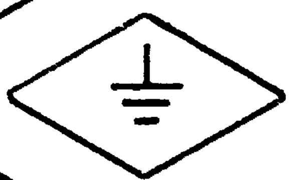
22.  . . . . ______________________

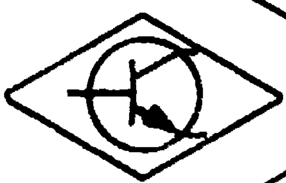
23.  . . . . . . ______________________

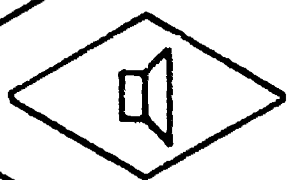
24.  . . . . ______________________

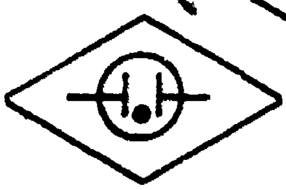
25  . . . . . . ______________________

26.  . . . . ______________________

27.  . . . . . . ______________________

28.  . . . . ______________________

29.  . . . . . . ______________________

30.  . . . . ______________________

Name: ____________

Date: ____________

Period: ____________

C. Give the letter identification or abbreviation for the following.

31. current: ____
32. switch: ____
33. vacuum tube: ____
34. light emitting diode: ____
35. battery: ____
36. milli: ____
37. ampere: ____
38. second: ____
39. average: ____
40. ground: ____
41. capacitance: ____
42. voltage: ____
43. peak to peak: ____
44. radio frequency: ____
45. resistor: ____
46. thermocouple: ____
47. plug: ____
48. relay: ____
49. OHM: ____
50. hertz: ____

D. Identify the following letter identification or abbreviations.

51. f: ____________
52. C: ____________
53. J: ____________
54. S: ____________
55. Q: ____________
56. DC: ____________
57. db: ____________
58. X_L: ____________
59. k: ____________
60. EFF: ____________
61. p: ____________
62. AM: ____________
63. Z: ____________
64. E: ____________
65. VHF: ____________
66. SPDT: ____________
67. D: ____________
68. F: ____________
69. IN: ____________
70. PK: ____________

SCORE:	
GRADE:	

Name: ______________

Date: ______________

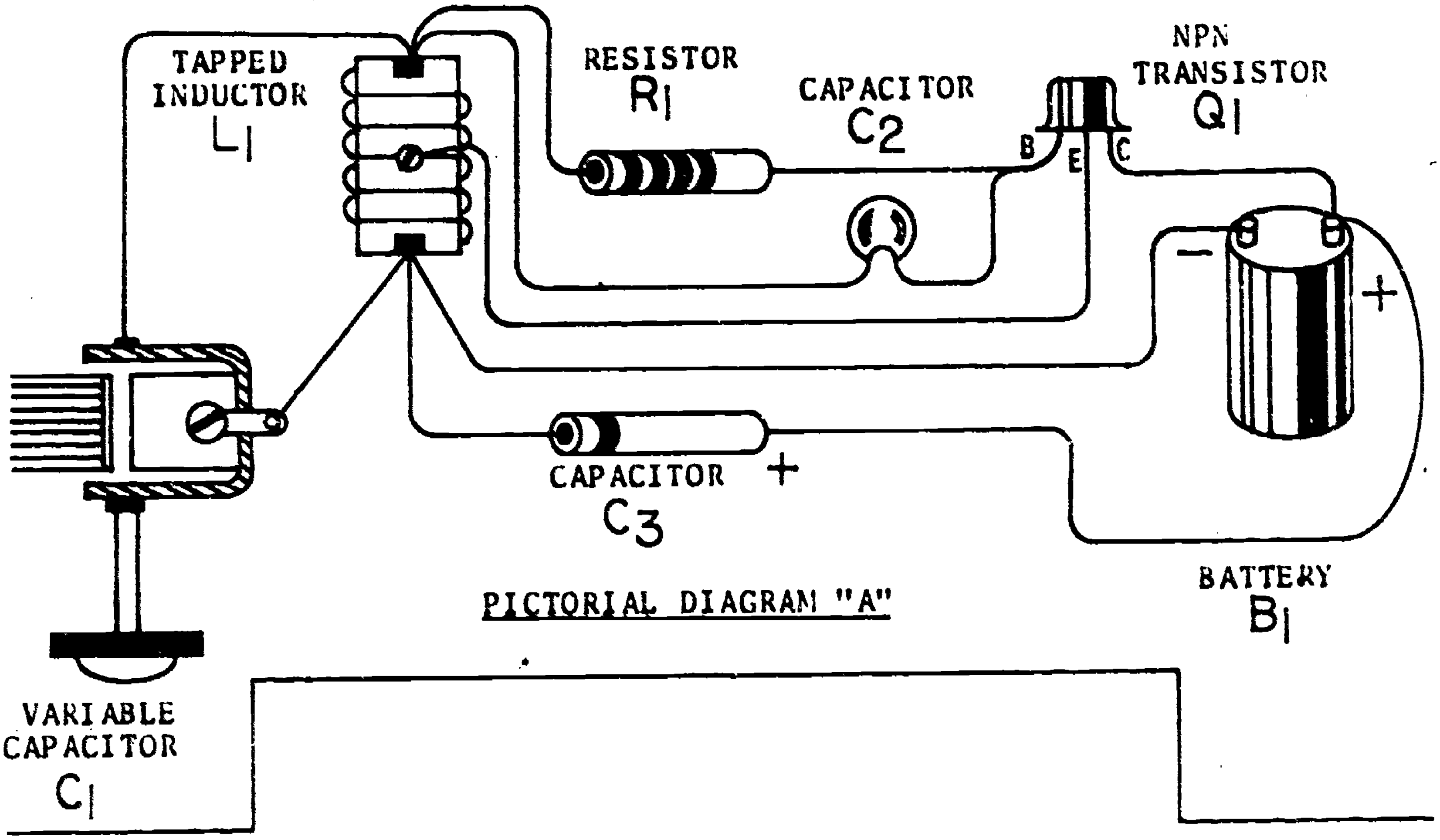
Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 5"

Carefully study pictorial diagram "A" below. Identify the components, and pay particular attention to the interconnecting wires. Your assignment is to convert pictorial diagram "A" into a schematic diagram. Use proper schematic form. -- Good Luck.



PICTORIAL DIAGRAM "A"

SCHEMATIC DIAGRAM

Name: ____________

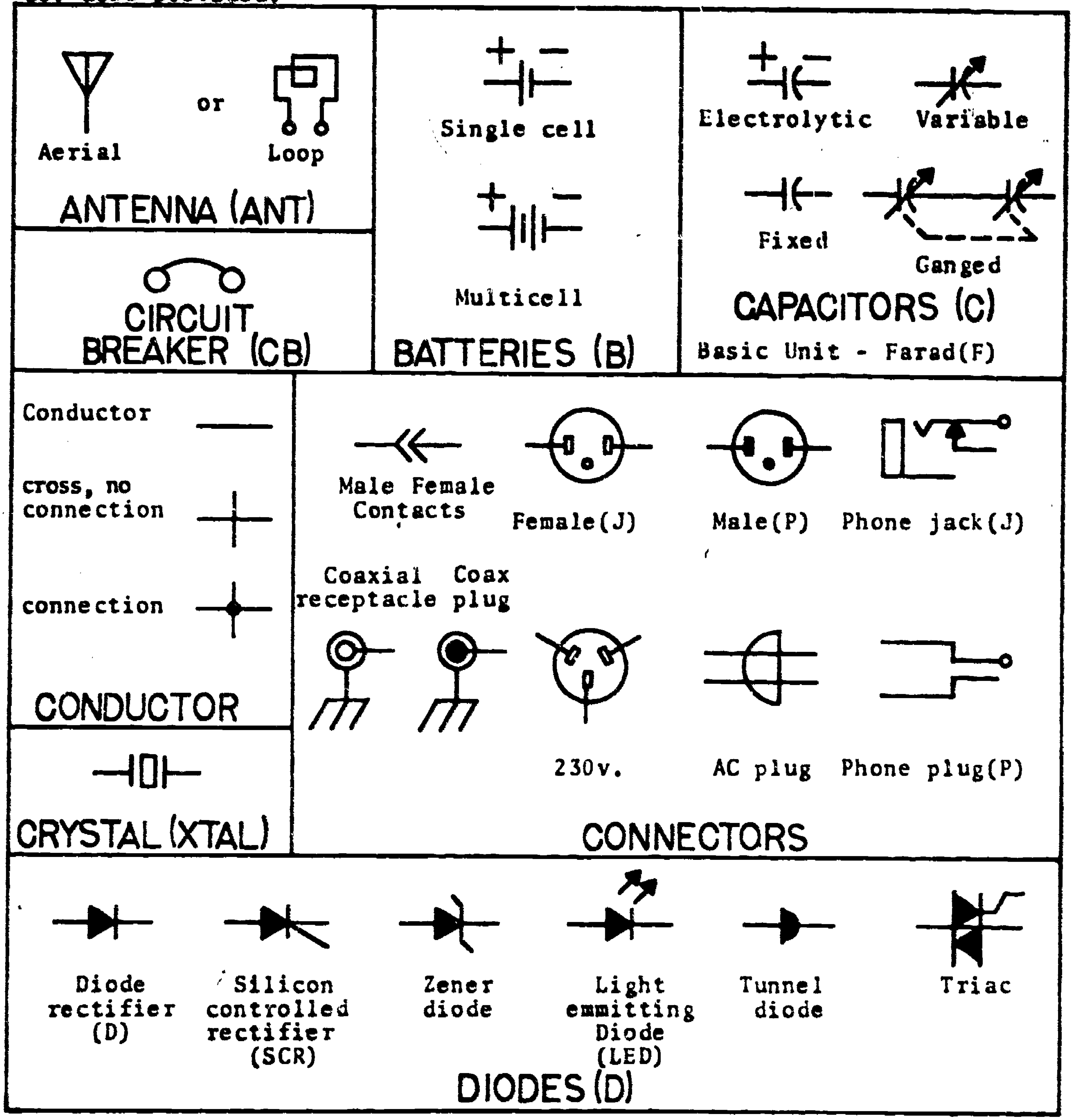
Date: ____________

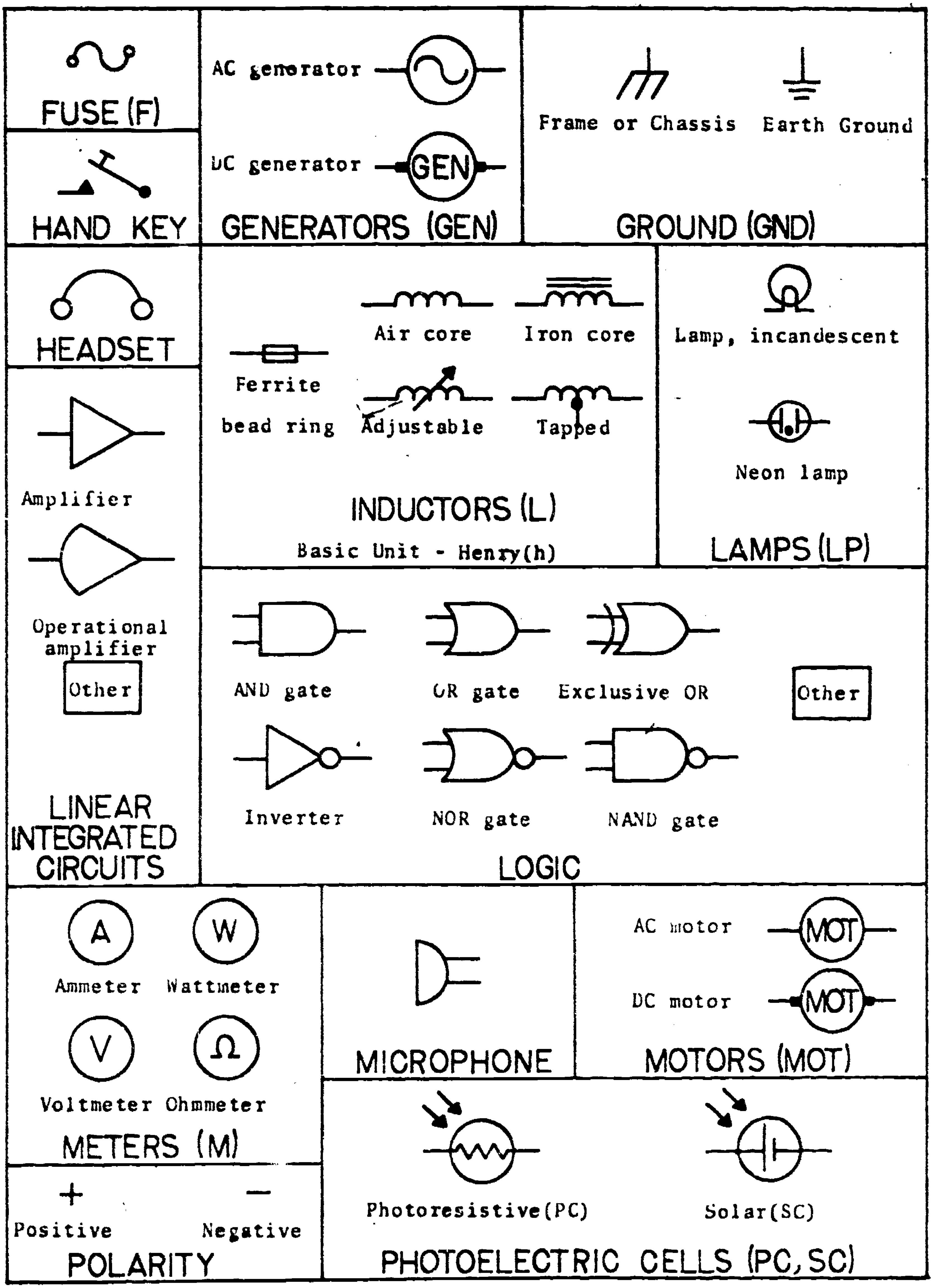
Period: ____________

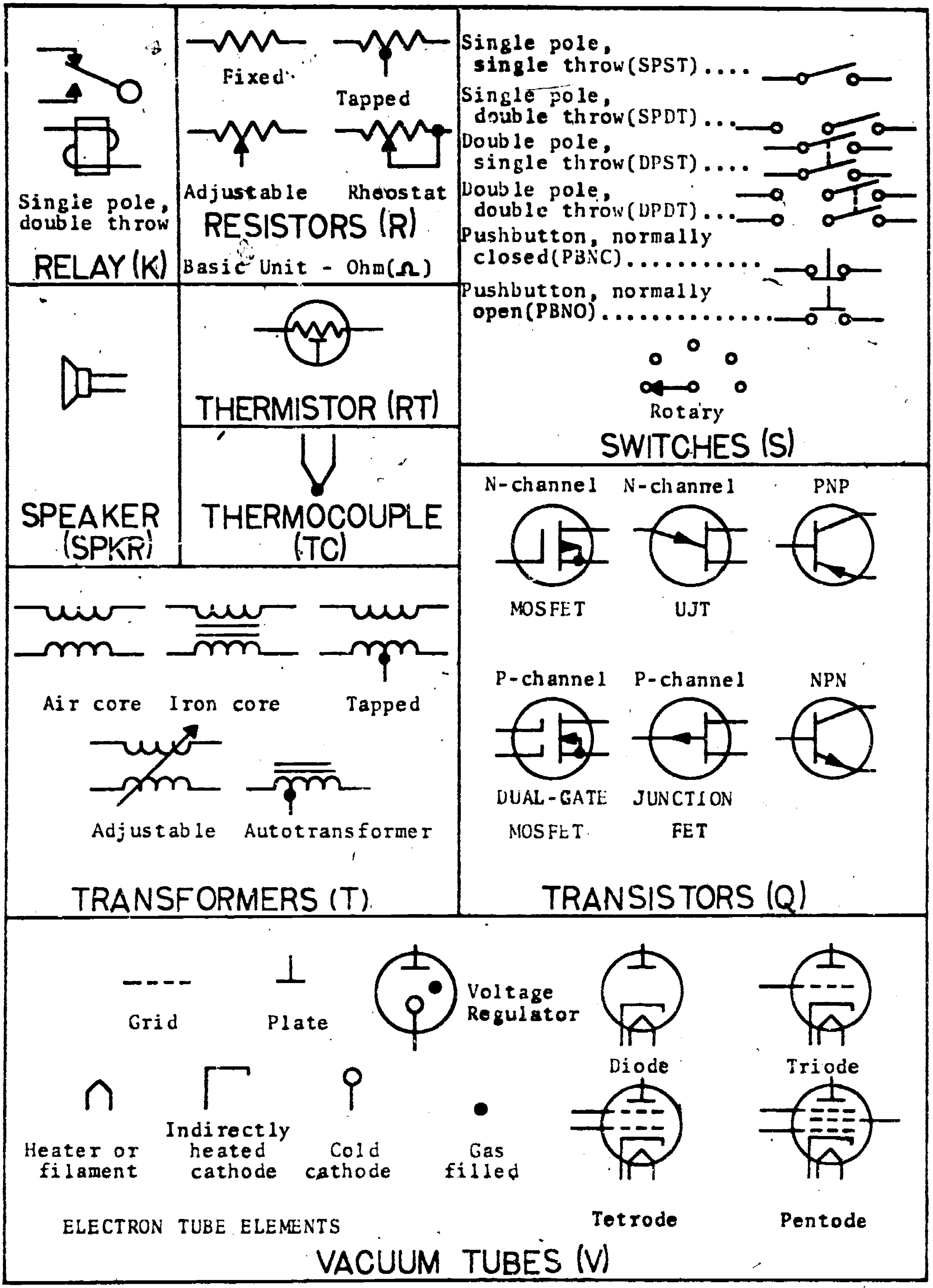
INFORMATIONAL HANDOUT

GRAPHIC SYMBOLS

Illustrated below is a list of graphic symbols commonly used to depict electrical and electronic devices and their connection into a circuit. Currently accepted letter designations and unit abbreviations are also provided.




FUSE (F)
HAND KEY
AC generator
DC generator
GEN
GENERATORS (GEN)
Frame or Chassis
Earth Ground
GROUND (GND)
HEADSET
Ferrite bead ring
Air core
Iron core
Adjustable
Tapped
INDUCTORS (L)
Basic Unit - Henry(h)
Lamp, incandescent
Neon lamp
LAMPS (LP)
Amplifier
Operational amplifier
Other
LINEAR INTEGRATED CIRCUITS
AND gate
OR gate
Exclusive OR
Other
Inverter
NOR gate
NAND gate
LOGIC
A
W
Ammeter
Wattmeter
V
Ω
Voltmeter
Ohmmeter
METERS (M)
MICROPHONE
AC motor
DC motor
MOT
MOTORS (MOT)
+
−
Positive
Negative
POLARITY
Photoresistive(PC)
Solar(SC)
PHOTOELECTRIC CELLS (PC, SC)


Single pole,
double throw
RELAY (K)
Fixed
Tapped
Adjustable
Rheostat
RESISTORS (R)
Basic Unit - Ohm(Ω)
Single pole,
single throw(SPST)....
Single pole,
double throw(SPDT)...
Double pole,
single throw(DPST)....
Double pole,
double throw(DPDT)...
Pushbutton, normally
closed(PBNC)..........
Pushbutton, normally
open(PBNO)...............
Rotary
SWITCHES (S)
SPEAKER
(SPKR)
THERMISTOR (RT)
THERMOCOUPLE
(TC)
N-channel
N-channel
PNP
MOSFET
UJT
P-channel
P-channel
NPN
DUAL-GATE
MOSFET
JUNCTION
FET
TRANSISTORS (Q)
Air core
Iron core
Tapped
Adjustable
Autotransformer
TRANSFORMERS (T)
Grid
Plate
Voltage
Regulator
Diode
Triode
Heater or
filament
Indirectly
heated
cathode
Cold
cathode
Gas
filled
Tetrode
Pentode
ELECTRON TUBE ELEMENTS
VACUUM TUBES (V)

The following abbreviations are standards adopted by the Institute of Electrical and Electronic Engineers (IEEE).

TERM			
alternating current	AC	mega	M
ampere or amp	A	micro	μ
amplitude modulation	AM	micro-micro	$\mu\mu$
audio frequency	AF	milli	m
average	AVG	nano	n
capacitance	C	ohm	Ω
capacitive reactance	X_C	output	OUT
conductance	G	peak to peak value	p-p
counter electromotive force	CEMF	peak value	PK
current	I	period	T
cycles per second	cps	pi	π
decibel	db	pico	p
direct current	DC	positive	+
effective	EFF	power	P
electromotive force	EMF	radio frequency	RF
farad	F	reactance	X
frequency	f	resistance	R
frequency modulation	FM	root mean square	RMS
ground	GND	second	s
henry	h	sine wave	$\sim$
hertz	Hz	time	t
impedance	Z	ultra high frequency	UHF
inductance	L	very high frequency	VHF
inductive reactance	X_L	volt	V
input	IN	voltage	E
kilo	k	watt	W
kilowatt-hour	kwh	wavelength	λ

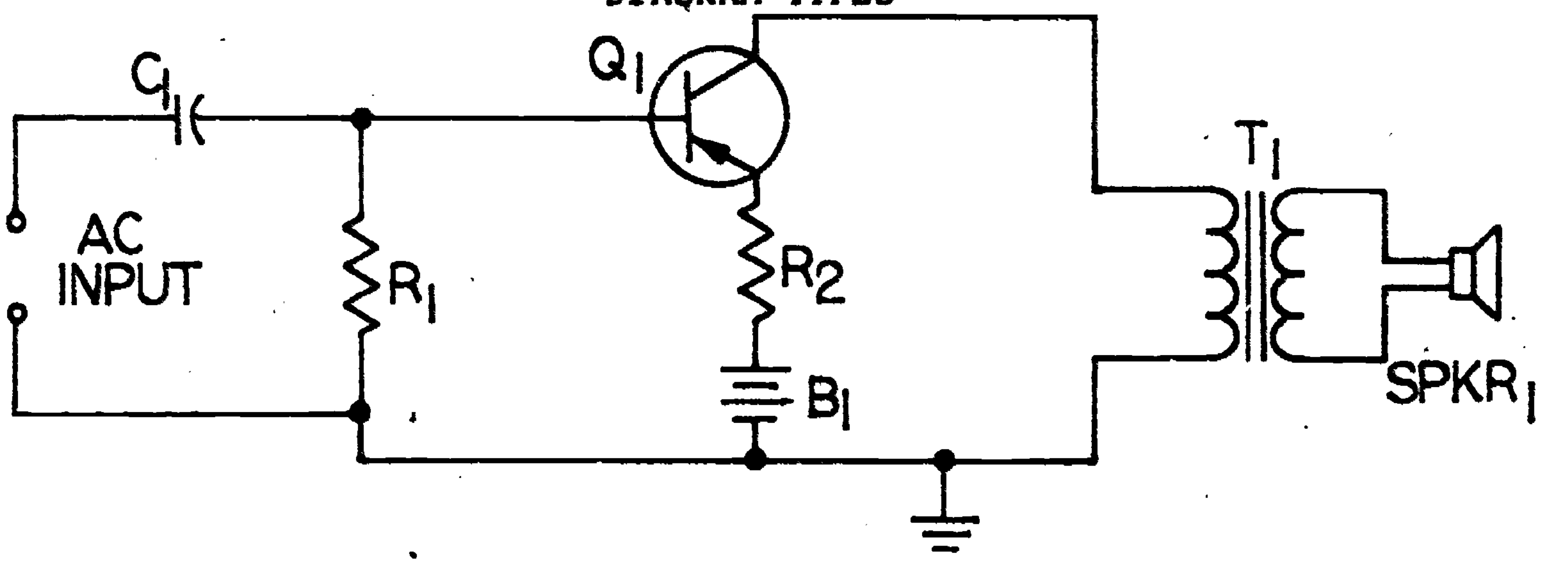
Name: ______________

Date: ______________

Period: ______________

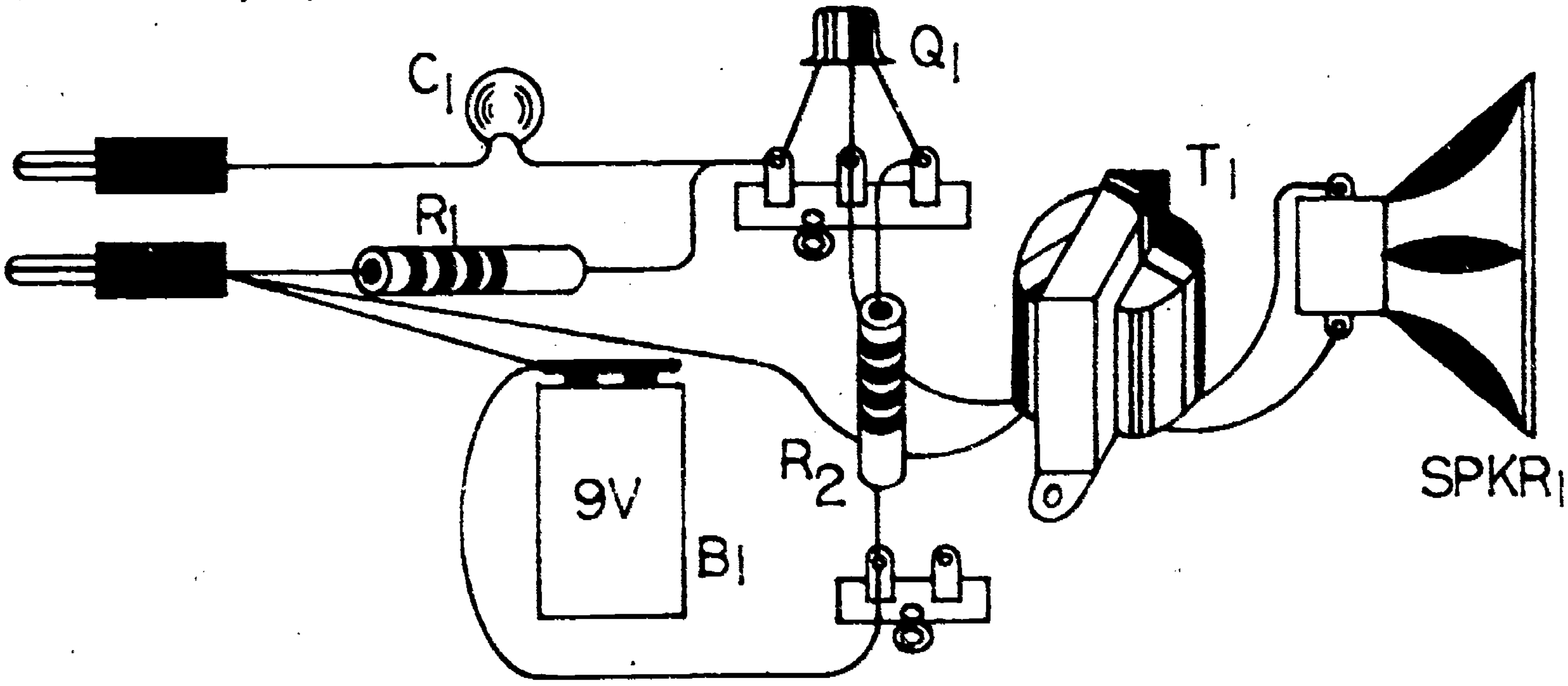
INFORMATIONAL HANDOUT

DIAGRAM TYPES



SCHEMATIC DIAGRAM

The schematic diagram is the most important diagram used by electronics personnel because it provides a convenient way of tracing circuit operation and signal flow. On this diagram the components are represented by graphic symbols, and the connecting lines indicate wires. The symbols and associated lines show how the components of a circuit are connected and the relationships among the various parts. The symbols are arranged so that the diagram can be "read" from left to right. Component symbols are assigned a letter designation for parts identification. Whenever possible connecting lines should be drawn either horizontally or vertically. The numerical values of components are often indicated directly on the diagram. Unlike the pictorial diagram, the schematic does not show the location of components or wires on the chassis; it also does not show wiring devices such as lugs, sockets, and terminals.



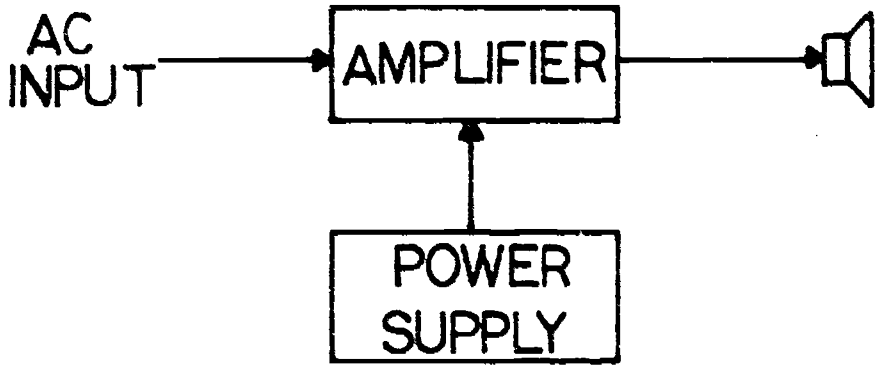
PICTORIAL DIAGRAM

Name: ______________

Date: ______________

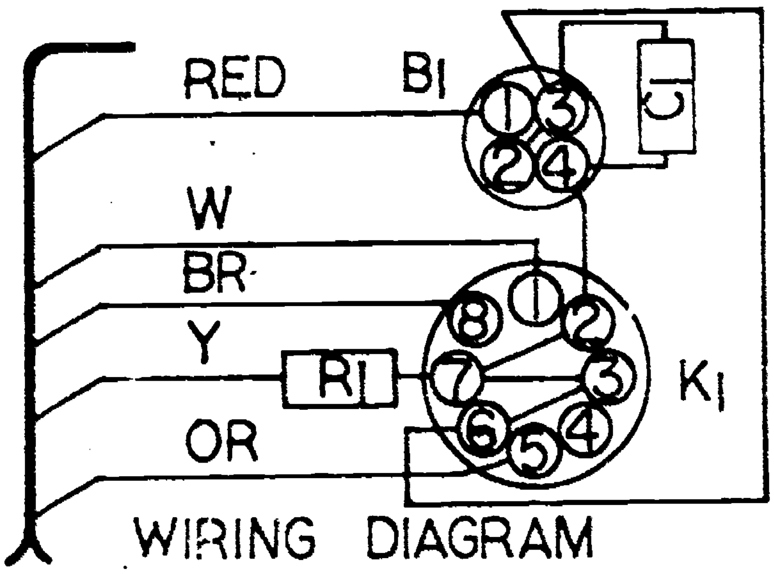
Period: ______________

The pictorial diagram is easy to read and interpret. The drawing shows the circuit components, their location on the chassis or panel, and how they are connected together. The diagram is usually drawn to scale, and wire connections are drawn with as little cross-over as possible. Components are generally identified by their reference designation. Pictorial diagrams are widely used in assembly line production work, maintenance activities, and do-it-yourself kits.



BLOCK DIAGRAM

The block diagram is used to show the relationship between various stages in a system. It indicates the path of signal flow through a circuit or the operational sequence that is followed by the circuit. The blocks, which represent a circuit or stage, are most often drawn as squares or rectangles, and joined by single lines. Arrowheads at the ends of the lines indicate the direction of signal flow. Each stage (block) is labeled with its function; as a general rule the stage operation is printed within the block. This diagram does not give any information on components used within the stages, or wiring connections. One use for block diagrams is as a first step in design or engineering of a system. The basic stages and signal flows are determined in block form. From there, a schematic diagram of each stage and interconnection can be developed.



WIRING DIAGRAM

The wiring diagram is used to show wiring connections in a simplified manner. The diagram can show circuit components in a pictorial manner, and is primarily a connecting and visual troubleshooting aid. Wires are labeled by color for ease in identification. Wiring diagrams are also applicable to wire harness layout and connection diagrams.

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

ANSWER SHEET

EXAM LIII US

	T A	F B	C	D
1.		■		
2.	■			
3.		■		
4.		■		
5.	■			
6.		■		
7.	■			
8.	■			
9.		■		
10.	■			
11.		■		
12.	■			
13.	■			
14.	■			
15.		■		
16.	L			
17.	S			
18.	J			
19.	M			
20.	I			
21.	E			
22.	K			
23.	P			
24.	N			
25.	H			

	T A	F B	C	D
26.	R			
27.	F			
28.	O			
29.	G			
30.	Q			
31.	resistor			
32.	neon lamp			
33.	transformer			
34.	diode			
35.	capacitor			
36.	inductor air core			
37.	P.B.N.O. switch			
38.	inductor iron core			
39.	DPDT switch			
40.	ammeter			
41.				
42.				
43.				
44.				
45.				
46.				
47.				
48.				
49.				
50.				

	T A	F B	C	D
51.				
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74.				
75.				

	T A	F B	C	D
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98.				
99.				
100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 5

A. GLOSSARY CRYPTIC

1. graphic symbols
2. block diagram
3. connection
4. component
5. schematic

B. ELECTRONIC GRAPHICS

1.
2.
3.
4.
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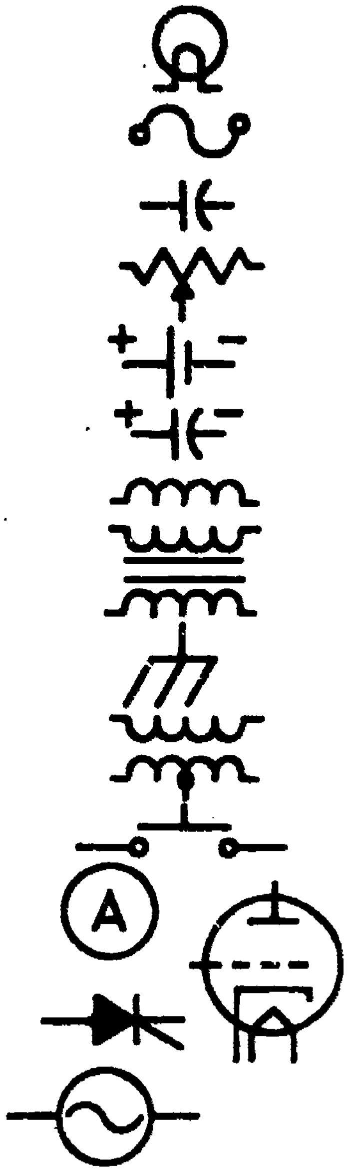
10.
11.
12.
13.
14.
15.



16. P.B.N.O. switch
17. variable capacitor
18. AC generator
19. diode
20. voltmeter
21. tapped resistor
22. solar photo electric cell
23. iron core inductor
24. AC plug
25. connection (wire)
26. diode
27. earth ground
28. transistor (NpN)
29. speaker
30. neon lamp

C. LETTER IDENTIFICATION OR ABBREV.

31. I
32. S
33. V
34. D
35. B
36. m
37. A
38. s
39. AVG
40. GND
41. C
42. E
43. p-p
44. RF
45. R
46. TC
47. P
48. K
49. Ω
50. Hz

D. IDENTIFICATION

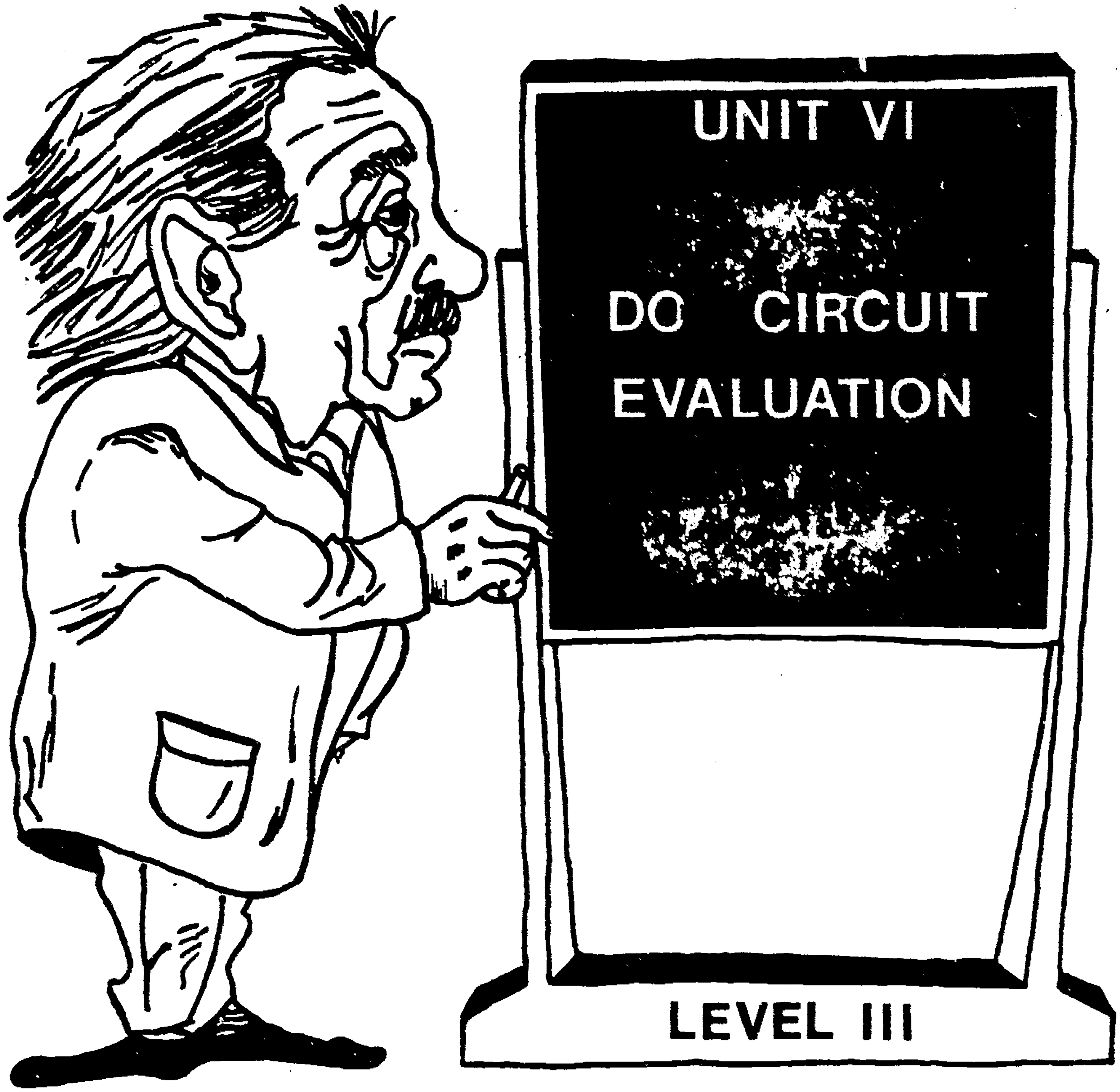
51. frequency
52. capacitance
53. jack
54. switch
55. transistor
56. direct current
57. decibel
58. inductive reactance
59. kilo
60. effective
61. pico
62. amplitude modulation
63. impedance
64. voltage
65. very high frequency
66. single pole double throw
67. diode
68. farad
69. input
70. peak value

E. QUEST ACTIVITY

(subjective evaluation)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME_______________

DATE STARTED__________

DATE COMPLETED_________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: D.C. Circuit Evaluation

Time Allocation: 4 weeks

Unit Goal:

To acquire those competencies which will allow a detail technical evaluation of circuits predicated on both Ohm's and Kirchhoff's Laws.

Unit Objectives:

The student will be able to:

1. identify series, parallel, and combination circuits in a diagram and list an example of practical uses for each type of circuit arrangement.

2. solve for total resistance utilizing proper formulas and units of measurement for each type of circuit discussed.

3. explain that voltage is dropped when there is a current flow through a resistance and demonstrate that the voltage drop is directly proportional to the resistance.

4. verify calculated values of voltage, current, and resistance for a series, parallel, and combination circuit by assembling a test circuit and measuring quantities with the proper meter.

5. recite and apply both Ohm's and Kirchhoff's Laws as requested when solving or evaluating circuits.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References.

Basic Electronic Systems Technology Unit 2. Dugger, Patrick, Suess, and Ziegler, Bruce, 1973. Lessons: 5-21.

Electricity and Basic Electronics. Stephen R. Matt, Goodheart - Willcox, 1977. Chapters: 5, 6, 7, and 9.

Introduction to Electricity and Electronics. Loper and AHR, Delmar 1973. Chapters: 2 and 3.

Overview:

Unit 6 is presented as a functional outgrowth of Units 4 and 5, and this unit should begin with a simple review of basic concepts and definitions previously presented.

Next, the conceptually more difficult series, parallel, and combination circuit analysis are introduced. In order for students to master complex circuit evaluation and to allow the student to feel comfortable initially, a slow methodical approach to solving resistance total should be taught prior to each topic application. The unit was designed to stress circuit analysis through the use of both Ohm's and Kirchhoff's Laws, however, an underlining lesson philosophy was that certain basic properties are common to all circuits regardless of how simple or elaborate the circuit may be.

Unit 6 concludes with an emphasis on combination circuits since most practical circuits in electronic and other sophisticated devices are variations of two basic circuits used in alliance.

This unit must be coordinated with a variety of step-by-step explanations and activities including laboratory exercises in a rigorous program in order to insure student comprehension and success.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. Try this activity "Spell Down": Organize the class into two teams. Using the unit Technical Glossary, the captain of #1 team will call out a term, student #1, team #2 will spell the word, while student #1, team #1, will define it. Alternate this procedure and judge student performance.
2. Do not overlook the fact that this unit does assume certain basic mathematical competencies, however, reteaching basic skills will greatly facilitate the disadvantage student. Students sometime find difficulty also in relating to a formula so try and present this concept so that students will view it like responding to a "recipe", the student must follow the recipe to obtain the desired results and any variation may bring disaster.
3. In addition to formal laboratory experiments, certain laboratory exploration can assist the instructor in vividly illustrating the physical configurations of series, parallel, or combination circuits. Have students physically wire used or extra parts into these positions as a means to familiarize the student with important circuit characteristics. Note; if meter reading is a major portion of student laboratory experiments, in this unit, be cognizant of the problems students

Methodology continued:

seem to always have in correct placement. Proper meter installation exercises are a precaution that will keep repair time down in the laboratory.

4. Solving circuit problems using Ohm's and Kirchhoff's Law require the student to evaluate circuits by utilizing logical strategy. This strategy should be stressed with emphasis on identifying the type of circuit, solving for the obvious, determining unknown quantities, applying formulas, combining resistors when necessary, recording results, indicating proper units of measurement, and checking results.

Supplemental Activities and Demonstrations:

1. Instructor assembles a demonstration board using a switch that when engaged in one direction, allows lamps to light in series, when engaged the other way, light in parallel. Many observations and measurements can be illustrated along with meter placement techniques and troubleshooting.
2. To emphasize the idea of items being connected in series or parallel have students in rows join hands end to end. Similarly, in rows across from each other allow students to clasps hands simulating a parallel configuration. These activities have the potential of providing a solid means in visualizing circuitry connections.
3. Instructors often resort to water flow analogies when describing current flow in basic circuit configuration, however, these comparisons must be selected carefully to insure technical accuracy. For example, voltage can be liken to water pressure, current can be represented as the rate of water flow, and resistance can be compared to as a small obstruction within the pipe. Note, explain that the pipes are always filled with water as wire always contains electrons as a vehicle for flow.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Word Decoding
5. Worksheet - Series Circuit Analysis #1 and #2
6. Worksheet - Parallel Circuit Analysis #1 and #2
7. Worksheet - Combination Circuit Analysis
8. Quest Activity
9. Informational Handout (Circuit Evaluation Principles)
10. Informational Handout (Deriving Equivalent Circuits)
11. Unit Module Answer Keys

VI. D.C. Circuit Evaluation

A. Kirchhoff's Laws

1. Series circuit analysis
   A. Solving for total resistance

   B. Application of Ohm's Law

   C. Application of Kirchhoff's Laws

2. Parallel circuits analysis
   A. Solving for total resistance

   B. Application for Ohm's Law

   C. Application of Kirchhoff's Law

3. Combination circuit analysis

A. Solving for total resistance

B. Application of Ohm's Law

C. Application of Kirchhoff's Law

LIII-U6

UNIT EXAM

D.C. CIRCUIT EVALUATION

IMPORTANT-
Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question- there is only one correct answer for each question.

1. When a series circuit is opened at any point, the entire circuit is dead. (T-F)

2. When one of the loads in a parallel circuit is turned off, all the remaining loads are also turned off. (T-F)

3. All of the resistors in a parallel circuit must operate with the same amount of current. (T-F)

4. The addition of parallel loads does not cause the total current of a parallel circuit to increase. (T-F)

5. The total resistance (R_T) of a parallel circuit is equal to the sum of the individual resistances in the circuit. (T-F)

6. To find the total resistance of a series circuit one must multiply the individual resistances. (T-F)

7. A DC ammeter is connected in series with the circuit. (T-F)

8. In a series circuit the sum of the current through each individual resistor is equal to the total current. (T-F)

9. The total resistance of a parallel circuit can be found using Ohm's Law. (T-F)

10. In each of the three forms of Ohm's Law, the value to be found is located on the left side of the equation. (T-F)

11. When utilizing any of the forms of Ohm's Law current, voltage, and resistance must be expressed with basic units of measurement. (T-F)

12. Only one of the values in a problem must be known before Ohm's Law can be used to find the unknown. (T-F)

13. D.C. circuit evaluation or analysis requires identifying which components are in parallel and which are in series. (T-F)

14. Resistors are in series when the current divides and flows through each branch resistor. (T-F)

15. E_T is an expression that indicates the value of total electromotive force in the circuit. (T-F)

16. The formula for finding total resistance in a parallel circuit is: (A) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots + \frac{1}{R_N}$ (B) $R_T = \frac{R}{N}$

(C) $R_T = \dfrac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$ (D) All of the above.

17. To find total resistance in a series circuit you should use the following formula: (A) $R_T = R_1 \times R_2 \times R_3 \times \cdots \times R_N$ (B) $R_T = \dfrac{1}{R_1 + R_2 + R_3 + \cdots + R_N}$ (C) $R_T = R_1 + R_2 + R_3 + \cdots + R_N$

(D) $R_T = R_1 * R_2 * R_3 * \cdots * R_N$

18. Three resistors are connected in series. Find the total resistance if each resistor has a value of 150 ohms. (A) 50 ohms (B) 450 ohms (C) 300 ohms (D) 150 ohms

19. When resistors are connected in series: (A) The equivalent resistance increases (B) The equivalent resistance decreases (C) The total resistance equals the sum of the individual resistance values (D) Both A and C

20. Two resistors measuring 100 and 200 ohms, respectively, are connected in parallel across a 100 volt source. If the voltage drop across the 200 ohm resistor is measured, it will be: (A) Higher than the voltage across the 100 ohm resistor. (B) Equal to the voltage across the 100 ohm resistor. (C) Less than the voltage across the 100 ohm resistor. (D) Exactly double the voltage across the 100 ohm resistor.

21. Two resistors measuring 100 and 200 ohms, respectively, are connected in series across a 100 volt source. If the voltage drop across the 200 ohm resistor is measured, it will be: (A) Equal to the drop across the 100 ohm resistor. (B) Less than the drop across the 100 ohm resistor. (C) Exactly twice the drop across the 100 ohm resistor. (D) Exactly one-half the drop across the 100 ohm resistor.

22. Adding another resistance branch to a parallel circuit would cause the total resistance to: (A) Increase (B) Decrease (C) Remain the same (D) Either A or B depending upon the value of the resistor

23. A voltage present across any load in a circuit is commonly called a: (A) Total voltage (B) Voltage drop (C) Part voltage (D) Circuit voltage

24. In a parallel circuit, the loads and their connecting wires are often referred to as: (A) Stems (B) Spurs (C) Branches (D) By passes.

25. When connecting a voltmeter into a DC circuit, (A) polarity is not important. (B) the meter is connected in series with the circuit. (C) the voltmeter is connected in parallel. (D) the negative meter lead connects to the most positive point in the circuit.

26. When a voltage is indicated at some point in a circuit, the actual meaning is: (A) the voltage between that point and a reference point. (B) the voltage without reference to any other point. (C) always the voltage between that point and the positive terminal of the source. (D) the voltage between that point and any other point.

27. In a series circuit, the current is: (A) Greater in the high resistance components. (B) The same in all parts of the circuit. (C) The sum of the branch currents. (D) Greater in the low resistance components.

28. In a parallel circuit, the current: (A) Is greatest in the highest resistance branch. (B) In each branch is added together to determine the total current. (C) Is the same in all parts of the circuit. (D) Is inversely proportional to the source voltage.

29. In a series circuit, the source voltage: (A) Is equal to the sum of the voltages across the components. (B) Is applied directly across each component. (C) Forces a different amount of current through each component. (D) Is always divided equally among all components.

30. In a parallel circuit, the source voltage: (A) Is equal to the sum of the voltages across the components. (B) Appears across each branch. (C) Is inversely proportional to the resistance of each branch. (D) Always forces the same amount of current through each branch.

31. When connecting an ohmmeter to measure the resistance of circuit: (A) Power should be removed from the circuit. (B) The ohmmeter is connected in series with the circuit. (C) Power should be applied to the circuit. (D) Make sure that only AC current is flowing in the circuit.

32. In a series circuit, (A) the current through each component is different. (B) the total resistance is found by the "product over the sum" formula. (C) the same voltage always appears across each component. (D) there is only one path for current.

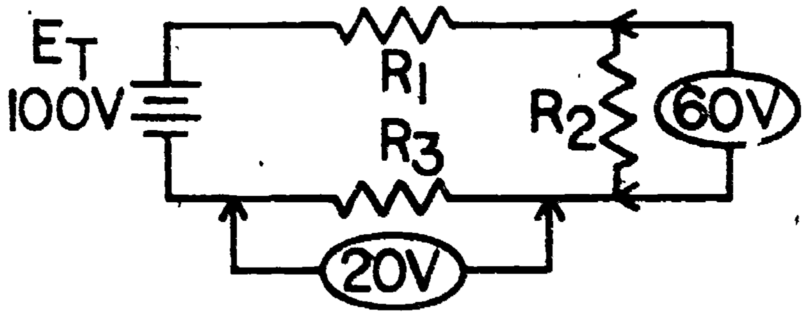
33. What is the total resistance of a 50 kΩ, a 25 kΩ, and a 1MΩ resistor connected in series: (A) 17.5 kΩ. (B) 1.075 MΩ. (C) 1.025 MΩ. (D) 100,750Ω.

34. If the total resistance in a series circuit decreases and the supply voltage remains the same, (A) circuit current increases. (B) the voltages across all components decrease. (C) circuit current decreases. (D) circuit current remains the same.

35. In a parallel circuit, (A) the same current flows through each component. (B) the total resistance is equal to the sum of the individual resistances. (C) only one current path exists. (D) the sum of the branch currents equals the total current.

36. What is the resistance of two 100kΩ resistors connected in parallel? (A) 20 kΩ. (B) 25 kΩ. (C) 50 kΩ. (D) 125 kΩ.

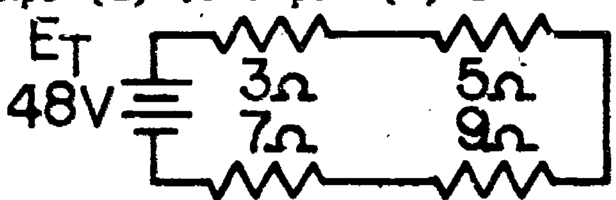
37. What is the value of E_{R1} in the diagram below? (A) 180 V (B) 100 V (C) 80 V (D) 20 V



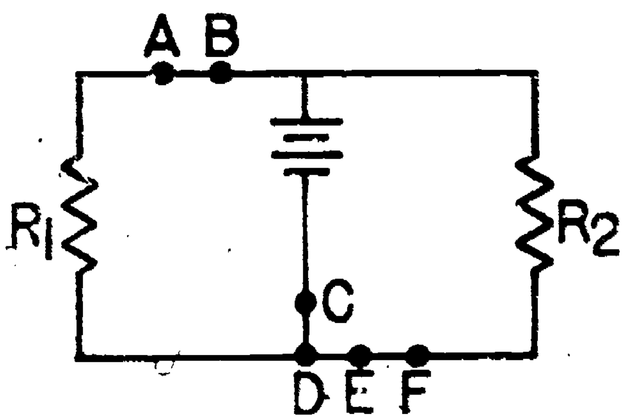
38. The statement, "Circuit current is directly proportional to the applied voltage and inversely proportional to circuit resistance," is known as: (A) Kirchhoff's Law (B) Watt's Law (C) Ohm's Law (D) Franklin's Law

39. What is the voltage drop across a 30 ohm resistor that has 2 amps of current flowing through it? (A) .06 volts (B) 15 volts (C) 60 volts (D) 120 volts

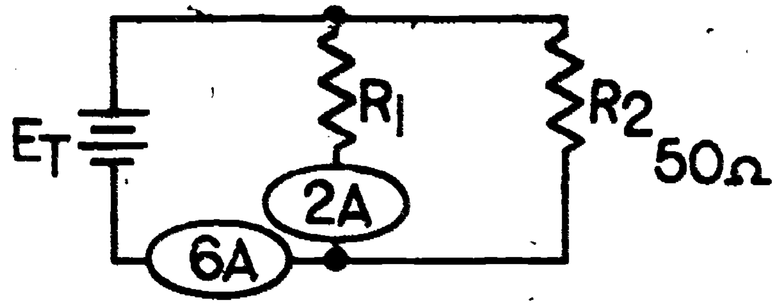
40. What is the total current in the circuit below? (A) 2 amps (B) 5 amps (C) .5 amps (D) 1152 amps.



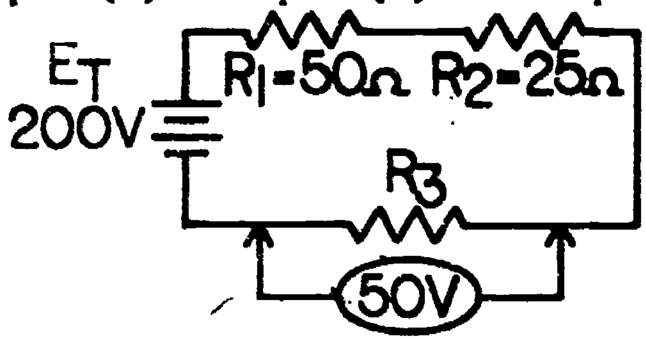
41. Between which two points of the circuit should an ammeter be connected to measure total circuit current. (A) A and B (B) C and D (C) D and E (D) E and F



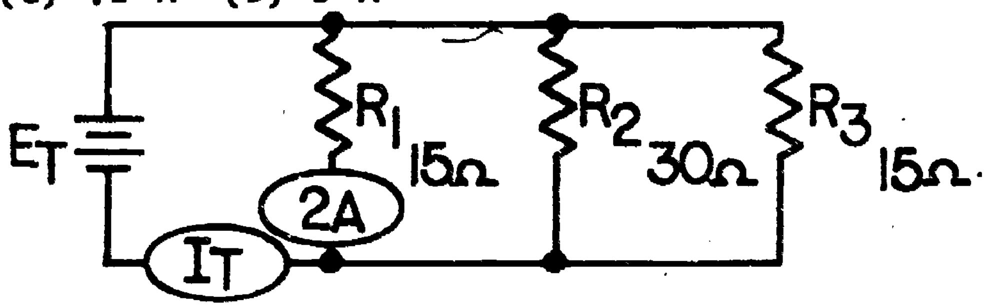
42. What is the total voltage in the circuit below? (A) 200 V (B) 100 V (C) 300 V (D) 25 V



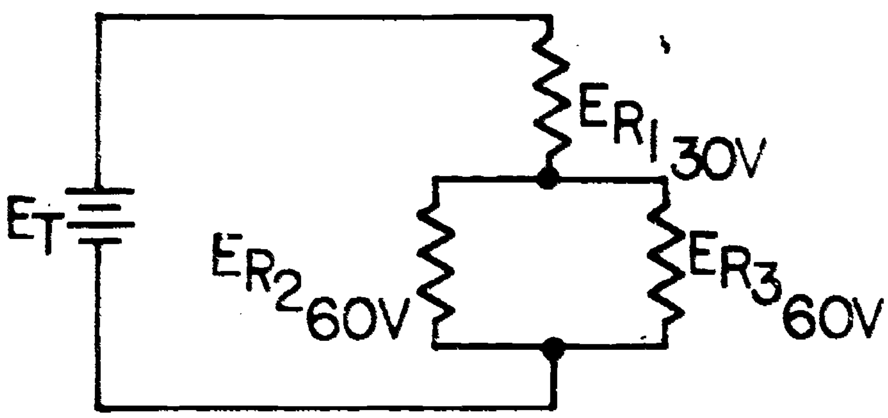
43. This series circuit has a total current of: (A) .5 amps (B) 4 amps (C) 2 amps (D) 2.6 amps.



44. Find the total current in this parallel circuit. (A) 30 A (B) 6 A (C) .2 A (D) 5 A



45. What is the value of the source voltage? (A) 30 V (B) 90 V (C) 120 V (D) 150 V



Name: ____________

Date: ____________

Period: ____________

TECHNICAL GLOSSARY

APPLIED VOLTAGE: The source voltage of a circuit, or the voltage introduced into a circuit, also referred to as Total Voltage (E_T).

BRANCH CURRENT: The current flow through one of the current paths of a parallel circuit.

CIRCUIT EVALUATION: The process of determining electrical circuit quantities - E, I, and R, etc. By applying basic laws such as Ohm's Law and Kirchhoff's Law.

DIRECTLY PROPORTIONAL: A relationship by which a change in one quantity causes an equal change in another quantity. For example; using Ohm's Law, if current is doubled, voltage will also double; hence voltage and current are directly proportional.

EQUIVALENT CIRCUIT: A simple circuit which has been reduced or derived from a complex circuit. Combination circuits may be simplified into an equivalent circuit by combining parallel resistance branches and series paths.

E_{R_N}: An abbreviation to indicate the voltage drop across resistor "N" in a circuit. The "N" is used to represent any resistor in the circuit. E_{R_1} means the voltage drop across resistor one.

FORMULA: The mathematical expression which explains a fixed relationship between values. Using a formula one can solve for an unkown value provided all necessary data is available.

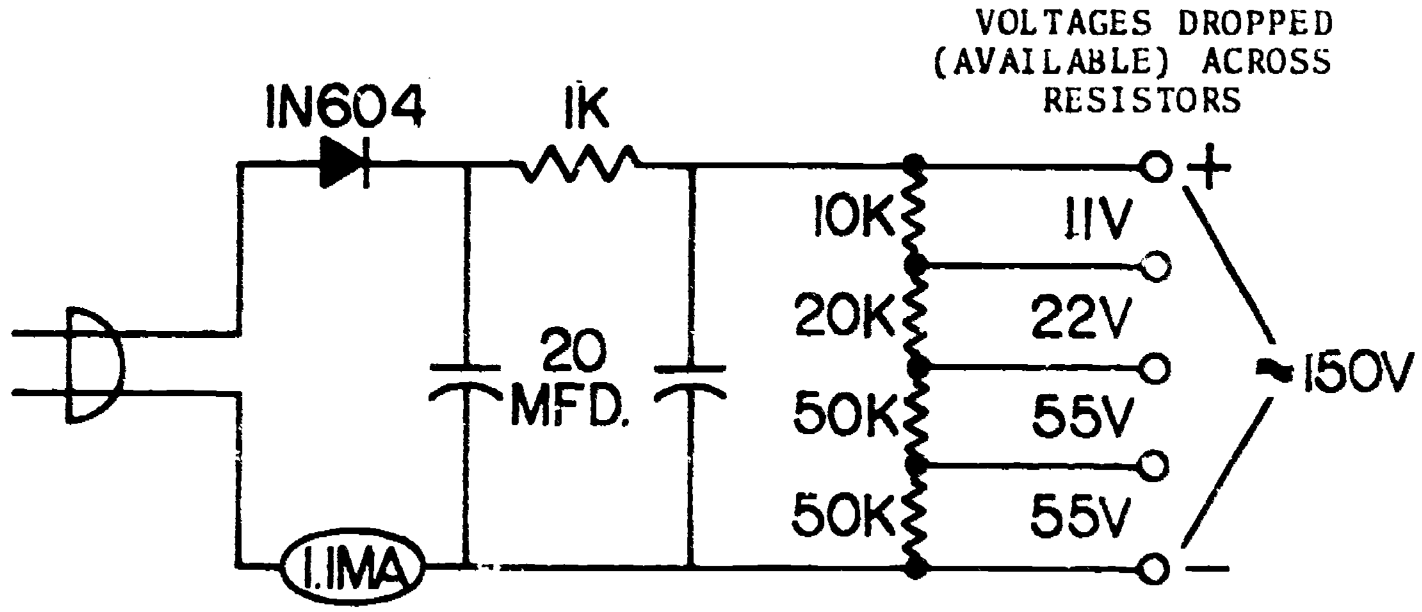
INVERSELY PROPORTIONAL: A relationship by which a change in one quantity produces an opposite change in another. For example; using Ohm's Law, if resistance is doubled in a circuit, current is reduced by half. Thus; current and resistance are inversely proportional.

I_{R_N}: An abbreviation indicating the current flow through resistor "N". The "N" is used to represent any resistor in the circuit. To be more specific I_{R_1} would indicate the current flow through resistor one.

I_T: An abbreviation indicating total circuit current, or the current delivered by the source to the circuit.

Name: ____________

JUNCTION:	A point in a circuit where several connections are made. The junction serves as the beginning point of a parallel circuit, and when current flows out of the junction it "Divides Up" flowing into each branch of the parallel circuit.
KIRCHHOFF'S CURRENT LAW:	A basic electrical law which states: The total current flowing into a junction in a circuit will always equal the total current flowing out of the junction.
KIRCHHOFF'S VOLTAGE LAW:	A basic electrical law which states: The sum of the voltage drops in a series circuit equals the source voltage.
R_T:	An abbreviation indicating the value, in OHMS, of resistor "N". "N" indicated any particular resistor in the circuit. For example; R_3 means the value of resistor three.
VOLTAGE DROP:	The voltage developed across a resistor due to current flow through the resistor. The voltage drop is directly proportional to current and resistance.



TYPICAL VOLTAGE DIVIDER NETWORK

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

VOCABULARY WORD DECODING

The words below have little meaning until they are decoded. Each letter actually represents another letter in the alphabet. Your task is to break the code and decode each word. The example will get you started by providing three decoded letters. The code remains the same throughout the worksheet.

EXAMPLE: A. F N X — A. [AMP]

A M P

1. I E Q W J Y M Q — 1. [ ]

_ _ _ _ _ _ _ _

2. G M T N E S F — 2. [ ]

_ _ _ _ _ _ _

3. F X X S Y U C A M S J F R U — 3. [ ]

_ _ _ _ _ _ _ _ _ _ _ _ _ _

4. W Y T W E Y J U A F S E F J Y M Q — 4. [ ]

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

5. A M S J F R U C T M X — 5. [ ]

_ _ _ _ _ _ _ _ _ _ _

6. B Y T W P P M G G Z S F O — 6. [ ]

_ _ _ _ _ _ _ _ _ _ _ _ _

7. H T F Q W P W E T T U Q J — 7. [ ]

_ _ _ _ _ _ _ _ _ _ _ _ _

8. J M J F S W E T T U Q J — 8. [ ]

_ _ _ _ _ _ _ _ _ _ _ _

9. C Y T U W J S D X T M X M T J Y M Q F S — 9. [ ]

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

10. J M J F S T U Z Y Z J F Q W U — 10. [ ]

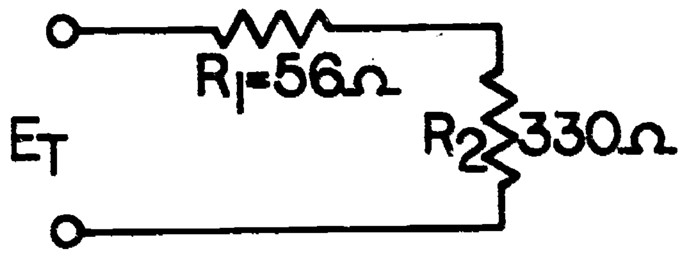
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _

SCORE:	Name: ____________
GRADE:	Date: ____________
	Period: ____________

WORKSHEET

SERIES CIRCUIT ANALYSIS #1

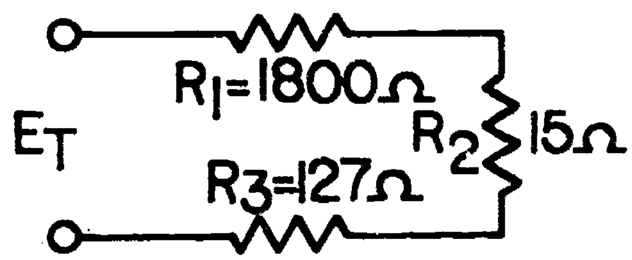
Solve the following circuit problems. Be certain to show work, and record your answer in the answer box.



1. Find the total resistance in the circuit above.

Show work

1. ____________



2. Find R_T

Show work

2. ____________

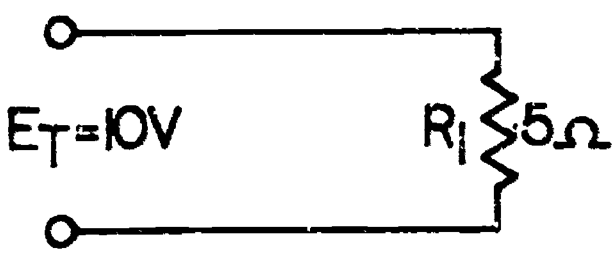
3A. Draw a series circuit which contains the following resistors - 100Ω, $47k\Omega$, $3.3k\Omega$, and 56Ω.

3B. Find the total resistance of the circuit.

Show work

3A. SCHEMATIC

3B. ____________



4. Find I_T

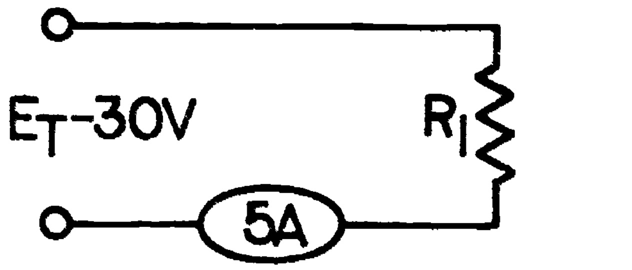
Show work

4. ____________

Name: ____________

Date: ____________

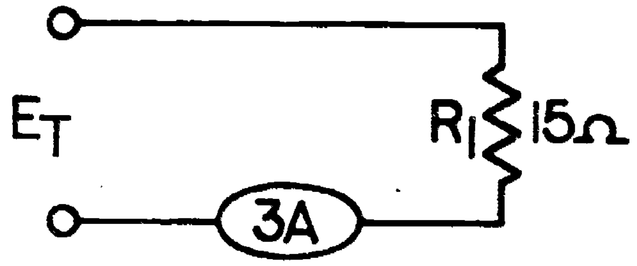
Period: ____________



5. Find R_1

Show work

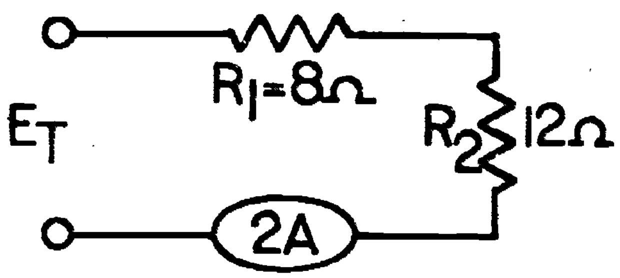
5. ____________



6. Find E_T

Show work

6. ____________



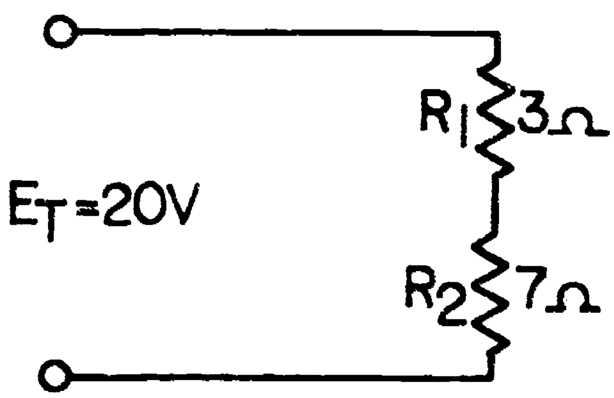
7. Find R_T

8. Find E_T

Show work

7. ____________

8. ____________



9. Find R_T

10. Find I_T

Show work

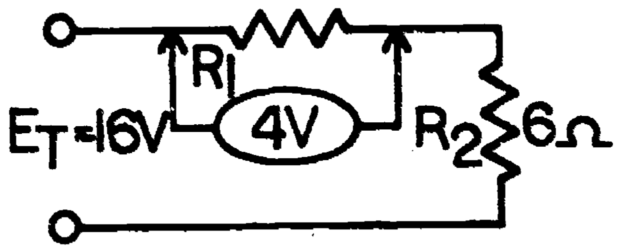
9. ____________

10. ____________

Name: ______________________

Date: ______________________

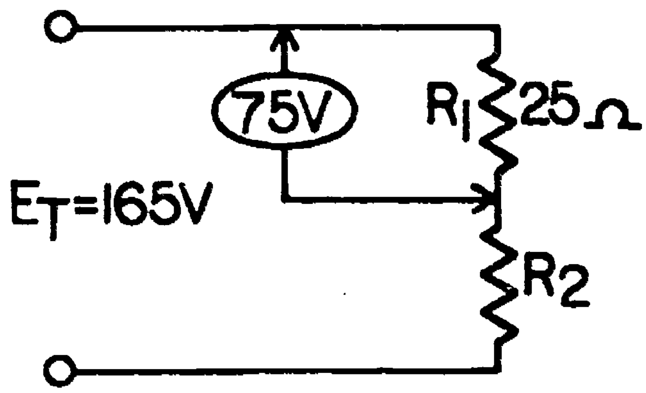
Period: ______________________



11. Find E_{R_2}
12. Find I_{R_2}
13. Find I_{R_1}
14. Find R_1

Show work

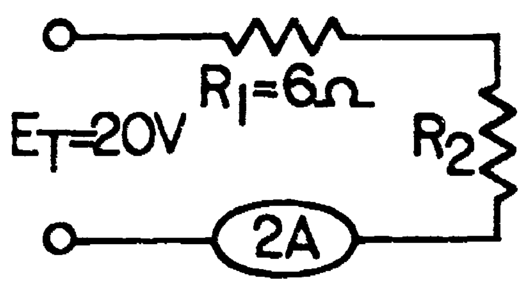
11. ____
12. ____
13. ____
14. ____



15. Find I_{R_1}
16. Find I_{R_2}
17. Find E_{R_2}
18. Find R_2
19. Find R_T

Show work

15. ____
16. ____
17. ____
18. ____
19. ____



20. Find I_{R_1}
21. Find E_{R_1}
22. Find E_{R_2}
23. Find R_2

Show work

20. ____
21. ____
22. ____
23. ____

SCORE:

GRADE:

Name: ____________

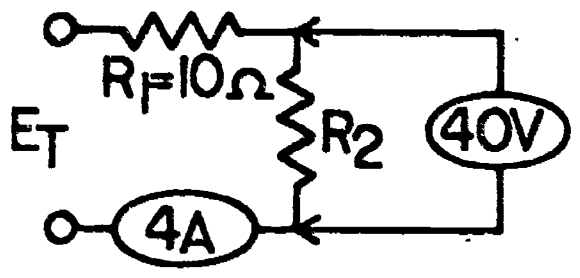
Date: ____________

Period: ____________

WORKSHEET

SERIES CIRCUIT ANALYSIS #2

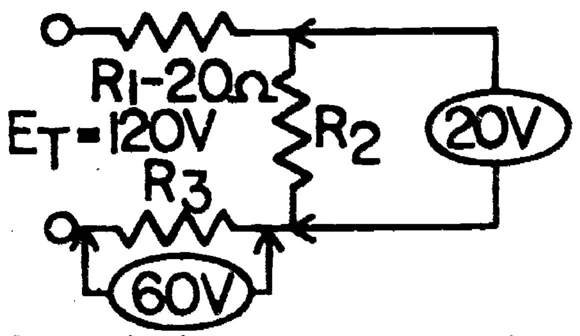
Solve the following circuit problems, be certain to show work, and record your answer in the answer box.



1. Find I_{R_2}
2. Find R_2
3. Find E_{R_1}
4. Find E_T

Show work

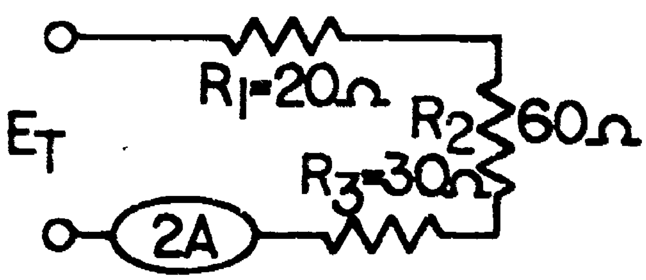
1. ____
2. ____
3. ____
4. ____



5. Find E_{R_1}
6. Find I_{R_1}
7. Find I_T
8. Find R_2
9. Find R_3

Show work

5. ____
6. ____
7. ____
8. ____
9. ____



10. Find R_T
11. Find E_{R_1}
12. Find E_{R_2}
13. Find E_{R_3}
14. Find E_T

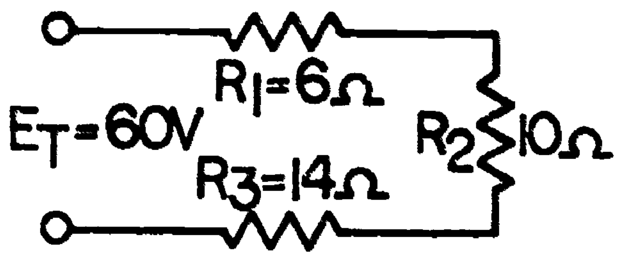
Show work

10. ____
11. ____
12. ____
13. ____
14. ____

Name: ______________

Date: ______________

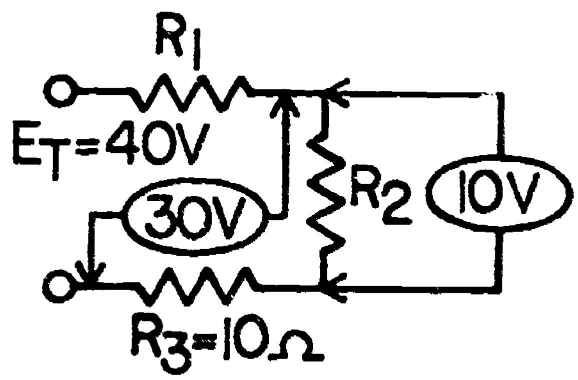
Period: ______________



15. Find R_T
16. Find I_T
17. Find E_{R_1}
18. Find E_{R_2}
19. Find E_{R_3}

Show work

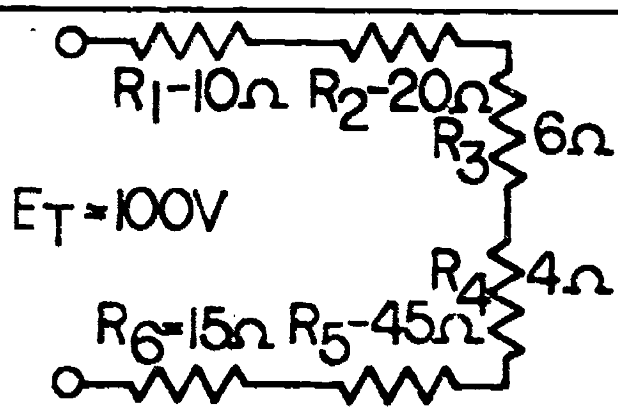
15. ______
16. ______
17. ______
18. ______
19. ______



20. Find E_{R_1}
21. Find E_{R_3}
22. Find I_{R_3}
23. Find R_2
24. Find R_1

Show work

20. ______
21. ______
22. ______
23. ______
24. ______



25. Find R_T
26. Find I_T
27. Find E_{R_1}
28. Find E_{R_2}
29. Find E_{R_3}
30. Find E_{R_4}
31. Find E_{R_5}
32. Find E_{R_6}

Show work

25. ______
26. ______
27. ______
28. ______
29. ______
30. ______
31. ______
32. ______

SCORE:

GRADE:

Name: ______________

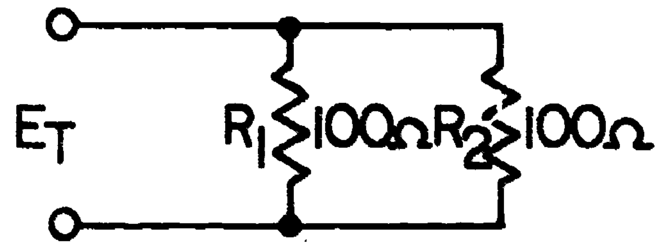
Date: ______________

Period: ______________

WORKSHEET

PARALLEL CIRCUIT ANALYSIS #1

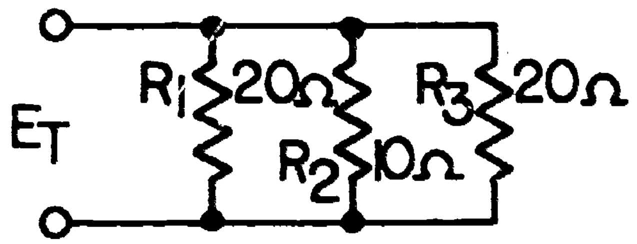
Solve the following circuit problems. Be certain to show work, and record your answer in the answer box.



1. Find the total resistance in the above circuit.

Show work

1. [ ]



2. Find R_T

Show work

2. [ ]

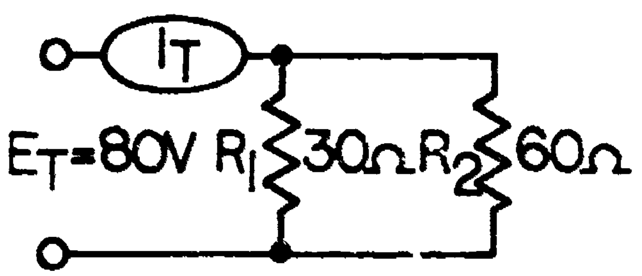
3A. Draw a parallel circuit which contains the following resistors 100Ω , 200Ω, 250Ω , and 1000Ω .

3B. Find the total resistance of the circuit.

Show work

3A. SCHEMATIC

3B. [ ]



4. Find R_T
5. Find I_T

Show work

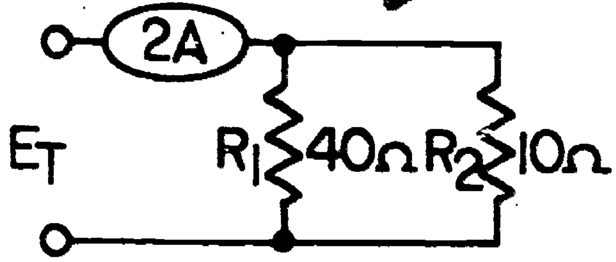
4. [ ]

5. [ ]

Name: ____________

Date: ____________

Period: ____________



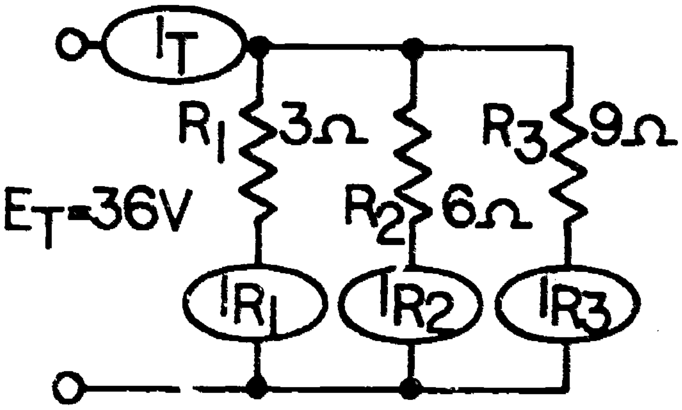
6. Find R_T

7. Find E_T

Show work

6. [ ]

7. [ ]



8. Find E_{R_1}
9. Find I_{R_1}
10. Find I_{R_2}
11. Find I_{R_3}
12. Find I_T

Show work

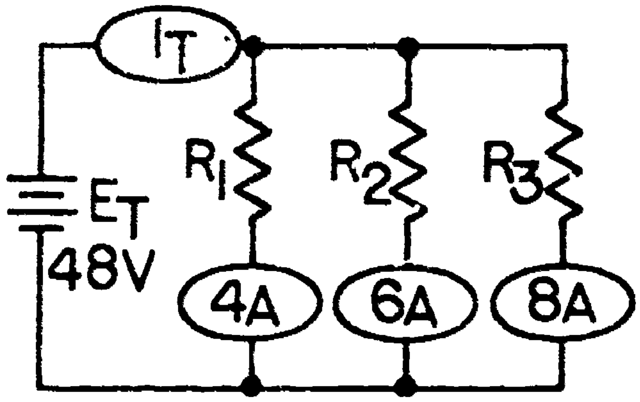
8. [ ]

9. [ ]

10. [ ]

11. [ ]

12. [ ]



13. Find I_T
14. Find E_{R_1}
15. Find R_1
16. Find R_2
17. Find R_3

Show work

13. [ ]

14. [ ]

15. [ ]

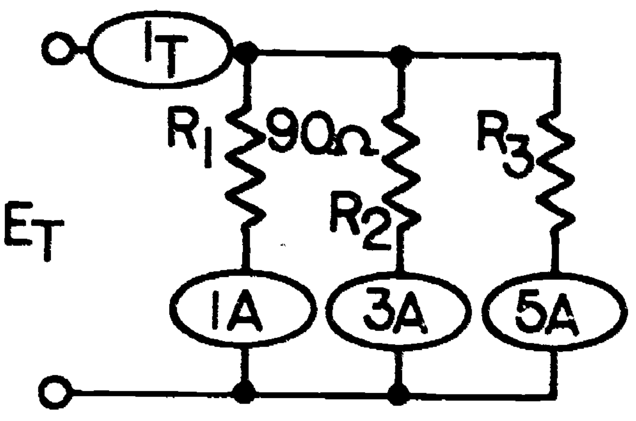
16. [ ]

17. [ ]

Name: ____________

Date: ____________

Period: ____________



18. Find I_T
19. Find E_{R_1}
20. Find E_T
21. Find R_2
22. Find R_3
23. Find R_T

Show work

18. [ ]
19. [ ]
20. [ ]
21. [ ]
22. [ ]
23. [ ]

Name: ____________

SCORE:

Date: ____________

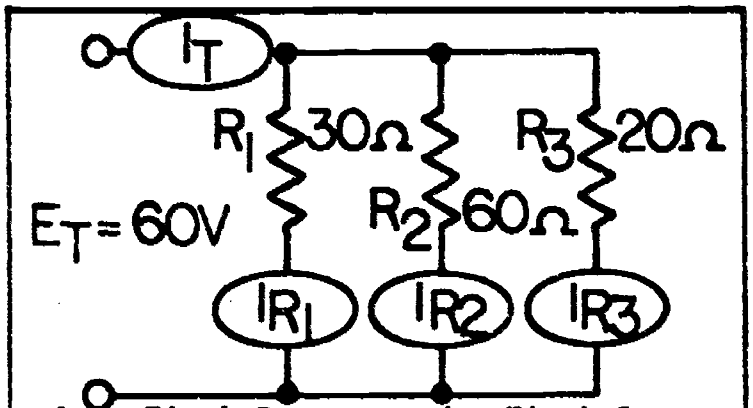
GRADE:

WORKSHEET

Period: ____________

PARALLEL CIRCUIT ANALYSIS #2

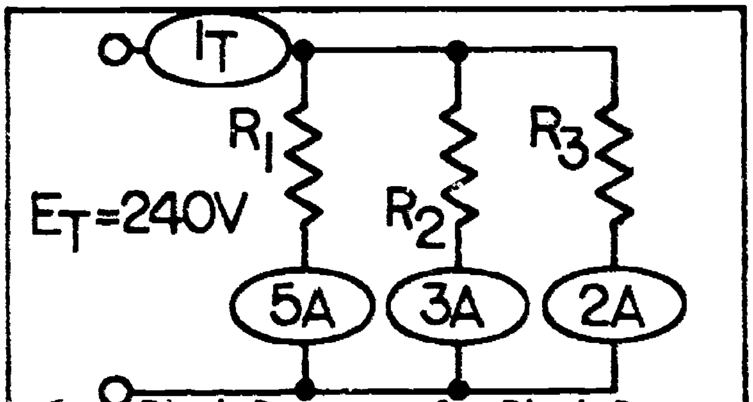
Solve the following circuit problems. Be certain to show work, and record your answer in the answer box.



1. Find R_T
2. Find I_T
3. Find I_{R_1}
4. Find I_{R_2}
5. Find I_{R_3}

Show work

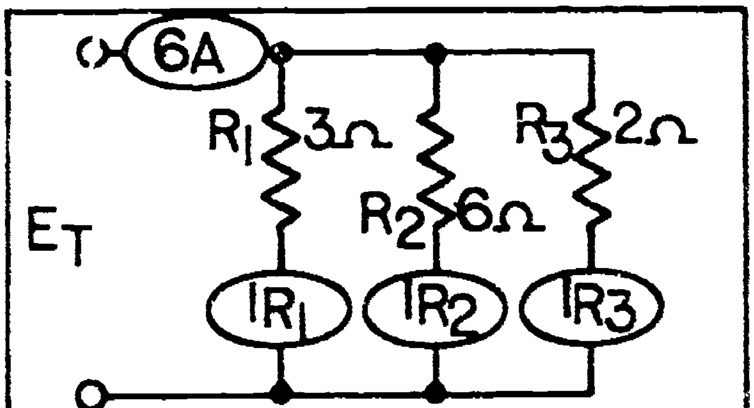
1.
2.
3.
4.
5.



6. Find R_1
7. Find R_2
8. Find R_3
9. Find I_T

Show work

6.
7.
8.
9.



10. Find R_T
11. Find E_T
12. Find I_{R_1}
13. Find I_{R_2}
14. Find I_{R_3}

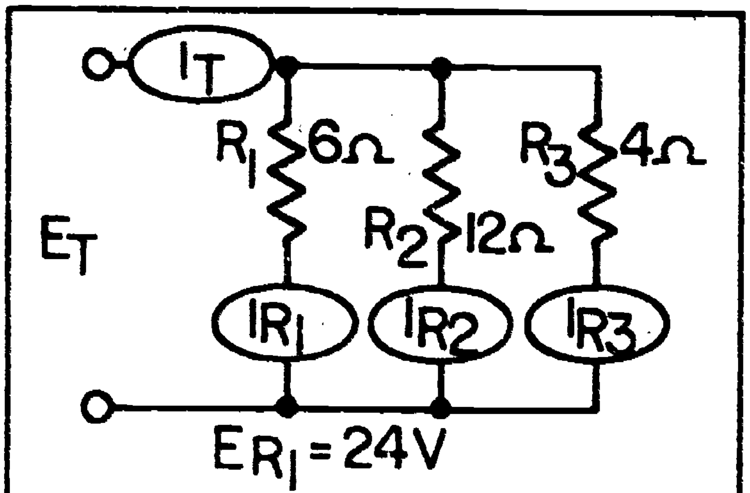
Show work

10.
11.
12.
13.
14.

Name: ______________

Date: ______________

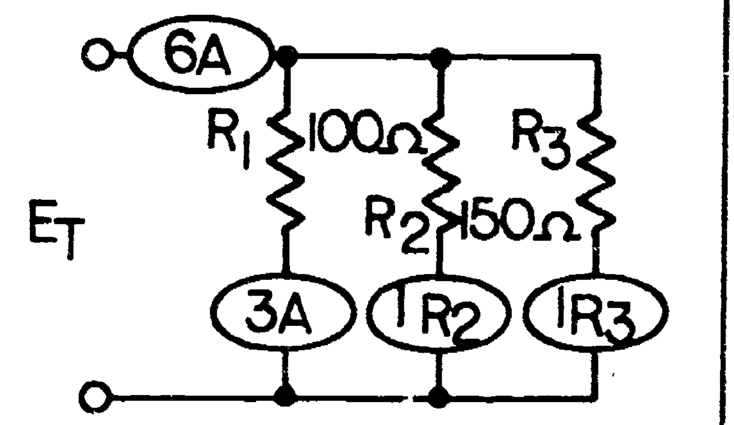
Period: ______________



15. Find I_{R_2}
16. Find E_T
17. Find I_{R_1}
18. Find I_{R_3}
19. Find I_T
20. Find R_T

Show work

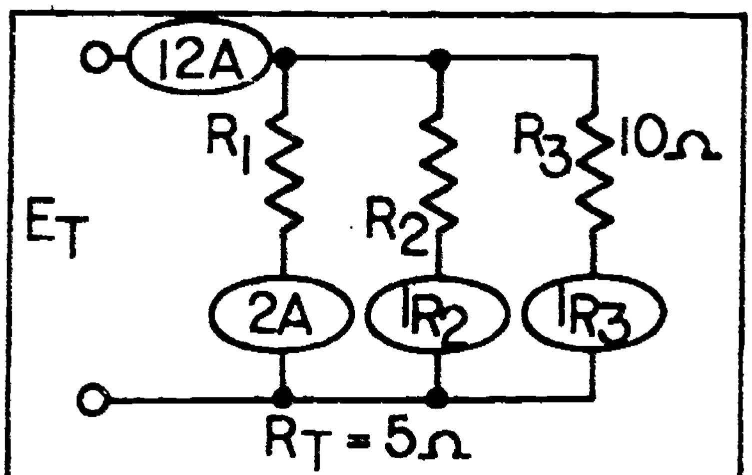
15. ______
16. ______
17. ______
18. ______
19. ______
20. ______



21. Find E_T
22. Find I_2
23. Find I_3
24. Find R_3
25. Find R_T

Show work

21. ______
22. ______
23. ______
24. ______
25. ______



26. Find E_T
27. Find R_1
28. Find I_3
29. Find I_2
30. Find R_2

Show work

26. ______
27. ______
28. ______
29. ______
30. ______

SCORE:

GRADE:

Name:

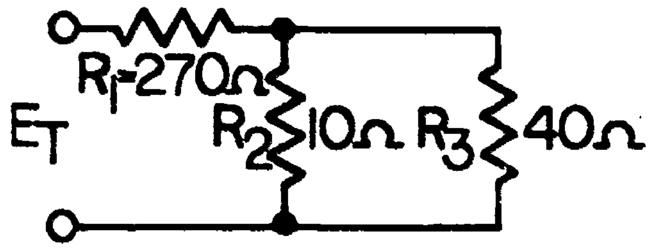
Date:

Period:

WORKSHEET

COMBINATION CIRCUIT ANALYSIS

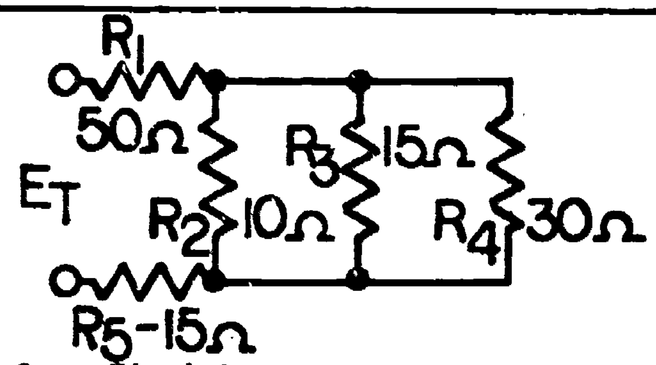
Solve the following circuit problems. Be certain to show work and record your answer in the answer box.



1. Find the total resistance in the above circuit.

Show work

1.



2. Find R_T

Show work

2.

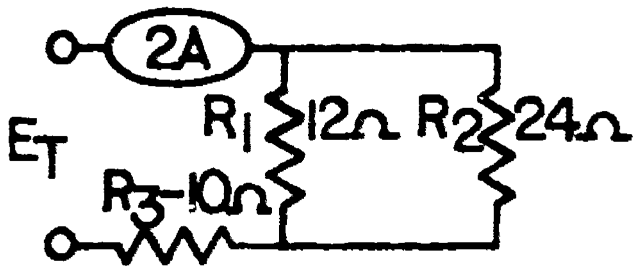
3A. Draw a combination circuit which contains the following resistors; a 39 ohm and 27 ohm connected in series with two parallel resistors each having a value of 33 ohms.

3B. Find the total resistance of the circuit.

Show work

3A. SCHEMATIC

3B.



4. Find R_T
5. Find E_T

Show work

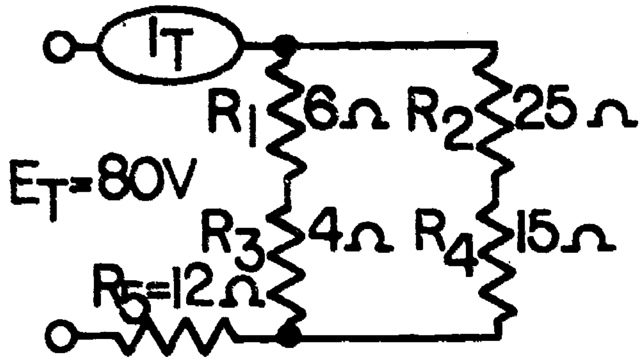
4.

5.

Name: ____________

Date: ____________

Period: ____________

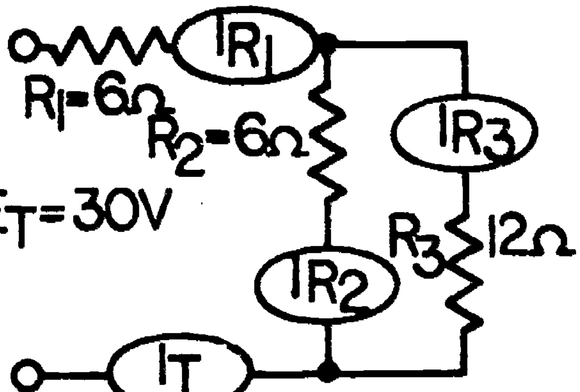


6. Find R_T
7. Find I_T

Show work

6.

7.



8. Find R_T
9. Find I_T
10. Find I_{R_1}
11. Find E_{R_1}
12. Find E_{R_2}
13. Find I_{R_2}
14. Find E_{R_3}
15. Find I_{R_3}

Show work

8.

9.

10.

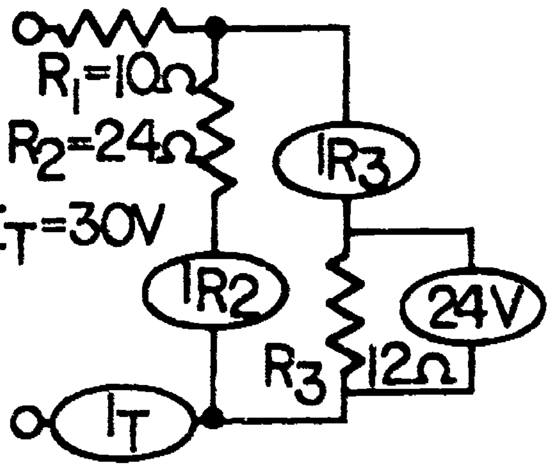
11.

12.

13.

14.

15.



16. Fine E_{R_1}
17. Find I_{R_3}
18. Find I_{R_2}
19. Find I_T
20. Find I_1

Show work

16.

17.

18.

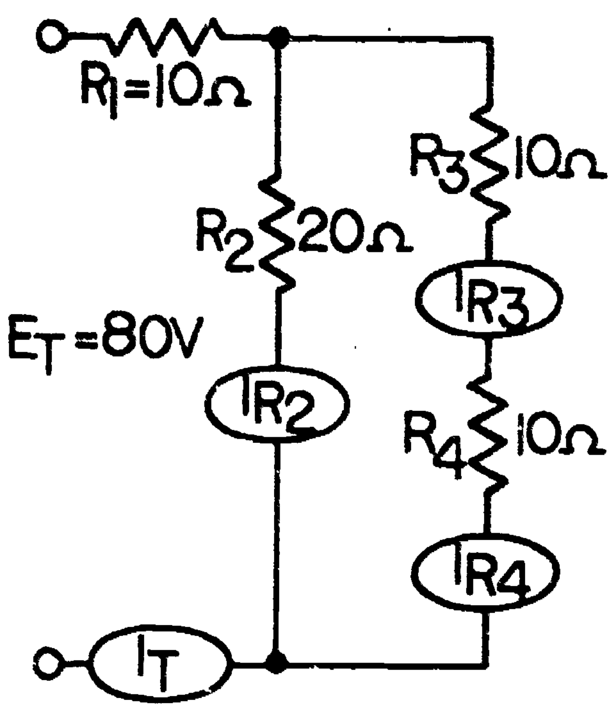
19.

20.

Name: ______________

Date: ______________

Period: ______________



21. Find R_T
22. Find I_T
23. Find E_{R_1}
24. Find E_{R_2}
25. Find I_{R_2}
26. Find I_{R_3}
27. Find I_{R_4}
28. Find E_{R_3}
29. Find E_{R_4}

Show work

21.

22.

23.

24.

25.

26.

27.

28.

29.

SCORE:
GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 6"

You have available five 100Ω resistors. To solve the problems below use any number of resistors one, all, or a combination. Your task will be to develop and draw circuits - either series parallel, or combination - that will provide a designated total resistance.

1. Develop the schematic for a circuit which would provide 200 ohms of resistance.

2. Draw a circuit which would provide 50 ohms of resistance.

3. Produce a 150 ohm resistive circuit.

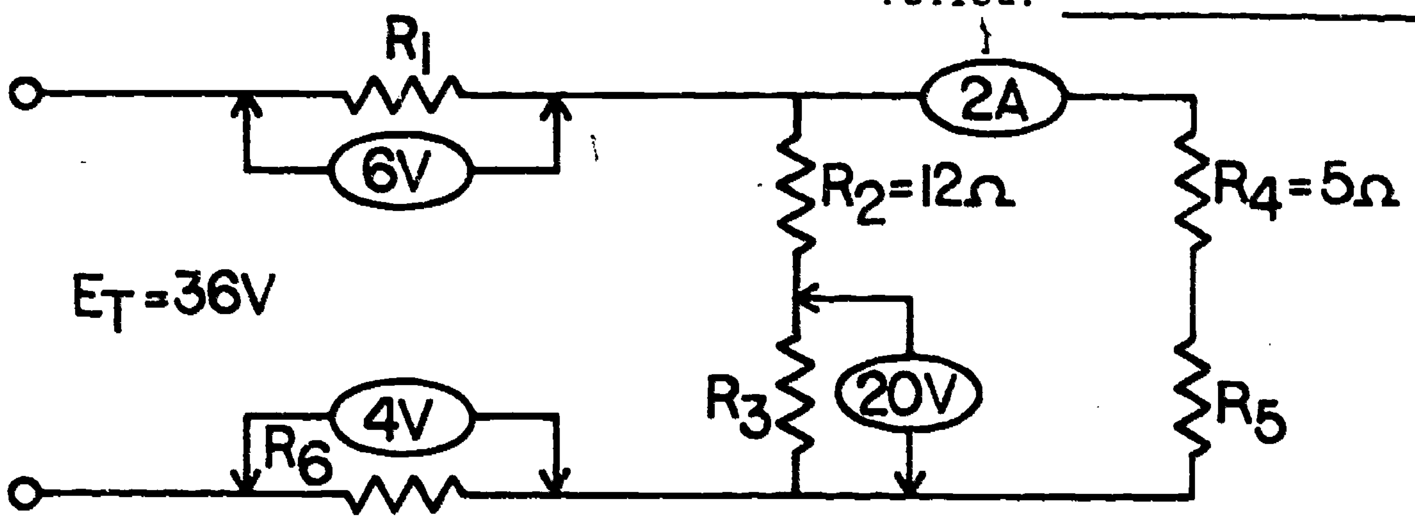
4. Draw a circuit to produce 160 ohms.

5. Develop a circuit which totals 37.5 ohms.

Name: ____________

Date: ____________

Period: ____________



Show work

6. E_{R_2}=		6.
7. I_{R_2}=		7.
8. I_{R_3}=		8.
9. R_3=		9.
10. E_{R_4}=		10.
11. E_{R_5}=		11.
12. R_5=		12.
13. I_{R_1}=		13.
14. R_1=		14.
15. R_6=		15.
16. R_T=		16.
17. I_T=		17.

2(0)

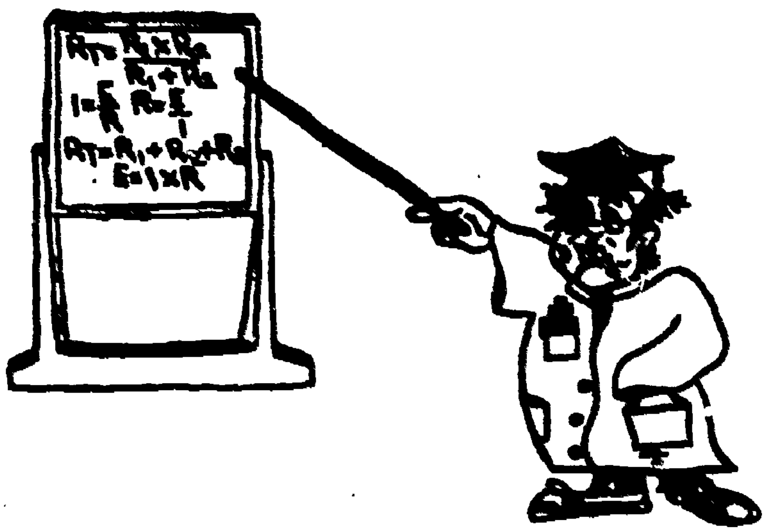
Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

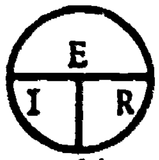
CIRCUIT EVALUATION PRINCIPLES



SERIES CIRCUIT FORMULAS/LAWS:

Total Resistance - $R_T = R_1 + R_2 + R_3 + \ldots + R_N$

Ohm's Law -



Kirchhoff's Law (interpretation) -

Current — The current is the same at any point in a series circuit. If the current is known at any point in a series circuit then that same current will be present throughout the circuit.

Voltage — The sum of the voltage drops around a series loop (or circuit) equals the source voltage.

PARALLEL CIRCUIT FORMULAS/LAWS:

Total Resistance - (Equal Resistance Values) $$R_T = \frac{R}{N} \quad \frac{\text{Resistance of one resistor}}{\text{Number of resistors}}$$

(Two Resistors Unequal Value) $$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

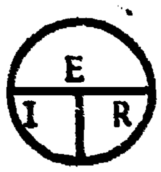
(General Formulas) $$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}$$

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N}}$$

Name: ________________

Date: ________________

Period: ________________

Ohm's Law - 

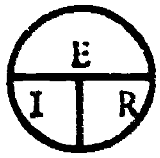
Kirchoff's Law (interpretation)-

<u>Current</u> The sum of the branch currents equals the total current.

<u>Voltage</u> The voltage drop across each element in a parallel circuit is the same. If the voltage across one resistor in a parallel circuit is known. Then the other voltage drops are also established.

COMBINATION CIRCUIT FORMULAS/LAWS:

Total Resistance - Begin circuit simplification with the parallel branch which is furthest from the source. Work toward the source, combining simplified parallel branches and series sections.

Ohm's Law - 

Kirchoff's Law (interpretation) -

Series Section (simplified)

<u>Current</u> The current is the same at any point in a series circuit. If the current is known at any point in a series circuit then that same current will be present throughout the circuit.

<u>Voltage</u> The sum of the voltage drops around a series loop (or circuit) equals the source voltage.

Parallel Branch (simplified)

<u>Current</u> The sum of the branch currents equals the total current.

<u>Voltage</u> The voltage drop across each element in a parallel circuit is the same. If the voltage across one resistor in a parallel circuit is known. Then the other voltage drops are also established.

NOTE:

Before attempting any calculations (total resistance, Ohm's Law, etc.) review the component values and convert to basic unit when necessary. Thus, if a resistance value is given as 4 k ohms, it should be converted to 4000 ohms (basic unit).

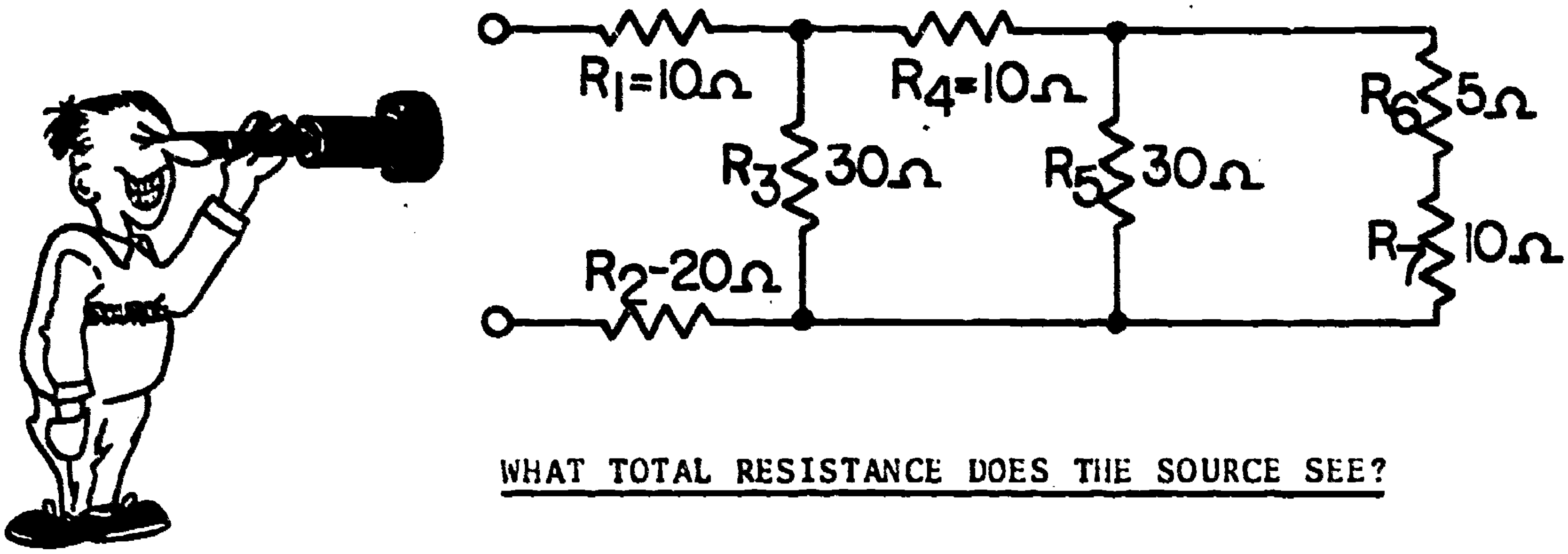
Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

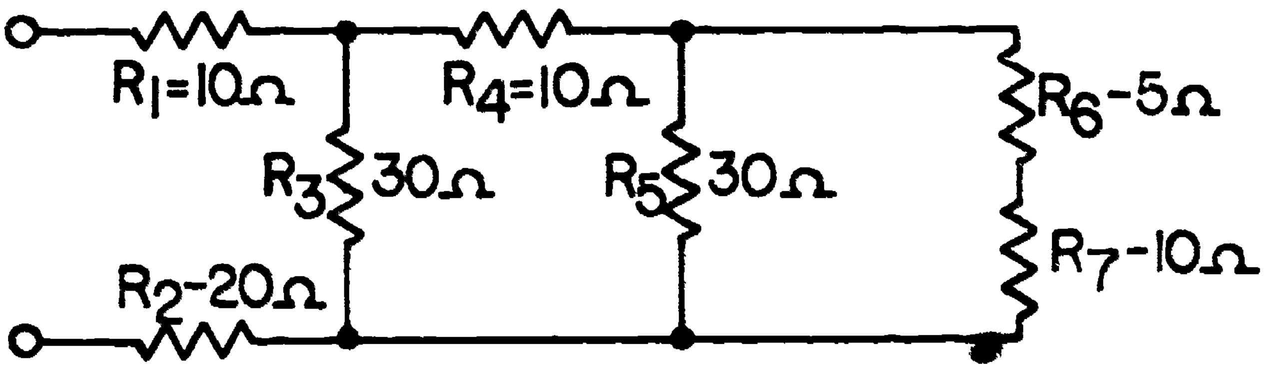
DERIVING EQUIVALENT CIRCUITS



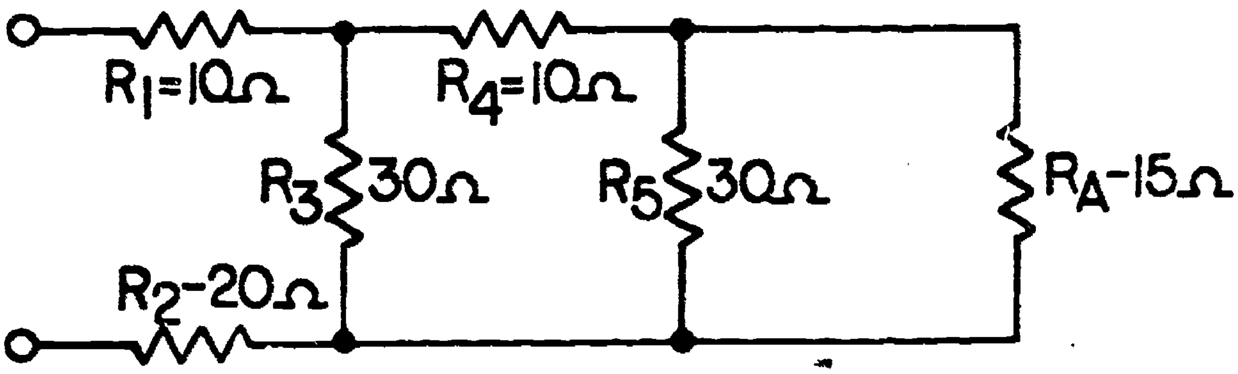
WHAT TOTAL RESISTANCE DOES THE SOURCE SEE?

A procedure for simplifying combination circuits:

STEP 1: Start your simplification with the branch that is farthest from the source.



Look at the R_5-R_6-R_7 branch - What can be simplified? Right! R_6+R_7 are in series. Combine R_6+R_7 and call the new equivalent resistor R_A.

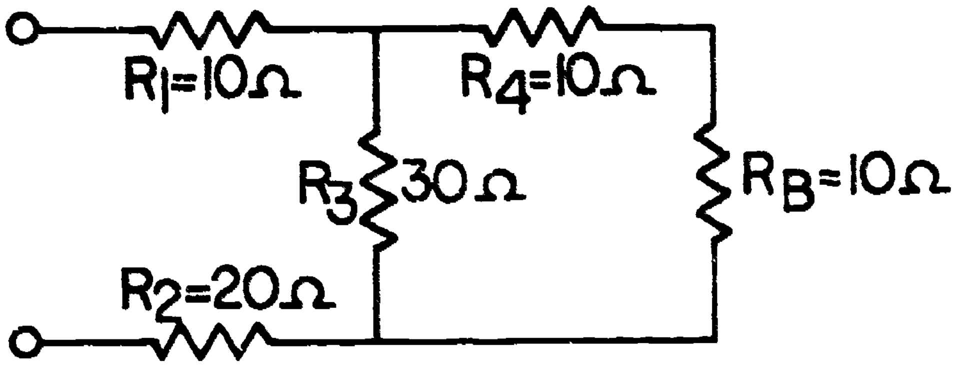


STEP 2: What's this? R_5 and R_A are now in parallel. Find the total resistance, and label the new equivalent resistor as R_B.

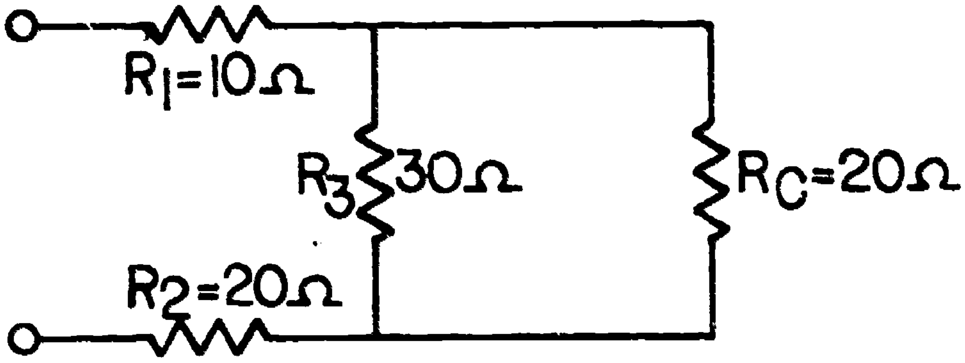
Name: ____________________

Date: ____________________

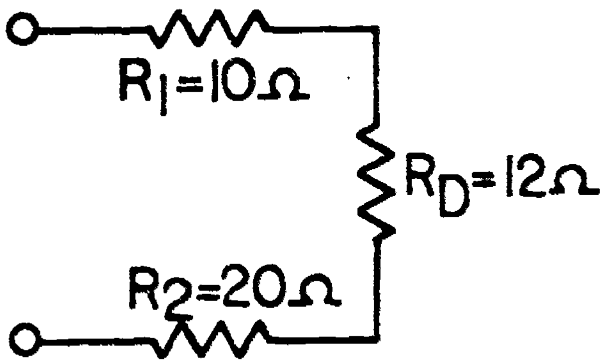
Period: ____________________



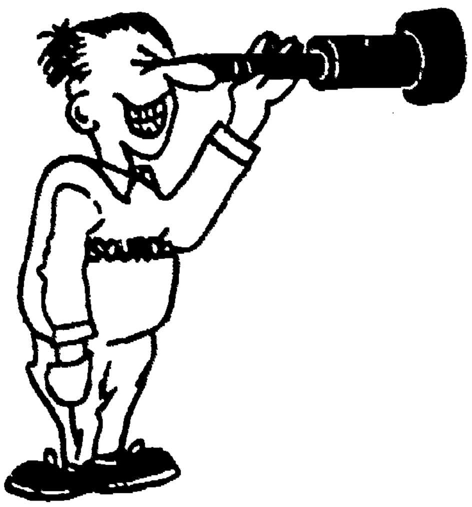
STEP 3: R_4 and R_B are now in series. Combine these values and label the equivalent resistor as R_C.

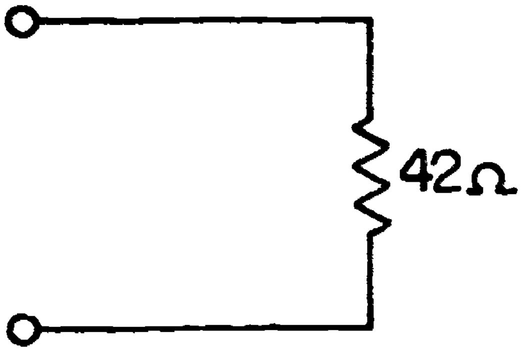


STEP 4: Now R_3 and R_C are in parallel. Combine these values and label the equivalent resistor as R_D.



STEP 5: Well "Low-and Behold" what's this? A simple series circuit! Add R_1, R_D, and R_2 to find the equivalent circuit resistance.





"I ONLY OBSERVE 42 ohms"

SCORE:
GRADE:

Name: ______________________

Date: ______________________

Period: ______________________

ANSWER SHEET

EXAM LIII U6

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.	■				26.	■				51.					76.				
2.		■			27.		■			52.					77.				
3.		■			28.		■			53.					78.				
4.		■			29.	■				54.					79.				
5.		■			30.		■			55.					80.				
6.		■			31.	■				56.					81.				
7.	■				32.				■	57.					82.				
8.		■			33.		■			58.					83.				
9.	■				34.	■				59.					84.				
10.	■				35.				■	60.					85.				
11.	■				36.			■		61.					86.				
12.		■			37.				■	62.					87.				
13.	■				38.			■		63.					88.				
14.		■			39.			■		64.					89.				
15.	■				40.	■				65.					90.				
16.				■	41.		■			66.					91.				
17.			■		42.	■				67.					92.				
18.		■			43.			■		68.					93.				
19.				■	44.				■	69.					94.				
20.		■			45.		■			70.					95.				
21.			■		46.					71.					96.				
22.		■			47.					72.					97.				
23.		■			48.					73.					98.				
24.			■		49.					74.					99.				
25.			■		50.					75.					100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 6

A. VOCABULARY DECODING

1. junction
2. formula
3. applied voltage
4. circuit evaluation
5. voltage drop
6. Kirchhoffs law
7. branch current
8. total current
9. directly proportional
10. total resistance.

B. SERIES CIRCUIT ANALYSIS #1

1. 386 ohms
2. 1942 ohms
3A. (subjective answer)
3B. 50,456 ohms
4. 2A
5. 6 ohms
6. 45 V
7. 20 ohms
8. 40 V
9. 10 ohms
10. 2 A
11. 12 V
12. 2 A
13. 2 A
14. 2 ohms
15. 3 A
16. 3 A
17. 90 V
18. 30 ohms
19. 55 ohms
20. 2 A
21. 12 V
22. 8 V
23. 4 ohms

C. SERIES CIRCUIT ANALYSIS #2

1. 4 A
2. 10 ohms
3. 40 V
4. 80 V
5. 40 V
6. 2 A
7. 2 A
8. 10 ohms
9. 30 ohms
10. 110 ohms
11. 40 V
12. 120 V
13. 60 V
14. 220 V
15. 30 ohms
16. 2 A
17. 12 V
18. 20 V
19. 28 V
20. 10 V
21. 20 V
22. 2 A
23. 5 ohms
24. 5 ohms
25. 100 ohms
26. 1 A
27. 10 V
28. 20 V
29. 6 V
30. 4 V
31. 45 V
32. 15 V

D. PARALLEL CIRCUIT ANALYSIS #1

1. 50 ohms
2. 5 ohms
3. 50 ohms
4. 20 ohms
5. 4 A
6. 8 ohms
7. 16 V
8. 36 V
9. 12 A
10. 6 A
11. 4 A
12. 22 A
13. 18 A
14. 48 V
15. 12 ohms
16. 8 ohms
17. 6 ohms
18. 9 A
19. 90 V
20. 90 V
21. 30 ohms
22. 18 ohms
23. 10 ohms

ANSWER KEY UNIT 6
(continued)

E. PARALLEL CIRCUIT ANALYSIS #2

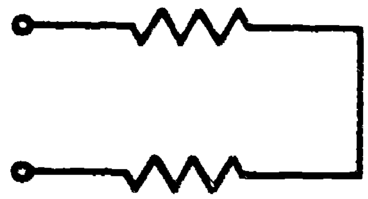
1. 10 ohms
2. 6 A
3. 2 A
4. 1 A
5. 3 A
6. 48 ohms
7. 80 ohms
8. 120 ohms
9. 10 A
10. 1 ohm
11. 6 V
12. 2 A
13. 1 A
14. 3 A
15. 2 A
16. 24 V
17. 4 A
18. 6 A
19. 12 A
20. 2 ohms
21. 300 V
22. 2 A
23. 1 A
24. 300 ohms
25. 50 ohms
26. 60 V
27. 30 ohms
28. 6 A
29. 4 A
30. 15 ohms

F. COMBINATION CIRCUIT ANALYSIS

1. 278 ohms
2. 70 ohms
3B. 82.5 ohms
4. 18 ohms
5. 36 V
6. 20 ohms
7. 4 A
8. 10 ohms
9. 3 A
10. 3 A
11. 18 V
12. 12 V
13. 2 A
14. 12 V
15. 1 A
16. 6 V
17. 2 A
18. 1 A
19. 3 A
20. 3 A
21. 20 ohms
22. 4 A
23. 40 V
24. 40 V
25. 2 A
26. 2 A
27. 2 A
28. 20 V
29. 20 V

F. QUEST ACTIVITY

1.



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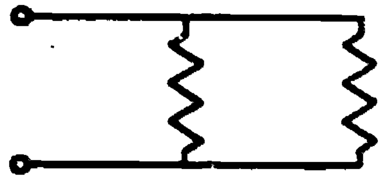

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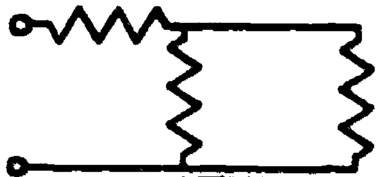

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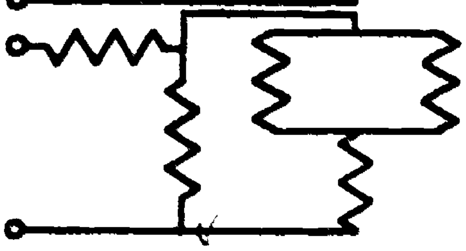
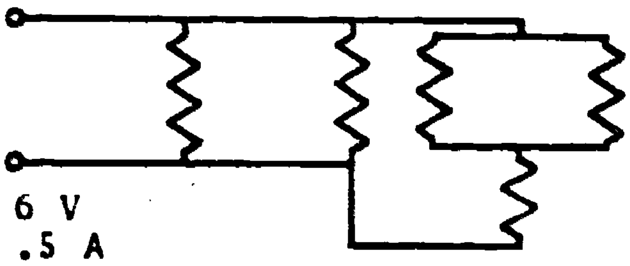


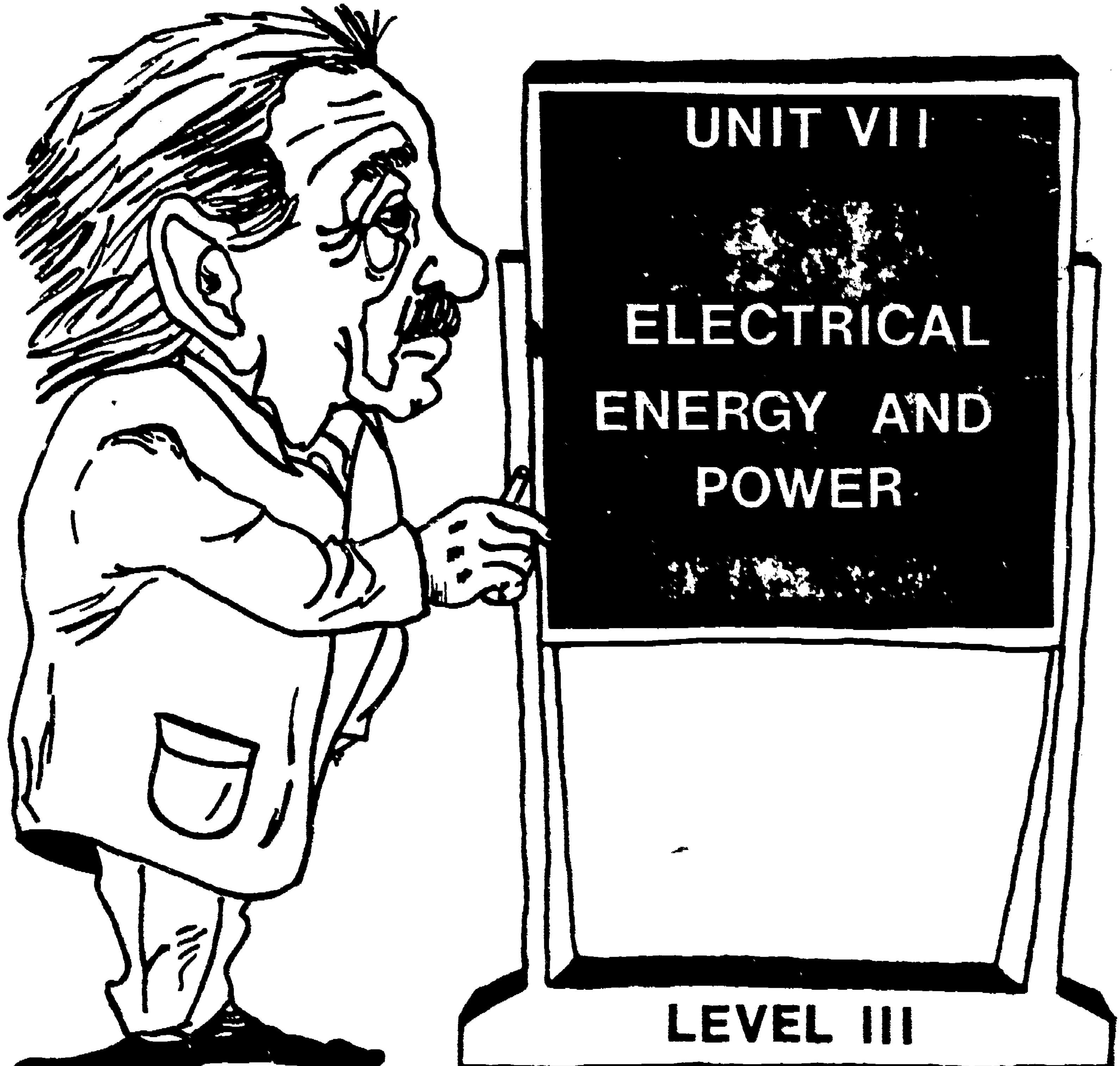
5.



6. 6 V
7. .5 A
8. .5 A
9. 40 ohms
10. 10 V
11. 16 V
12. 8 ohms
13. 2.5 A
14. 2.4 ohms
15. 1.566 ohms
16. 14.46 ohms (approx.)
17. 2.5 A

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________________
DATE STARTED______________
DATE COMPLETED____________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Electrical Energy and Power

Time Allocation: 2 weeks

Unit Goal:

To achieve student competence in grasping the various relationships that electrical energy and power have to circuit performance, including applications of problem solving techniques.

Unit Objectives:

The student will be able to:

1. distinguish between the following units of measurement and/or terms; work, joule, watt, power and energy.
2. recite and apply both Ohm's and Watt's Law as requested when solving or evaluating circuits.
3. summarize and discuss power loss as I^2R loss and explain its relationship to heat or power dissipation.
4. differentiate and compare power rating data of appliances or devices, and solve typical electric company bill based on electrical consumption, measurement, and charge rate for electricity.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Basic Electricity: Theory and Practice. Milton Kaufman and J.A. Wilson, McGraw-Hill Book Co., 1973. Topic 9.

Basic Electronics. Bernard Grob, McGraw-Hill Book Co., 1977. Chapter 2.

Electronic and Electrical Fundamentals Volume I. Published by C.T.I. Education Products, Inc., 1976. Chapter 8.

Overview:

In the previous unit students acquired the necessary skills in computing and solving series, parallel, and combination circuit problems. In conjunction with these essential skills this unit will complement those competencies and facilitate a more in depth study of D.C. circuitry.

The unit should be introduced by examining the purpose of any power source in an electrical circuit, and this description can be utilized as a vehicle to acquaint students with new terminology.

The main thrust of this unit is to illustrate that many problems can be conveniently solved with some arrangement or modification of Ohm's and Watt's Law. This concept however, can be over shadowed if instructor and students become paralyzed with the definitions or terminology related to the concepts of energy and power.

The next topic emphasized is concerned with power and heat loss, nevertheless, this is an ideal time to review power rating of resistors, and an opportunity to introduce equipment/device ratings.

This unit concludes with an informative yet practical topic enabling students to understand electrical consumption or work, and to realize that this is used by electric companies as a means to measure and charge for electricity.

A variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. Distinguish to the class between the concept of useful power versus wasted power and their relationship to this unit. Have students provide examples to illustrate their understanding of the concept. Impress students with the idea that power which is wasted is referred to as dissipated power.
2. The key to this unit is instuctor organization of terms presented, be mindful to take care of technical word accuracy. Many authors, educators, and instructors are vague when introducing power and energy because this topic traditionally was based on the premise of separate units of measurement for indicating such things as heat, mechanical and light energy. This technique encourages erroneous interpretations or at best difficulty in comprehension.
3. In addition to basic knowledge and formulas related to power, illustrate the method in which electricity is generated and distributed for general consumer usage. Many local power companies supply to educational institutions free of charge the following; films, filmstrips, tapes, pamphlets, books, ditto masters, and other kinds of media materials.
4. Be careful to watch student performance in formula work especially the handout that contains the Watt's and Ohm's Law Formula Wheel. Mathematics used in completing some of these problems may present a stumbling block for some stu-

dents. Take some extra time and effort to assist those who cannot square a number, nor find the square root of a given integer.

5. Do not overkill the concept of energy conservation but develop several activities which might allow thought provoking discussions. Consider having the class answer an essay question on the topic of ways to reduce the total energy used at home or have students paste pictures of appliances on cards and indicate their wattage consumption. These kinds of activities provide an opportunity to discuss the impact of this critical social issue upon their personal life.

Supplemental Activities and Demonstrations:

1. Instructor demonstrates the procedure necessary in order to read and compute power used. Draw a set of dials (without needles) to simulate a Kilowatt-hour Meter, then adjust needles to indicate a reading and obtain student response. Drawings can be applied to blackboard, cardboard, acetate sheet or flip chart.
2. Instructor can assemble a variety of different size incandescent lamps from 10 watts to 1000 watts in ascending order on a predrilled demonstration board. This type of aid will allow students to vividly see the contrast in size and the relationship to power rating.
3. When presenting materials on power and energy it is quite simple to expand discussions, experiments, and demonstrations to include housewiring and replacement of fuses. A wall frame or section in minature can be constructed with appropriate electrical boxes and switches mounted, then have pairs of students complete wiring under instructor's guidance.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Crossword
5. Worksheet - Power Rating and Cost Analysis
6. Worksheet - Watt's Law
7. Quest Activity
8. Informational Handout (How Electricity is Distributed)
9. Informational Handout (Measuring & Monitoring Energy Consumption)
10. Informational Handout (Watt's Law Formulas)
11. Unit Module Answer Keys

VII. Electrical Energy and Power

A. Introduction

B. Terminology
   1. Work

   2. Joule

   3. Watt

   4. Power

   5. Energy

C. Watt's Law

D. Using the power formulas
   1. Power formulas

2. Applying Watt's Law for circuit evaluation

3. Utilizing Watt's and Ohm's Law for circuit evaluation

E. Power and heat
   1. The phenomenon of I^2R heat

   2. Power loss

   3. I^2R devices

      a. Incandescent lamps and heating devices

      b. Fuses

F. Energy consumption
   1. Kilowatt-hour meter

   2. Computing energy consumption

G. The decibel

Test Number ______

LIII-U7

UNIT EXAM

ELECTRICAL ENERGY AND POWER

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. The ability of a resistor to dissipate heat depends mainly upon its physical size. (T-F)

2. To find power of a given circuit P = I x E or P = E x I. (T-F)

3. Power is measured in the basic unit of whats. (T-F)

4. The term power refers to the rate of doing work or using energy. (T-F)

5. Electrical energy is an invisible force which can be harnessed to do work. (T-F)

6. Electrical work and power have a similar basic unit which is the joule. (T-F)

7. The comparison of one power level to another power level is often expressed in decibels. (T-F)

8. A milliwatt is equivalent to one millionths of a watt. (T-F)

9. I^2R heat refers to the heat produced in an electric circuit when resistance flows by a current. (T-F)

10. One way that an electrical circuit can do work, is by converting the force of moving electrons or protons into some other form of energy, such as heat, sound, light, or magnetism. (T-F)

11. The common energy unit that most electric companies base customers bills on is the watt-hour. (T-F)

12. Power is directly proportional to current. That is, as current increases in a circuit (resistance held constant) power also increases. (T-F)

13. The greater both voltage and current, and more energy will be delivered to a load during a given time. (T-F)

14. Watt's Law explains the relationship between voltage, power, and current. (T-F)

15. The individual dials of a kilowatt-hour meter all have the same kwh value. (T-F)

16. In an electric circuit where the source voltage is 400 volts and the total circuit current is 1.5 amperes, how much power is being used? (A) 100 watts. (B) 400 watts. (C) 600 watts. (D) 202 watts.

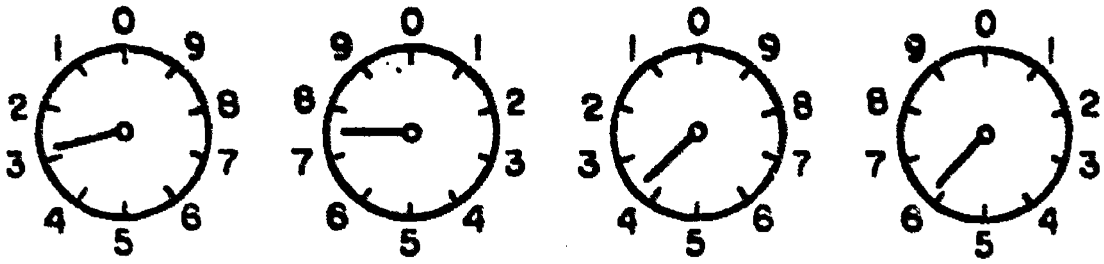
17. Of the following sources, which can provide the most power? (A) A 30 volt source capable of supplying 5 amperes. (B) A 100 volt source capable of supplying 2 amperes. (C) A 12 volt source capable of supplying 10 amperes. (D) A 30 volt source capable of supplying 10 amperes.

18. The basic unit of measure for electric power is the (A) ampere. (B) watt. (C) volt. (D) ohm.

19. When a resistor has a 20 watt rating, this means that it (A) always dissipates exactly 20 watts of power. (B) always provides 20 watts of power. (C) should be used in a circuit where it will dissipate more than 20 watts of power. (D) can safely dissipate 20 watts, of power or less.

20. In a circuit consisting of three resistors, the total power being dissipated is (A) less than the power being dissipated by any one resistor. (B) equal to the sum of the powers dissipated in all three resistors. (C) divided equally among the resistors. (D) determined by multiplying the source voltage by the current through one of the resistors.

21. What is the reading on the kilowatt-hour meter?



A) 6372
B) 2736
C) 3746
D) 2746

22. Find power if E = 50V and I = 2A. P = ________ watts. (A) 100W (B) 25W (C) .04W (D) 500W

23. Find power if E = 12V and R = 48 ohms. P = ________ watts. (A) 4W (B) .25W (C) 3W (D) 576W

24. Find power if I = 2A and R = 150 ohms. P = ________ watts. (A) 300W (B) 600W (C) 75W (D) 37.5W

25. Find voltage if P = 100W and I = 4A E = ________volts. (A) .04V (B) 400V (C) 104V (D) 25V

26. Find current if E = 120V and P = 600W I = ________ amperes. (A) .2A (B) 5A (C) 720A (D) 60A

27. How much current is drawn by a circuit which dissipates 4800 watts of power when the source voltage is 120 volts? (A) 20 amperes. (B) 40 amperes. (C) 400 amperes. (D) 200 amperes.

28. How much power is dissipated by a circuit that has a 75-volt source and a current flow of 5A? (A) 375W (B) 3.75W (C) 0.375W (D) 37.5W

29. An electric iron operating from a 120 volt power source draws or uses 4 amperes. How much power does it consume? (A) 30 watts. (B) 480 watts. (C) .033 watts. (D) 48 watts.

30. What is the wattage rating of a TV receiver, which is connected to 100 volts and drawing 3.5 amperes? (A) 35 watts. (B) 3.50 watts. (C) .350 watts. (D) 350 watts.

Name: ______________

Date: ______________

Period: ______________

TECHNICAL GLOSSARY

CIRCUIT BREAKER: A current sensing device which automatically opens a circuit when current exceeds a set value. A circuit breaker may be reset after it trips. The circuit breaker, like a fuse, is used to protect a circuit against excess current. Letter symbol: CB Symbol:

COULOMB: The magnitude or measure of electrical charge, one coulomb is equal to the combined charge of 6,280,000,000,000,000,000 electrons (6.28×10^{18}).

DECIBEL: A measurement of the ratio of one power to another power. Decibel ratings are based upon logarithmic increases or decreases. Abbrev. dB

EFFICIENCY: A percent measurement of how effective a device is in using electrical power. A machine which has an output power equal to its input power is said to be 100% efficient; but this as you know is impossible. Formula:

$$\text{Efficiency} = \frac{\text{OUTPUT (WATTS)}}{\text{INPUT (WATTS)}} \times 100$$

ENERGY: The capacity or ability to do work. Energy is a force (electrical, mechanical, kinetic, etc.) which can be used to do work.

ENERGY CONSUMPTION: The rate of using energy. Electrical energy consumption is the product of power and time. A common unit for measuring energy consumption in the home is the kilowatt-hour

FUSE: A device used to protect a circuit against excess current. The fuse utilizes a metal link which melts and opens the circuit when the current exceeds a set value. Letter symbol: F Symbol:

HEAT SINK: A metallic device, usually aluminum, used to carry heat away from a component. Heat sinks are commonly found on transistors, SCR'S, and other semiconductor devices which produce heat during operation.

HORSEPOWER: A measurement of mechanical power equal to the product of work in footpounds and time in seconds. Electrical power and mechanical power can be compared by using the conversion 746 watts = 1HP.

I^2R HEAT: This term describes the heat produced by a circuit when current flows through a resistance. Also referred to as I^2R loss or copper loss.

Name: ____________________

JOULE:	The basic unit of electrical energy and/or work.
KILOWATT-HOUR:	The basic unit of measurement for electrical energy consumption for both home and industry. Equivalent to 1000 watts of power used in one hour. Letter symbol: kwh
KILOWATT-HOUR METER:	A meter used to measure electrical energy consumption in kilowatt-hours, and which is monitored by the power company.
POWER:	A measure of the time rate of doing work or using electrical energy, power = $\frac{\text{work}}{\text{time}}$. Electrical power is frequently expressed as the product of voltage and current, and is measured in watts. (See Watt's Law) Letter symbol: P.
POWER DISSIPATION:	The power wasted, in an electrical circuit, due to heat or I^2R losses.
WATT:	The basic unit of measurement for electrical power. One watt of power is provided when one ampere of current flows through a load with a one volt drop across its terminals. Letter symbol: W.
WATTAGE RATING:	A measure, in watts, of the maximum power a device consumes or dissipates, and frequently referred to as the power rating.
WATT'S LAW:	An electrical law which expresses the relationship between power, voltage, and current. It states that power (in watts) is equal to voltage (in volts) times current (in amperes). Mathematically this is expressed as $P = E \times I$.
WORK:	Electrical work is considered as power x time. The basic unit for work is the joule.

SCORE:

GRADE:

Name: ____________

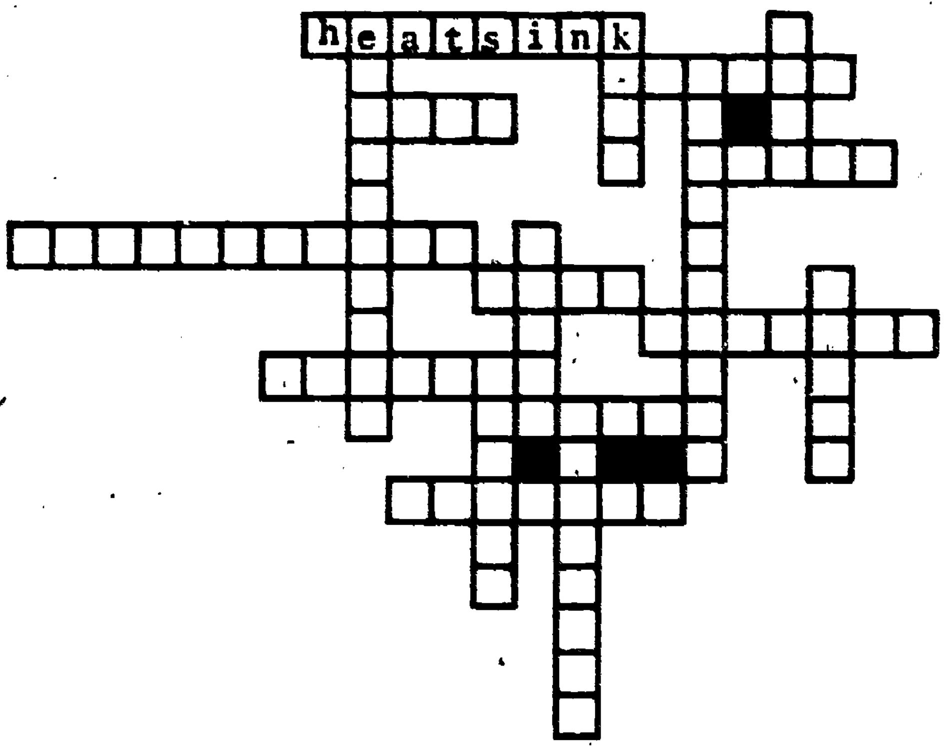
Date: ____________

Period: ____________

WORKSHEET

VOCABULARY - CROSSWORD PUZZLE

Below are clues to electrical terms. To solve the puzzle find the terms, and fit them into the proper places in the diagram. A key word has been provided on the puzzle as a starting point from which other terms can be added or branched as necessary.



1. One ________ is equal to the combined charge of 6,280,000,000,000,000,000. — 1. [ ]

2. Abbreviated dB. ________ — 2. [ ]

3. Power lost due to heat. Power ________. — 3. [ ]

4. $\frac{\text{OUTPUT}}{\text{INPUT}} \times 100 =$ ____________. — 4. [ ]

5. Some kind of force that can be used to do work. ________ — 5. [ ]

6. Another name for a mathematical formula. ____________ — 6. [ ]

7. Something used to solve for an unknown value provided all necessary data is available. ____________ — 7. [ ]

Name: ______________

Date: ______________

Period: ______________

8. Protects a circuit against excess current. ______________ 8. [ ]

9. 746 watts = 1 ______________. 9. [ ]

10. Heat produced when current flows through a resistance. ______________ 10. [ ]

11. The basic unit of electrical energy. ______________ 11. [ ]

12. Prefix meaning 1,000. ______________ 12. [ ]

13. The pointer on a meter. ______________ 13. [ ]

14. ______________ = voltage x current. 14. [ ]

15. A mathematical relationship comparing one number to another. ______________ 15. [ ]

16. Basic unit of measurement for electrical power. ______________ 16. [ ]

17. Power x Time = ______________. 17. [ ]

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

WATT'S LAW

1. Power equals voltage multiplied by the ________. — 1. [ ]

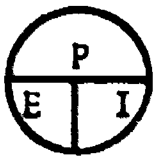
2. One _______ is equal to one thousand watts. — 2. [ ]

3. The three commonly used power formulas are A)P = _____ , B)I = _____ , and C)E = _____ — 3A. [ ] 3B. [ ] 3C. [ ]

4. The ________ is the electrical unit of power. — 4. [ ]

5. What is the power dissipation of a 40 ohm resistor with 3 amps flowing through it? Hint: $P = I^2 \times R$. — 5. [ ]

Using the Watt's Law magic circle solve the following power problems.



6. E = 100V, I = 2A, P = _______ watts — 6. [ ]

7. E = 150V, I = .5A, P = _______ watts — 7. [ ]

8. P = 400W, E = 80V, I = _______ amperes — 8. [ ]

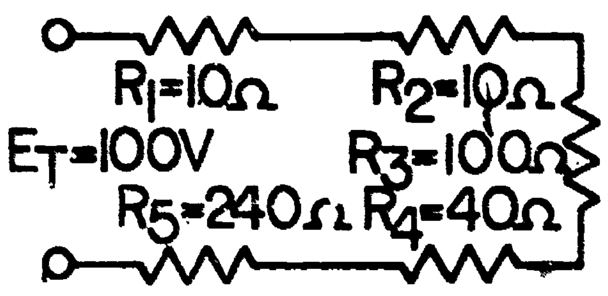
9. P = 100W, I = 2.5A, E = _______ volts — 9. [ ]

10. P = 1800W, I = 4A, E = _______ volts — 10. [ ]

Name: ______________

Date: ______________

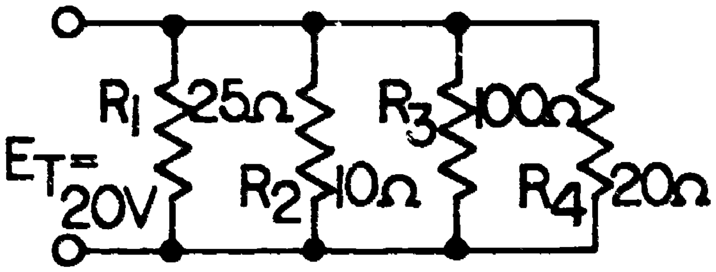
Period: ______________



11. Find I_T
12. Find P_T
13. Find P_{R_1}
14. Find P_{R_2}
15. Find P_{R_3}
16. Find P_{R_4}
17. Find P_{R_5}

Show work

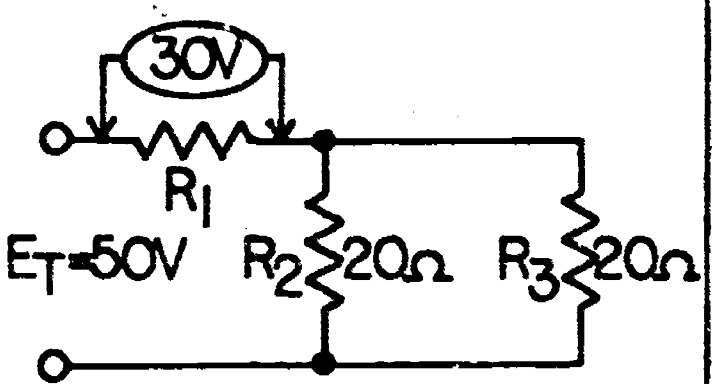
11.
12.
13.
14.
15.
16.
17.



18. Find R_T
19. Find I_T
20. Find P_{R_1}
21. Find P_{R_2}
22. Find P_{R_3}
23. Find P_{R_4}
24. Find P_T

Show work

18.
19.
20.
21.
22.
23.
24.



25. Find I_T
26. Find P_{R_2}
27. Find P_{R_3}
28. Find P_{R_1}
29. Find P_T
30. Find R_T

Show work

25.
26.
27.
28.
29.
30.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

ELECTRICAL ENERGY CONSUMPTION CHART

This chart indicates the average wattage, average hours of use per year, and the estimated kwh's of energy used by each appliance per year. The calculations have been completed for you, but it will be necessary to recall the method used to compute kilowatt-hours.

NOTE:

$$\text{kwh} = \frac{\text{Wattage x Hours of use}}{1000}$$

Locate and mark the starred (*) items, from page one, on the chart below.

ENERGY CONSUMPTION CHART

Item	Average Wattage	Average Hours Per Year	Est. kwh used Per Year
COMFORT CONDITIONING			
Air Cleaner	50	4,320	216
Air Conditioner (room)	860	1,000	860
Blanket (Electric)	177	831	147
Dehumidifier	257	1,467	377
Fan (attic)	370	786	291
Fan (circulating)	88	489	43
Fan (roll away)	171	807	138
Fan (window)	200	850	170
Heater (portable)	1,322	133	177
Heating Pad	65	154	10
Humidifier	177	921	163
Lamps and Lighting	600	1,460	876
HEALTH AND BEAUTY			
Blow Dryer	1,000	121	121
Curling Iron	40	71	3
Hair Dryer	750	51	38
Heat Lamp (infared)	250	52	13
Hot Curlers	840	68	57
Shaver	14	129	1.8
Sun Lamp	279	57	16
Tooth Brush	7	71	0.5
HOME ENTERTAINMENT			
Radio	71	1,211	86
Radio/Record Player	109	1,000	109
Projector (slide/Movie)	350	5	1.8
Tape Recorder	5	624	3
TV Black and White	108	2,186	236
TV Color Solid State	250	2,200	550
TV Color Tube	300	2,200	660
TV Games	4	24	0.1
HOUSE WARES AND TOOLS			
Clock	2	8,760	17
Drill	5	1	0.1
Electric Typewriter	180	48	9
Floor Polisher	305	49	15
Sewing Machine	75	147	11
Table Saw	720	5	3.6
Vacuum Cleaner	630	73	46

Item	Average Wattage	Average Hours Per Year	Est. kwh used Per Year
FOOD PREPARATION			
Blender	386	39	15
Broiler	1,436	70	100
Can Opener	240	4	1
Carving Knife	92	87	8
Coffe Maker	894	119	106
Crock Pot	1,600	72	115
Deep Fryer	1,448	57	83
Dishwasher	1,201	302	363
Egg Cooker	516	27	14
Food Processor	600	52	31
Fry Pan	1,196	155	185
Hot Plate	1,257	72	90
Ice Cream Maker	10	6	1
Meat Slicer	600	12	7
Oven, Microwave	1,450	131	190
Pop Corn Popper	490	3	1
Range With Oven	12,200	96	1,171
Range With Self-Cleaning Oven	12,200	99	1,208
Roaster	1,333	154	205
Sandwich Grill	1,161	28	33
Toaster	1,146	34	39
Trash Compactor	400	125	50
Waffle Iron	1,116	20	22
Waste Disposer	445	67	30
FOOD PRESERVATION			
Freezer (15 cu. ft.)	341	3,504	1,195
Freezer Frostless, (15 cu. ft.)	440	4,9002	1,761
Refrigerator/Freezer (19 cu. ft.)	396	3,791	1,501
Refrigerator/Freezer Frostless, 14 cu. ft.	615	2,974	1,829
LAUNDRY			
Clothes Dryer	4,856	205	995
Iron (hand)	1,008	143	144
Washing Machine (automatic)	512	201	103
Water Heater	2,475	1,705	4,220
Water Heater (quick recovery)	4,474	1,705	7,810

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

POWER RATING AND COST ANALYSIS

After accumulating all the pertinent data from the preceding two sheets, list your 10 starred appliances under "Item" below. Then list the estimated kwh used per year - which you located on the electrical energy consumption chart. Complete computations to find cost per year, cost per day, and total costs. Complete the assignment by answering questions 12, 13, and 14.

Item	Estimated KWH used per year	x Current price per KWH	= Cost per year	- Days in a year	= Estimated cost per day
Example: Freezer, 15cu. ft.	1.195 KWH	.05	$59.75	365	$.16
1.		.05		365	
2.		.05		365	
3.		.05		365	
4.		.05		365	
5.		.05		365	
6.		.05		365	
7.		.05		365	
8.		.05		365	
9.		.05		365	
10.		.05		365	
11. TOTALS (sum of cost per year and cost per day column)					

12. Which electrical appliance in your home has the highest wattage rating? ____________

13. Which appliance or device is operated for the greatest time? ____________

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

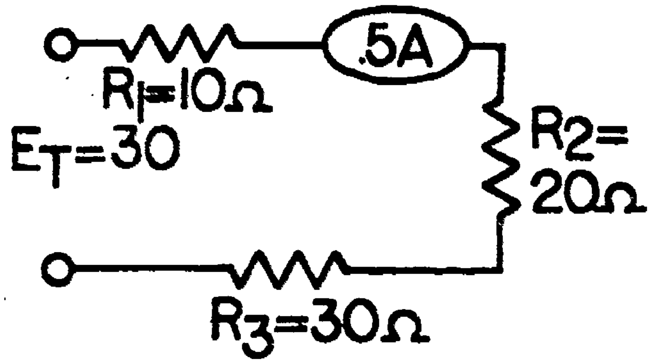
WORKSHEET

QUEST ACTIVITY

"UNIT 7"

MATCHING

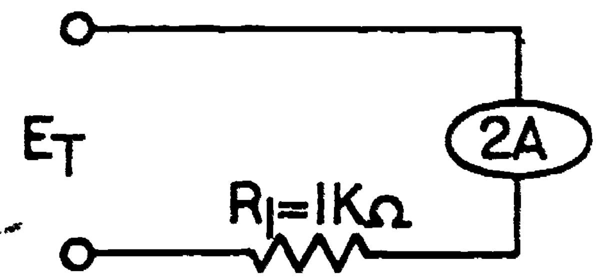
1.	Efficiency = ______	A.	I^2R	1.	
2.	746 Watts = 1 ______	B.	Watt	2.	
3.	Power = ______	C.	Work	3.	
4.	Electrical energy unit	D.	Output ÷ Input	4.	
5.	P equals E x I	E.	6.28×10^{18}	5.	
6.	Power Rating Unit	F.	Horsepower	6.	
7.	Power x time	G.	Watt's Law	7.	
8.	Coulomb = ______	H.	Joule	8.	



9. Find P_T

Show work

9. ______



10. Find P_T

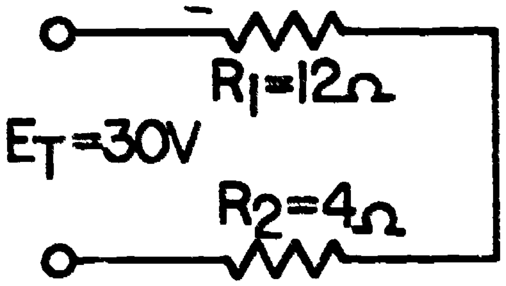
Show work

10. ______

Name: ________________

Date: ________________

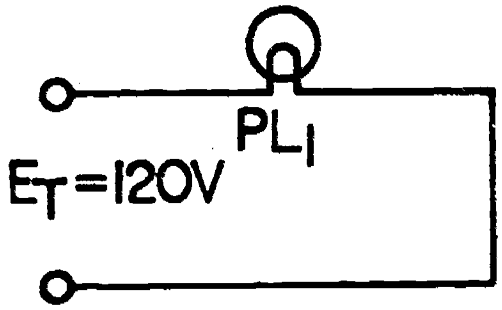
Period: ________________



11. Find P_T

Show work

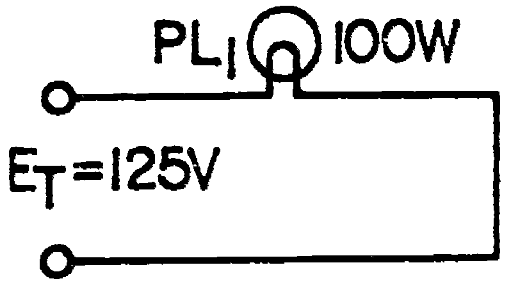
11. [ ]



12. Resistance of PL_1 is 144 ohms. What is the wattage rating of the lamp? ________

Show work

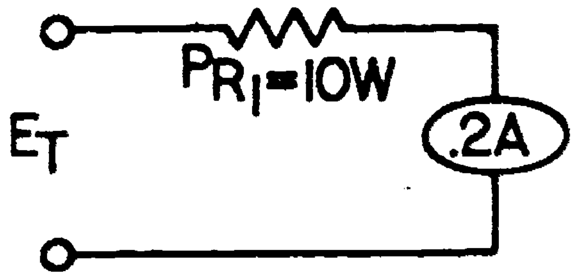
12. [ ]



13. Find I_T

Show work

13. [ ]



14. Find E_T

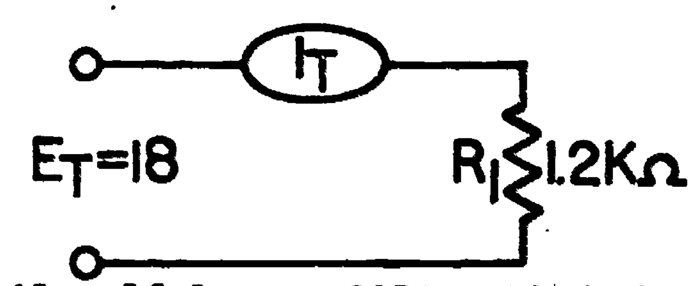
Show work

14. [ ]

Name: ____________________

Date: ____________________

Period: ____________________



15. If I_T = .015A: Find the total power dissipated by the resistor.

15. [ ]

16. If a motor consumes 2238 watts of power:

   A. What is the power rating in horsepower? 16A. [ ]

   B. What is the power rating in kilowatts? 16B. [ ]

Show work

17. If a 10 ohm resistor is connected across an 18 volt source; how many watts of power are dissipated as heat? 17. [ ]

Show work

18. If a 300 watt lamp bulb is lit for 10 hours, how many kilowatt-hours of energy are used? 18. [ ]

Show work

Name: ________________

Date: ________________

Period: ________________

19. If a 1000 ohm resistor is connected across an 18 volt source, it must have a wattage rating of at least: 19. [ ]

1/4W, 1/2W, 1W, or 2W

Remember, if the wattage rating is too low, the resistor will burn up.

Show work

20. A toaster oven consumes 1350 watts of power. It is connected to a 120 volt source.

A. How much current flows through the heating element? 20A. [ ]

B. What is the resistance of the heater element? 20B. [ ]

Show work

Name: ______________

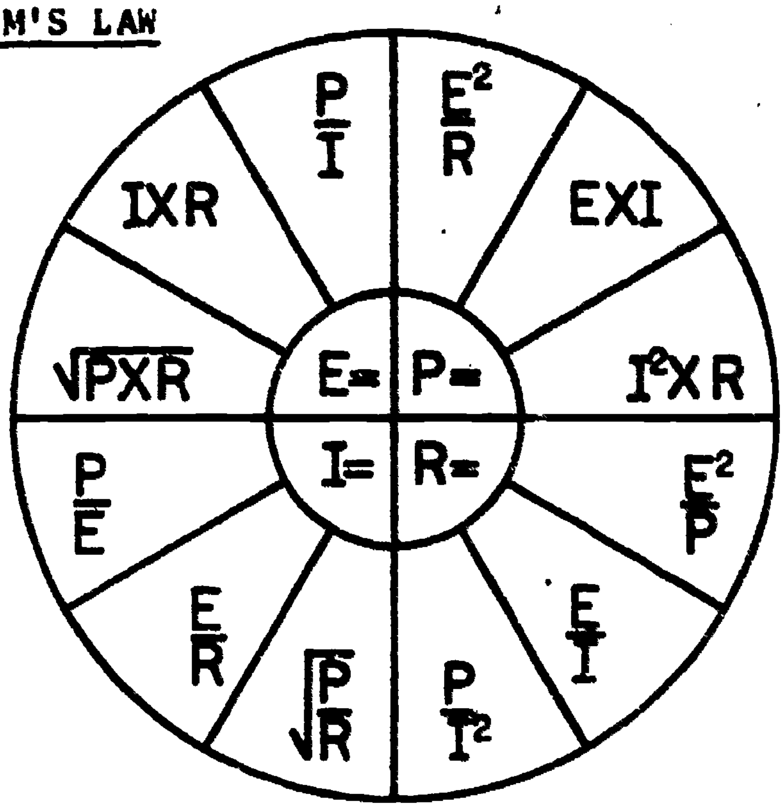
Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

WATT'S LAW

WATT'S LAW and OHM'S LAW FORMULA WHEEL

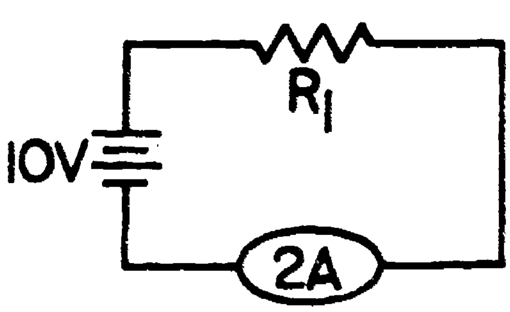


Terms - Symbols - and Units:

1. The term power (P) is measured in the unit watts (W).
2. The term voltage (E) is measured in the unit volts (V).
3. The term current (I) is measured in the unit amperes (A).
4. The term resistance (R) is measured in the unit ohms (Ω).

SAMPLE PROBLEMS:

Solving for power



E = 10V
I = 2A

Formula: P = E x I

Enter values: P = 10 x 2

Multiply: P = 20

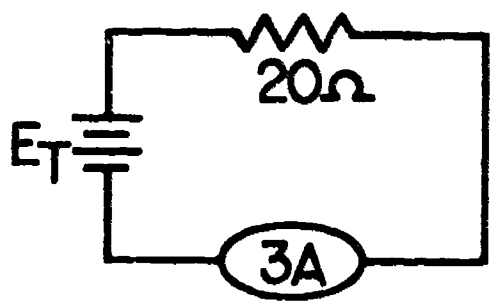
Enter unit: P = 20W

Name: ____________

Date: ____________

Period: ____________

Solving for power



I = 3A
R = 20

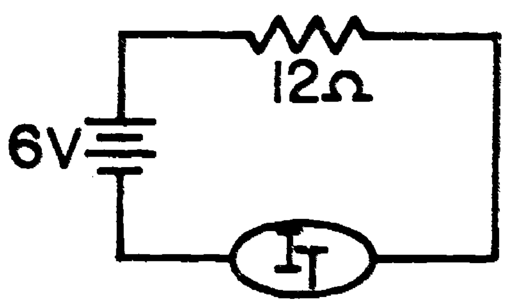
Formula: $P = I^2 \times R$

Enter values: $P = 3^2 \times 20$

Square "3": $P = 9 \times 20$

Enter unit: $\underline{P = 180\ W}$

Solving for power



Formula: $P = \frac{E^2}{R}$

Enter values: $P = \frac{6^2}{12}$

Square "6": $P = \frac{36}{12}$

Divide: $P = 3$

Enter unit: $\underline{P = 3W}$

Name: ____________

Date: ____________

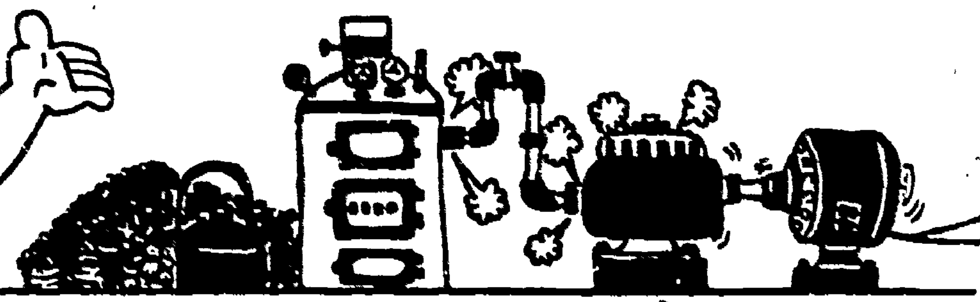
Period: ____________

INFORMATIONAL HANDOUT

HOW ELECTRICITY IS GENERATED AND DISTRIBUTED

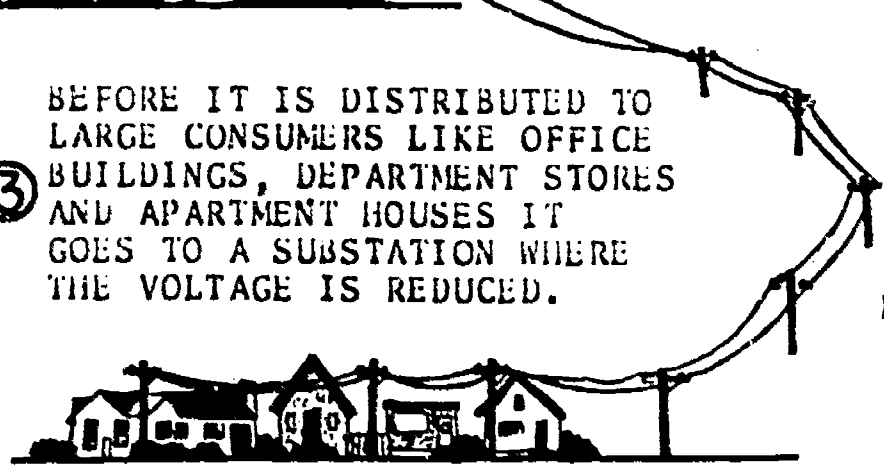
START

① COAL, OIL, OR GAS IS USED TO HEAT WATER TO MAKE STEAM WHICH TURNS A STEAM TURBINE. THIS IS CONNECTED TO AN ELECTRIC GENERATOR WHERE THE ELECTRICITY IS ACTUALLY MADE.



② FROM THE GENERATOR THE ELECTRICITY GOES THROUGH A SUBSTATION WHERE ITS VOLTAGE IS RAISED TO 32,000 VOLTS SO THAT IT CAN BE SENT OVER HIGH VOLTAGE TRANSMISSION LINES FOR LONG DISTANCES.

③ BEFORE IT IS DISTRIBUTED TO LARGE CONSUMERS LIKE OFFICE BUILDINGS, DEPARTMENT STORES AND APARTMENT HOUSES IT GOES TO A SUBSTATION WHERE THE VOLTAGE IS REDUCED.



④ BEFORE THE ELECTRICITY IS DELIVERED TO PRIVATE HOMES, SMALL STORES, AND SCHOOLS, THE VOLTAGE IS FURTHER REDUCED.

FINISH ← **120/240V**

Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

MEASURING AND MONITORING ENERGY CONSUMPTION

Wattage ratings printed on light bulbs and appliances indicate the rate at which the device uses electric energy. If you know the speed of a car, and the time operated, you can find the distance traveled. In the same way if you know the rate at which electrical energy is used, and for how long, you can find the total energy consumed.

The energy consumed in your home is measured by the Kilowatt-hour Meter, which is monitored by the local power company. The power company in turn computes your monthly electric bill based upon the number of kilowatt-hours of energy consumed and the rate schedule which prices each kilowatt-hour.

READING THE KILOWATT-HOUR METER

FIG. 1

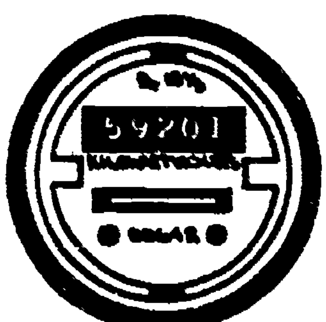


FIG. 2

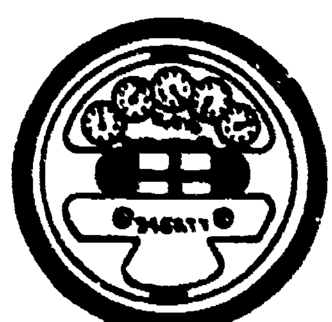


FIG. 3

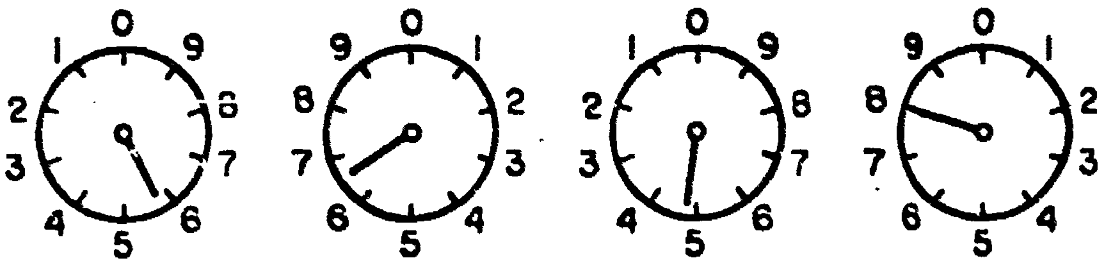
The drawing above shows several styles of kilowatt-hour meters. Locate your meter at home - however, it may be different from those pictured.

Reading the meter in fig. 2 is a simple matter, but reading the pointer style meter is slightly more complex.

Name: ____________________

Date: ____________________

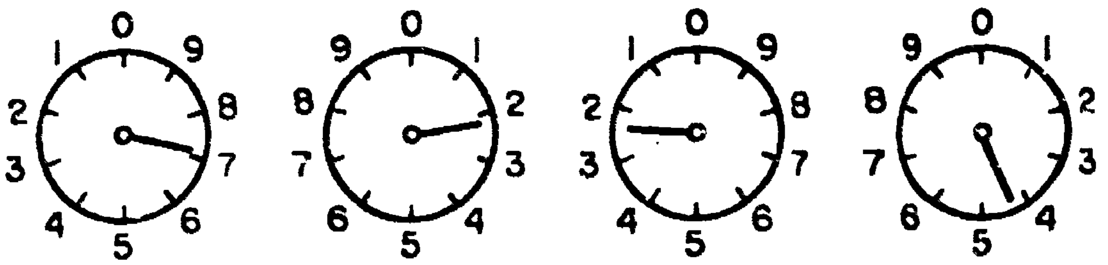
Period: ____________________



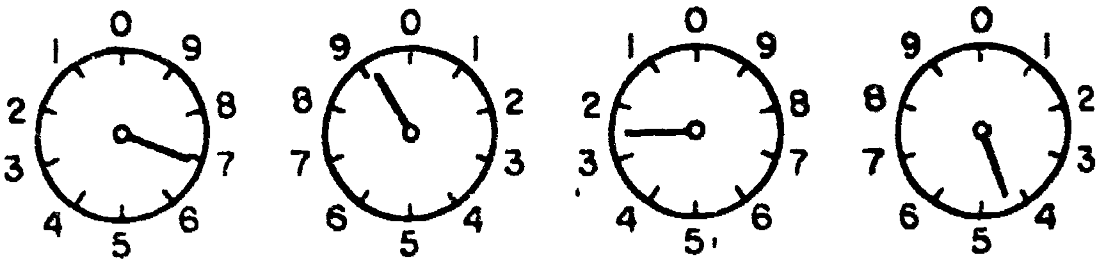
Thousands Hundreds Tens Ones

The meter pictured above is indicating a reading of 5648 kwh's. Notice; even though the pointer falls between two numbers, you always read to the lower value; also, each dial corresponds to a place value in our numbering system (ones, tens, hundreds, etc.)

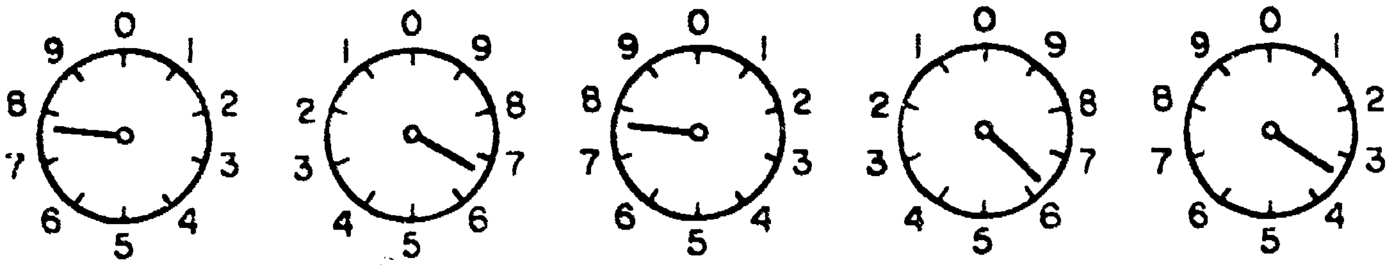
What reading is indicated on the kwh meters below?



Reading ____________________



Reading ____________________



Reading ____________________

ANSWERS: (1) 7224 (2) 6924 (3) 76763

Name: ____________

Date: ____________

Period: ____________

COMPUTING ELECTRIC ENERGY COSTS

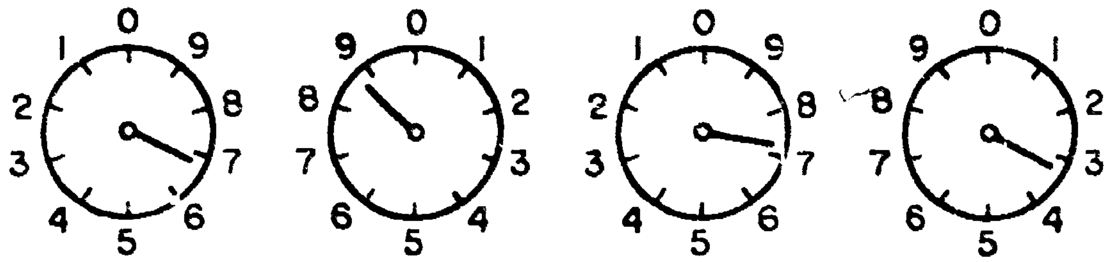
Being able to read the kwh meter is only part of the process in determining monthly energy costs. We will now examine how a power company computes your monthly electric bill.

Step 1. Determine the number of kwh's used per billing period by subtracting beginning meter reading from ending meter reading.

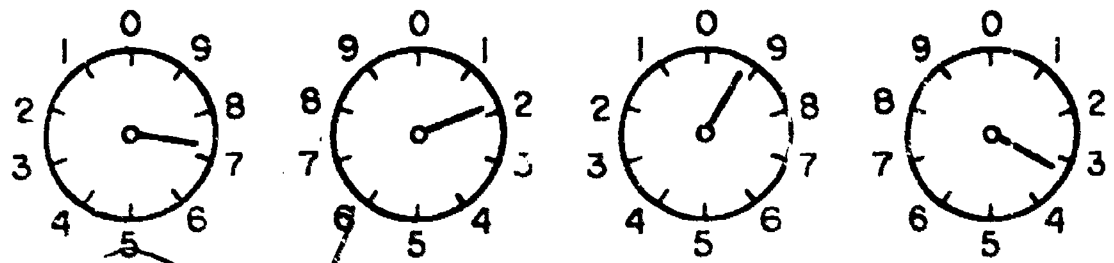
Step 2. Using the rate schedule below calculate the cost by grouping, and multiplying the number of kwh by the cost per kwh. Total the charges to find total cost.

EXAMPLE:

Beginning of billing period:



End of billing period:



Rate Schedule

Fixed customer charge--------------------------------$1.60
Energy charge (includes energy cost adjustment)
    First 300 kwh, per kwh-------------------------$ .045
    Over 300 kwh, per kwh -------------------------$ .046

Step 1. Determine the number of kwh's used.

End of period reading	7193
Beginning of period reading	– 6873
Difference	320 kwh's

Step 2. Calculate cost using rate schedule.

Fixed customer charge--------------------------------$ 1.60
    First 300 kwh, at $.045 each (300 x .045)-------$13.50
    Over 300 kwh, at $.046 each (20 x .046)---------$ .92
                                        Total----------$16.02

Name: ____________

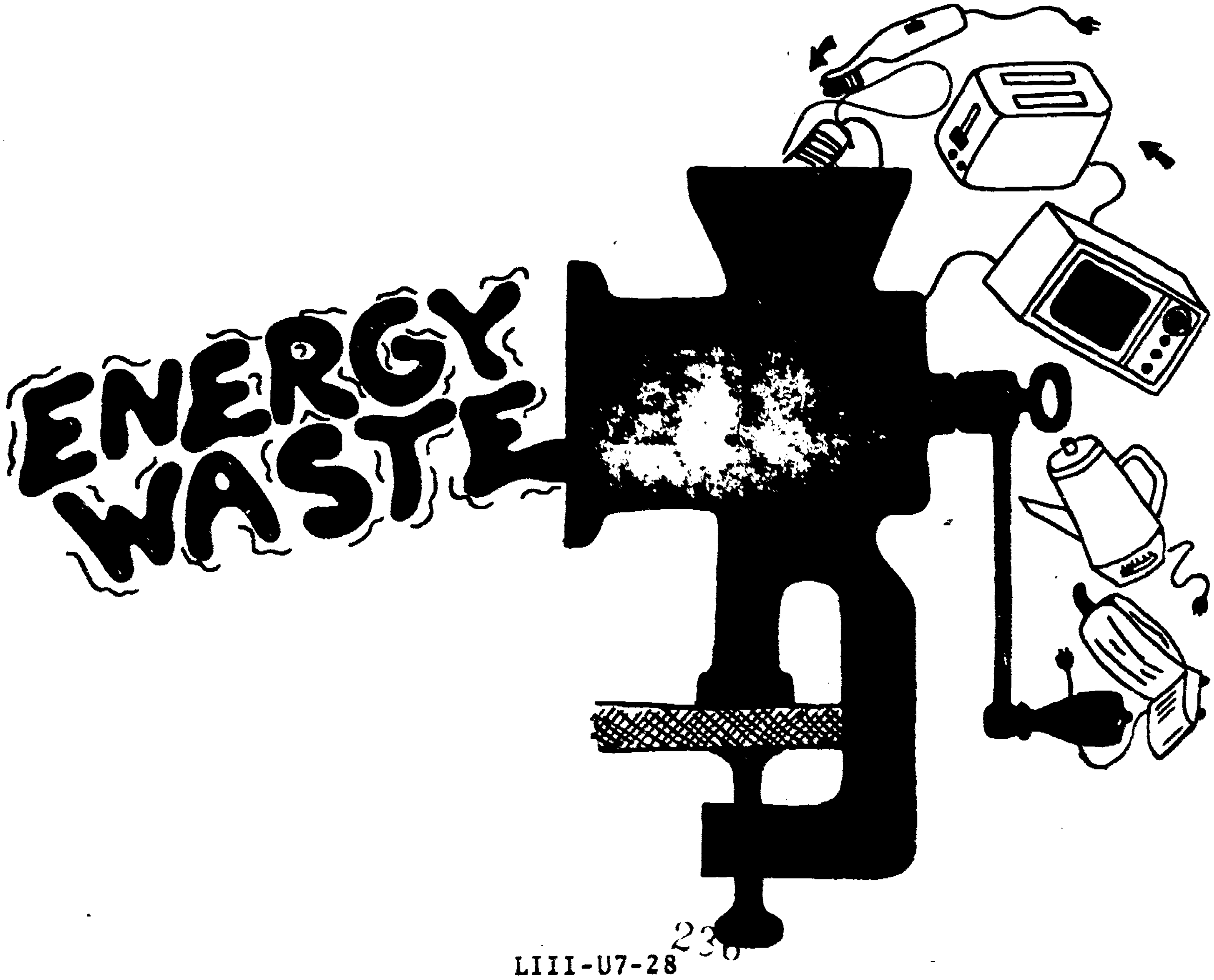
Date: ____________

Period: ____________

How many times have you been told to turn off the lights when you leave a room, or to be sure to turn off the TV or radio when you are not watching or listening? Why all this concern over using a "little" electric energy? Well, obviously it costs money to operate these devices, but more important it wastes energy! Let's try to compute the cost of operating two 100 W lamps for 6 hours - A typical night of study.

		EXAMPLE
Step 1.	Find total power in watts.	Two 100 W lamps = 200 W
Step 2.	Convert watts to kilowatts.	200 W = .2kw
Step 3.	Determine the time - in hours - that the device is in operation.	Given as 6 hours.
Step 4.	Multiply kilowatts x time in hours to find kilowatt-hours.	.2 kw x 6 hr = 1.2 kwh
Step 5.	Multiply kwh by the cost per kwh. To find cost of operation.	1.2 kwh x $.05 = $.06

Thus it will cost approximately 6¢ to operate the two 100 W lamps for 6 hours.



SCORE:
GRADE:

Name: ____________________

Date: ____________________

Period: ____________________

ANSWER SHEET

EXAM LIII U7

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.	■				26.		■			51.					76.				
2.	■				27.		■			52.					77.				
3.		■			28.	■				53.					78.				
4.	■				29.		■			54.					79.				
5.	■				30.				■	55.					80.				
6.		■			31.					56.					81.				
7.	■				32.					57.					82.				
8.		■			33.					58.					83.				
9.		■			34.					59.					84.				
10.		■			35.					60.					85.				
11.		■			36.					61.					86.				
12.	■				37.					62.					87.				
13.	■				38.					63.					88.				
14.	■				39.					64.					89.				
15.		■			40.					65.					90.				
16.			■		41.					66.					91.				
17.				■	42.					67.					92.				
18.		■			43.					68.					93.				
19.				■	44.					69.					94.				
20.		■			45.					70.					95.				
21.		■			46.					71.					96.				
22.	■				47.					72.					97.				
23.			■		48.					73.					98.				
24.		■			49.					74.					99.				
25.				■	50.					75.					100.				

*Show work for problems on back of answer sheet.

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ANSWER KEY
UNIT 7

A. VOCABULARY CROSSWORD

1. coulomb
2. decibel
3. dissipation
4. efficiency
5. energy
6. equation
7. mathematics
8. fuse
9. horsepower
10. I^2R heat
11. joule
12. kilo
13. needle
14. power
15. ratio
16. watt
17. work

```
       heatsink   w
        f     IRheat
        fuse  l o t
        i     o ratio
        c       s
mathematics j   e
        e  work p  p
        n   u  coulomb
      decibel   w  w
        y  needle  e
           e q  r  r
         formula
           g a
           y t
             i
             o
             n
```

B. WATTS LAW

1. current
2. kilowatt

3A. P = E x I

3B. I = P/E

3C. E = P/I

4. watt
5. 360 watts
6. 200 watts
7. 75 W
8. 5 A
9. 40 V
10. 450 V
11. .25 A
12. 25 W
13. .625 W
14. .625 W
15. 6.25 W
16. 2.5 W
17. 15 W
18. 5 ohm
19. 4 A
20. 16 W
21. 40 W
22. 4 W
23. 20 W
24. 80 W
25. 2 A
26. 20 W
27. 20 W
28. 60 W
29. 100 W
30. 25 ohms

C. QUEST ACTIVITY

1. D
2. F
3. A
4. H
5. G
6. B
7. C
8. E
9. 15 W
10. 4 KW
11. 56.25 W
12. 100 W
13. .8 W
14. 50 V
15. .27 W

16A. 3 HP

16B. 2.238 KW

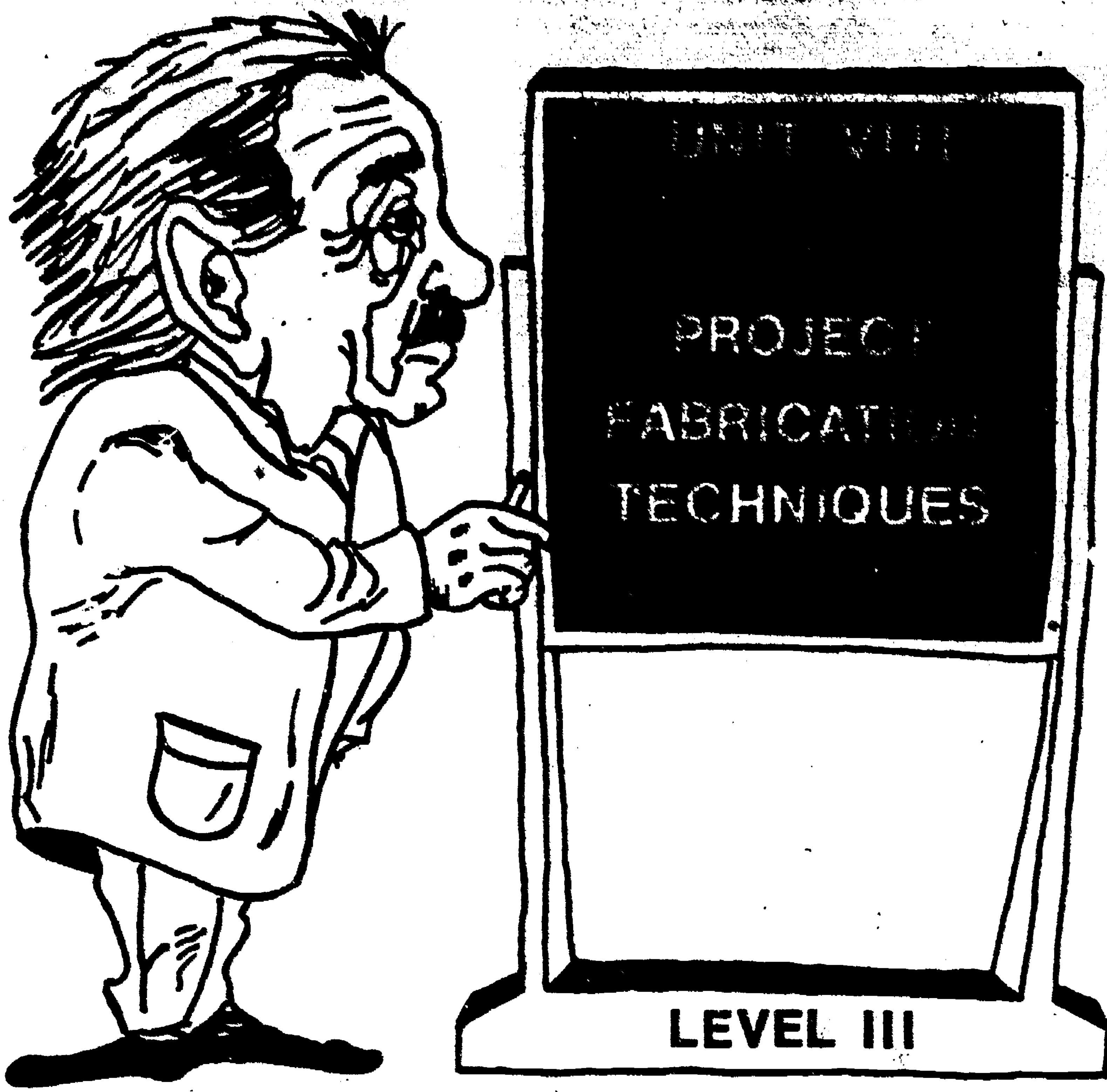
17. 32.4 W
18. 3 KWH
19. 1/2 W

20A. 11.25 A

20B. 10.666 ohms

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME____________________
DATE STARTED____________
DATE COMPLETED__________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Project Fabrication Techniques

Time Allocation: 3 weeks

Unit Goal:

To stimulate interest in electronics by divulging and developing those competencies pertinent to successful project building including fabrication and wiring techniques, troubleshooting, and technical report writing.

Unit Objectives:

The student will be able to:

1. describe the function, list safety precautions, and illustrate the correct use of each construction tool presented in this unit.

2. identify five different circuit fabrication methods and explain the main characteristics of each.

3. appraise project workmanship and demonstrate the proper procedure for producing an appropriate project chassis or enclosure, locating and mounting circuit components on a chassis, and creating a neat and accurate circuit wiring arrangement.

4. perform basic inspection, testing, and troubleshooting steps in order to locate and remedy defects when evaluating a simple circuit or project.

5. justify the relative importance of technical writing as a vital support function within the electronics field, and specifically demonstrate writing skills in the creation of a technical report.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Electronics Assembly and Fabrication Methods. S.R. Duarte and R.L. Duarte, McGraw-Hill Book Co., 1973. Chapters: 1,5,6,7,8,9,and 10.

Electronic Techniques. R.S. Villanucci, A.W. Avtgis, and W.F. Megow, Prentice-Hall, Inc., 1974. Chapters: 3-8, 12,14,15,and 16.

Technical Electricity and Electronics. Peter Buban and Marshall L. Schmitt, McGraw-Hill Book Co., 1977. Units: 28, 30, and 31.

Overview:

Unit 8 is unique in content in that it focuses on a fascinating aspect of the electronics field that can generate enough motivation and enthusiasm to maintain or stimulate student interest. This unit will allow the student to develop competencies that will act as a foundation for future mechanical and electrical assembly tasks.

The unit should be introduced as a valuable resource in project planning and construction. The idea of constructing a project should be stressed as a necessary "hands on" experience in order to facilitate working with devices and processes.

The central idea or theme is to present various project fabrication techniques, however, craftsmanship is a quality that must be emphasized by the instructor as an on going process that should permeate all levels of activities.

The next topic, which is basically concerned with troubleshooting procedures, is directly applicable to the entire field of repair or service. The concept of logically deducing error is the main philosophical goal.

This unit concludes with a short yet informative description on the significance and methodology of report writing. This topic can be coordinated with the student laboratory project and submitted as a complete package.

A variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. When illustrating basic construction tools and describing function, an overhead projection can be easily adapted as a means to show tool outline or shape. In addition, physically tracing tools with color pencils can assist disadvantaged students in learning the basic differences in size, shape, function, etc.
2. Often teachers introduce a project or kit construction simply as a process in assembly without devoting enough emphasis to technical comprehension of project circuitry. This is an ideal time to instead have students breadboard their circuits and explain component purpose or system function to the instructor and class. If students are exceptionally competent then remove from the kit any materials or reference to wiring and/or component placement and let the individual develop and complete the project utilizing their own resources and abilities.
3. Many schools have access to either classroom or portable V.T.R. systems, and the topic of tools especially ends itself to this kind of presentation. Usually when demonstrating tool function it is difficult for students to actually view the objects but with close camera work and a monitor one can circumvent typical problems.

Methodology continued:

4. A method which insures student attentiveness and promotes a profound understanding of the "troubleshooting" process can be presented within a lesson. Prior to class the teacher should fill out 3" x 5" cards with prepared appliance symptoms. Students are told that they are technicians at a local service center and have just received this item. Have students read symptom card, analyze problem, and explain their procedure for locating and correcting improper operating conditions.

Supplemental Activities and Demonstrations:

1. In order for students to have an opportunity to acquaint themselves with the diversified nature of tools, present and demonstrate circuit construction tools within three categories; 1) mechanical assembly 2) electrical assembly, and 3) microelectronics assembly. Indicate with each when appropriate; function, safety, limitations, advantages, size, and capacity rating.
2. Class examines a box containing both good and defective components. Call upon a selected student to demonstrate proper testing to determine quality.
3. Instructor cuts ten (10) five-foot lengths of stranded wire in front of the class and while holding up a piece of string ask a student to tie the wire. Illustrate now, the proper technique in using spot ties and cable lacing. After the bundle has been secured have another student describe the manner in which one could identify the corresponding ends of each wire.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Spelling Puzzle
5. Worksheet - Circuit Assembly and Wiring
6. Worksheet - Visual Troubleshooting
7. Quest Activity
8. Informational Handout (Hints on Project and Kit Building)
9. Informational Handout (Project Report Writing Format)
10. Instructor's Form (Project Evaluation Sheet)
11. Unit Module Answer Key

VIII. Project Fabrication Techniques

A. Basic circuit construction tools
   1. Essential hand tools and equipment

   2. Care and usage review

B. Circuit fabrication methods
   1. Breadboarding procedures

   2. Point-to-point wiring

   3. Perforated board wiring

   4. Circuit construction with mini-mounts

   5. Printed circuit boards

C. Chassis assembly procedures
  1. Location of components or circuit boards

  2. Component operation consideration

  3. Heat dissipation requirements

  4. Parts replacement and convenience

D. Preparation of chassis and enclosures
  1. The chassis layout

  2. Drilling and punching holes

  3. Chassis construction

E. Special component mounting

1. Heavy components

2. Large resistors and capacitors

3. Insulators and terminal strips

4. Jacks and connectors

5. Potentiometers and rheostats

6. Hardware requirements

7. Heat sink hardware

F. Wires and wiring techniques
   1. Wires and cables

   2. Connectors

   3. Bus wire and grounding system

4. Cable lacing and ties

G. Project inspection, testing, and troubleshooting
   1. Visual inspection

   2. Problem isolation

   3. Testing of tubes and/or solid state devices

   4. Voltage and resistance checks

   5. Replacement of defective components

   6. Project analysis for normal operation

H. Project report writing

LIII-U8

UNIT EXAM

PROJECT FABRICATION TECHNIQUES

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question there is only one correct answer for each question.

1. Longnose pliers are designed primarily for holding and bending small-gauge wires. (T-F)

2. When fastening a wire to a screw terminal, the wire should be wound around the screw in a counterclockwise direction. (T-F)

3. Diagonal-cutting pliers are designed mainly for the purpose of stripping wires. (T-F)

4. Pliers that have longer and thinner gripping jaws than longnose pliers are often called needless nose pliers. (T-F)

5. Side-cutting pliers are sometimes called lineman pliers. (T-F)

6. Wire strippers are tools that are used to remove the conductor from wires. (T-F)

7. A type of circuit assembly used for experimentation, for making prototypes, or for first models of circuits is commonly referred to as a breadboard. (T-F)

8. Point to point wiring involves connecting wires directly to components without using terminals or mounting hardware. (T-F)

9. Printed circuit boards require special press in terminals for soldering on components and interconnecting wires. (T-F)

10. Perforated board or "vector" board provides a convenient surface for breadboarding experimental circuit layouts. (T-F)

11. Components which generate high heat, while operating, require special mounting considerations; 1) heat sinking, 2) proper location on the chassis, and 3) special insulating requirements. (T-F)

12. The purpose of a fuse is to turn off a circuit when the current becomes too low. (T-F)

13. Fuses are always connected in series with the circuit. (T-F)

14. One phase of project construction involves the building of a chassis which forms the base upon which a circuit is assembled or mounted. (T-F)

15. Drilling holes in sheetmetal can be a dangerous operation. (T-F)

16. A handpunch or chassis punch is commonly used to punch round holes in sheetmetal. (T-F)

17. One method for planning a chassis layout is to use puppets to simulate components and experiment with different position or placement schemes. (T-F)

18. The preferred solder to utilize in electronic project construction is 60-40 acid-core solder. (T-F)

19. Availability of plans and parts for a project are of little concern to the builder because the instructor can always locate needed materials. (T-F)

20. A stranded wire is less flexible than a solid wire of the same gauge. (T-F)

21. Connectors are generally used for a one-time permanent contact between wires, cables, and/or printed circuit boards. (T-F)

22. The chassis is always used as a common or ground point in electronic circuits. (T-F)

23. Pre-tinned hook-up wire is coated with a thin layer of tin to prevent the copper conductor from oxidizing. (T-F)

24. A circuit in which the correct size fuse blows out repeatedly should be checked for an overload or short circuit condition. (T-F)

25. Conductors or traces on a printed circuit board often cross or overlap each other. (T-F)

26. When doing a repair job on a P.C. board use a high wattage soldering iron in order to quickly remove the component. (T-F)

27. Lifted traces on a P.C. board can be glued back into place. (T-F)

28. A dull-colored solder joint, on a P.C. board, is acceptable as long as enough solder is used. (T-F)

29. Plastic insulating tubing is often called "spaghetti." (T-F)

30. Troubleshooting usually begins with a thorough visually inspection of the metal chassis. (T-F)

31. The schematic seldom contains information usable in troubleshooting. (T-F)

32. Systematic troubleshooting involves following logical rules or procedural steps. (T-F)

33. Manufacturing defects account for the majority of resistor burn outs. (T-F)

34. Once you have isolated a circuit malfunction, an appropriate step would be to test the associated tube or solid state device. (T-F)

35. The sense of smell, can play an important role in the troubleshooting process. (T-F)

36. The process of determining why a device or circuit does not operate properly is called technical inspection. (T-F)

37. When replacing a defective component in a circuit be sure the powe is on.. (T-F)

38. Voltage checks can be properly made with an ohmmeter. (T-F)

39. Voltage measurements are usually made between the leads of transistors or tubes and the circuit common or ground. (T-F)

40. Several wires bound together with ties form a lacing. (T-F)

Name: ______________

Date: ______________

Period: ______________

TECHNICAL GLOSSARY

BREADBOARDING: Breadboarding allows convenient experimental wiring of circuit components to check circuit operation design, and component placement, after a successful operational model of the circuit is finalized, the components are removed from the breadboard and assembled into final form.

BUS WIRE: A wire that provides a common point of connections for several components or wires. This wire is usually a solid, large diameter, pretinned wire, often used as the ground or circuit common lead.

CABLE: A group of insulated conductors bound together with ties or an insulating cover. Shielded cables contain a braided metal layer which surrounds the insulated inner conductor or conductors.

CABLE LACING: The process of tying a group of wires using lacing cord or tape to form a cable.

CABLE TIES: Small self locking belts or straps of nylon used in place of lacing cord or tape to bind wires together.

CHASSIS: An enclosure or frame, usually metal, on which electronic components or assemblies are mounted and wired.

CONNECTORS: A device at the end of a wire or cable used to facilitate a permanent, yet removable connection to another cable, circuit board, or panel.

CONTINUITY TEST: An electrical test to check for a complete conducting path between; points in a circuit, ends of a conductor, or terminals of a component. The ohmmeter is frequently employed for this purpose.

FABRICATION: The process of designing and constructing a product or project, which includes the processes of planning, forming, assembly, and finishing.

HARDWARE: Items such as screws, bolts, nuts, rivets, etc. which supply physical support for electronic equipment, or items such as sockets, insulators, lugs, clips, etc. which supply electrical support for electronic equipment.

INSPECTION: The technique of examining a circuit or assembly for faults, flaws, or defects.

LAYOUT: A two dimentional diagram used to locate holes, bends, or mounted parts on a chassis.

Name: _______________

MINI-MOUNTS:	Printed circuit elements used as solderable bases for wires and components such as resistor, capacitors, integrated circuits, transistor, etc. The mounts have self stick backs for attaching them to a panel.
PERFORATED BOARD:	A non-conductive phenolic or fiber board with a matrix of drilled holes. Components can be wired to terminals which press into the holes or the board can be used alone as a substratum for mounting.
POINT TO POINT WIRING:	A method of circuit construction where wires and components are connected directly together. Support for components is provided by terminal strips and/or sockets.
PRINTED CIRCUIT BOARD:	A phenolic or epoxy-glass board with printed copper conductors traces. The board is designed and drilled in such a way that components mount securely on the board, and solder to the interconnecting traces.
SHRINKABLE TUBING:	A special insulating plastic tubing or sleeve which shrinks when exposed to heat. Typical applications would be in cable making, and insulating connections.
TECHNICAL WRITING:	The process of presenting technical facts in written form. Technical writing is tightly structured many times using standardized formats or report forms. The goal of technical writing is to record for evaluation, and present results or procedures and experiments. Some examples of technical writings are; experiment results, product evaluations, assembly instructions, repair and troubleshooting guides, operating manuals, etc.
TERMINAL STRIP:	A piece of insulating material on which lugs, terminals, or tie points are mounted. The terminal strip also has some form of mounting bracket for attachment to a chassis.
TROUBLE-SHOOTING:	The process of logically locating and correcting improper operating conditions within an electronic circuit or system.
WIRE HARNESS:	A group of wires, tied into a neat bundle, and routed so that interconnections can be made between various electronic components.
WORKMANSHIP:	The skill, quality, and care dedicated to the construction of an item. The ability to properly choose and use tools to produce a quality product. Synonymous with craftsmanship.

SCORE:
GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

VOCABULARY - SPELLING PUZZLE

Identify the correct spelling for the words listed below.

A.	(example)	(exhample)	(xample)	A. example
1.	(cabel)	(cable)	(kable)	1.
2.	(laceing)	(laycing)	(lacing)	2.
3.	(connecttors)	(connectors)	(connecktors)	3.
4.	(fabrication)	(fabrikasion)	(fabracation)	4.
5.	(continuety)	(continuity)	(contanuety)	5.
6.	(breadbording)	(bredboarding)	(breadboarding)	6.
7.	(layout)	(laeout)	(laiout)	7.
8.	(preforated)	(perferated)	(perforated)	8.
9.	(workmanship)	(workmenship)	(werkmenship)	9.
10.	(harness)	(hareness)	(harnes)	10.
11.	(tecknical)	(tecknecal)	(technical)	11.
12.	(termanel)	(termenal)	(terminal)	12.
13.	(hardwhere)	(hardware)	(hardwore)	13.
14.	(circut)	(sirkit)	(circuit)	14.
15.	(srinkable)	(shrinkabel)	(shrinkable)	15.
16.	(chasiss)	(chassis)	(chassie)	16.
17.	(tyes)	(thies)	(ties)	17.
18.	(inspection)	(enspection)	(inspecsion)	18.
19.	(wireing)	(wiring)	(wareing)	19.
20.	(trobleshot)	(troublshoot)	(troubleshoot)	20.

SCORE:
GRADE:

Name: ______________

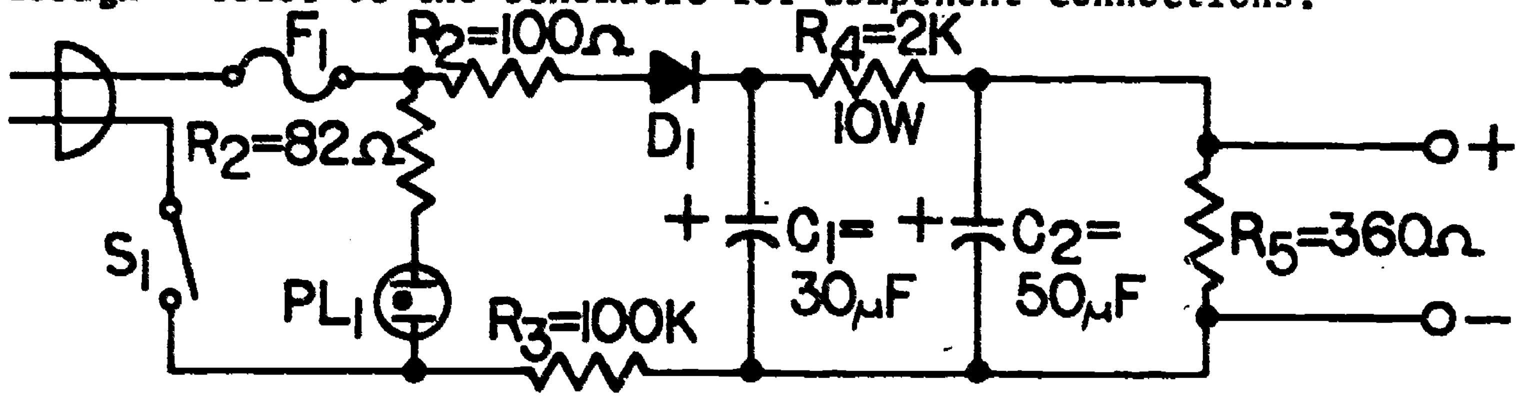
Date: ______________

Period: ______________

WORKSHEET

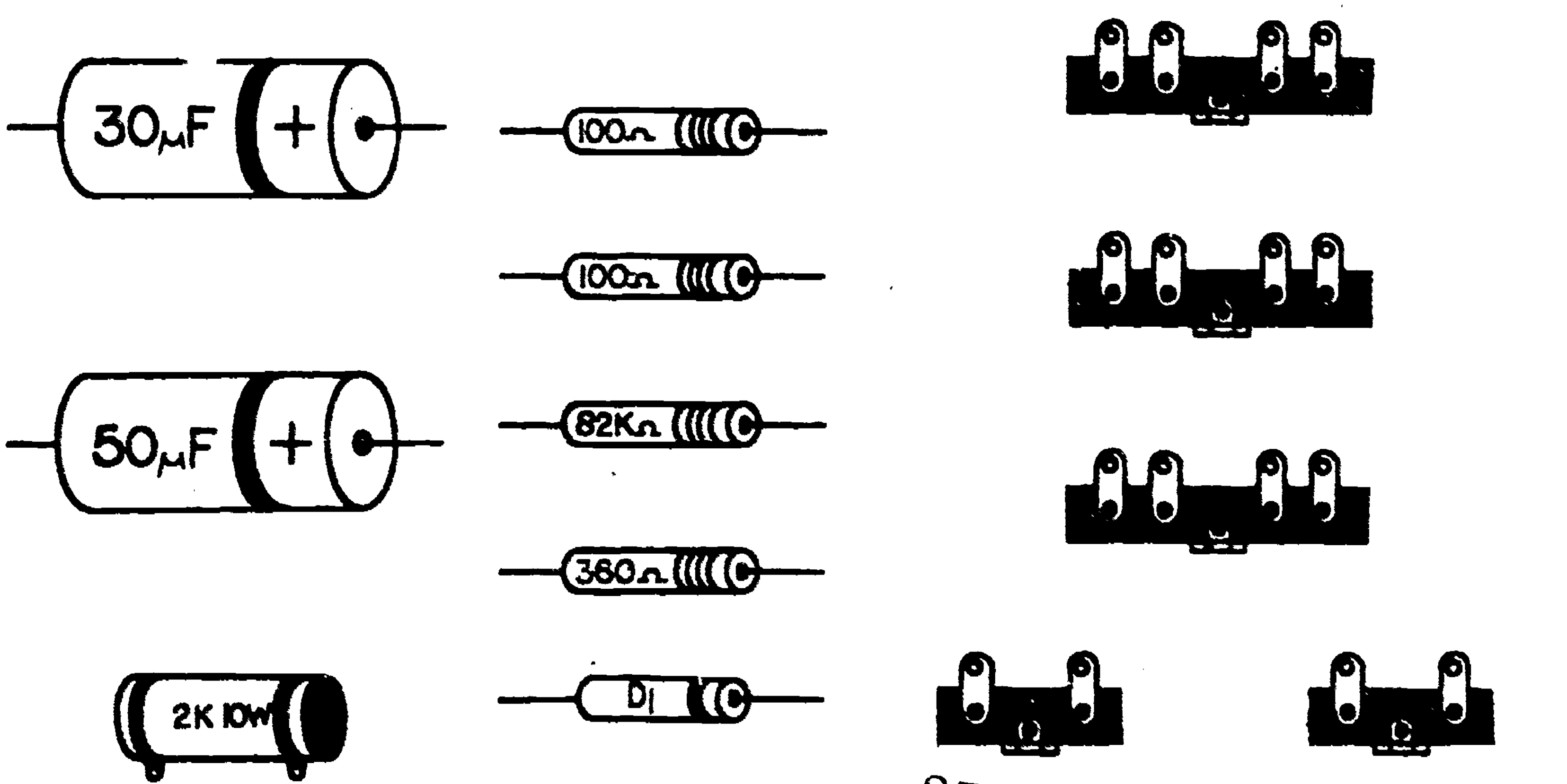
CIRCUIT ASSEMBLY AND WIRING

The purpose of this worksheet is to provide an opportunity for you to design a circuit layout using point to point wiring. You will use the power supply schematic below as a basis for your circuit design - refer to the schematic for component connections.



Carefully cut out the component puppets below. Cut as close to the outline as possible; this will simplify the "mounting and wiring" of the components. Locate the chassis plan - most of the hardware items are already premounted. Your job is to plan and arrange the terminal strips, and components on the chassis. Once you have determined a satisfactory layout, glue the terminal strips and components to the chassis. Using colored pencils or pens insert the necessary interconnecting wires. Observe proper techniques of parts placement (layout), wiring, and harnessing.

COMPONENT PUPPETS



SCORE:
GRADE:

Name: ____________

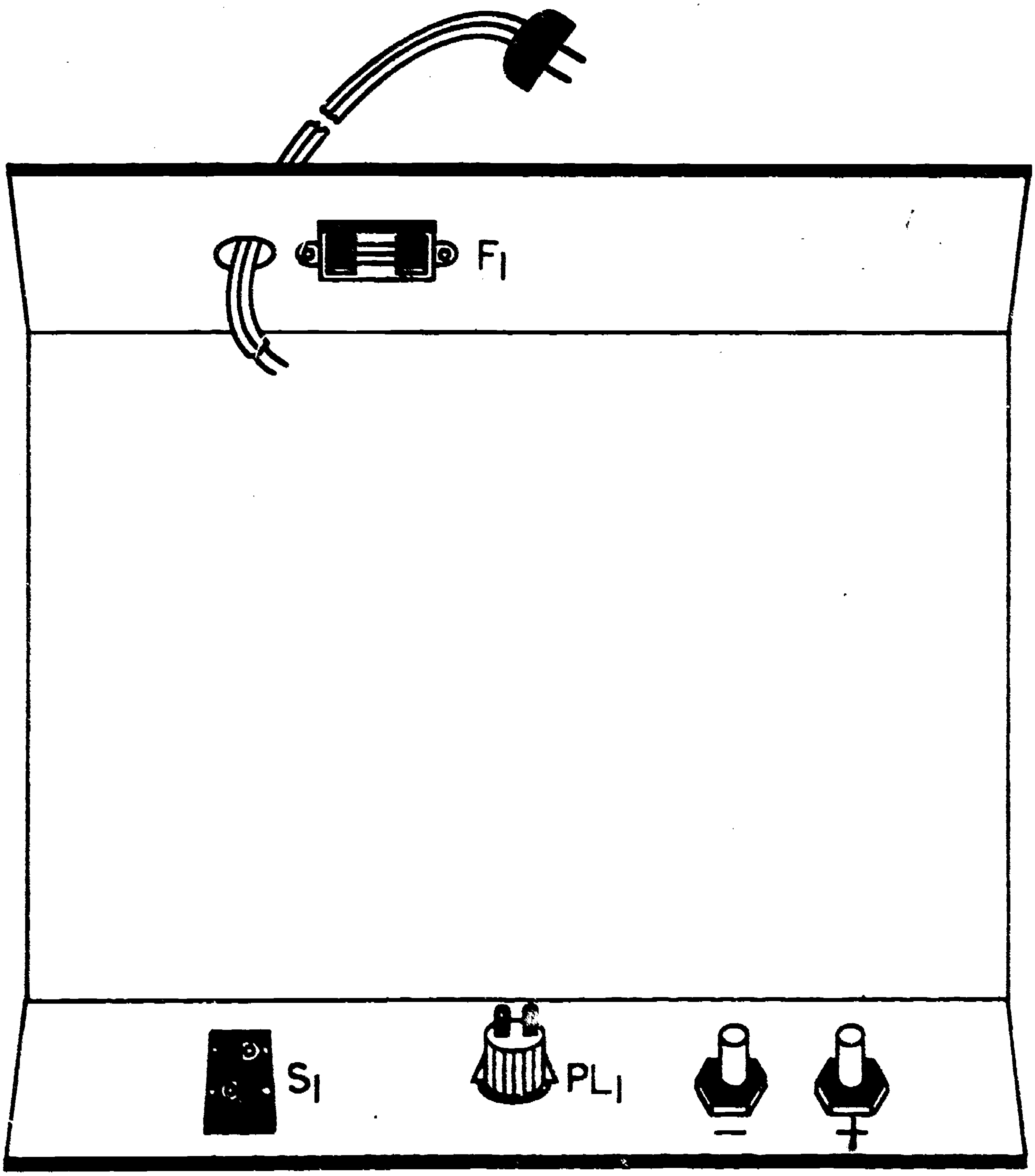
Date: ____________

Period: ____________

WORKSHEET

CIRCUIT ASSEMBLY AND WIRING

CHASSIS PLAN



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Name: ____________

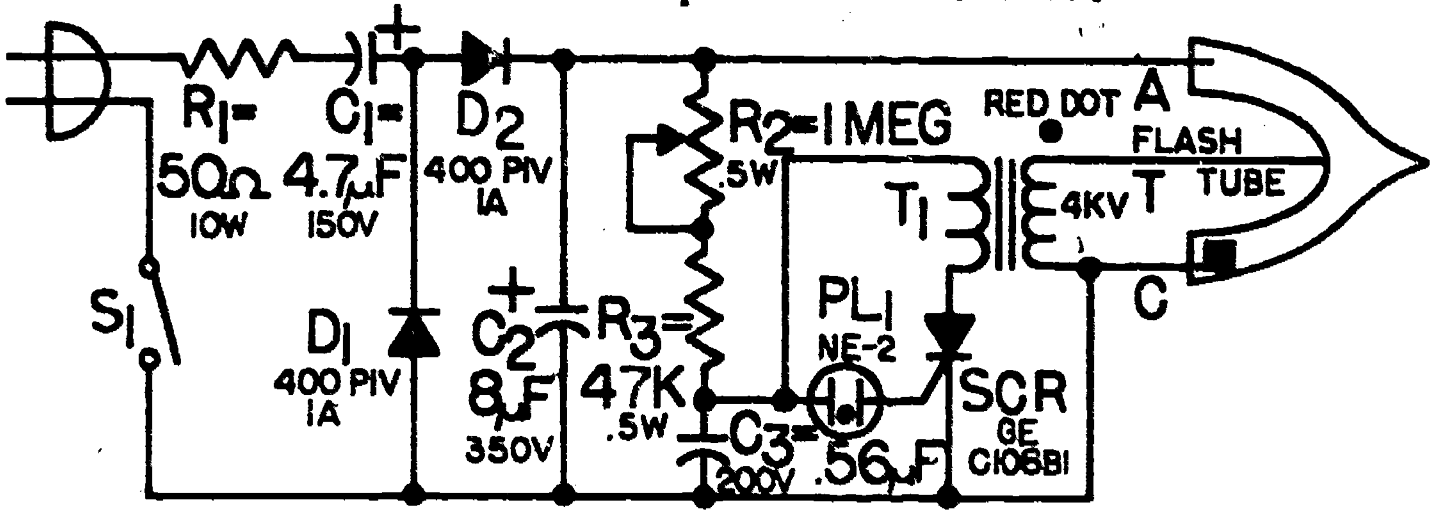
Date: ____________

Period: ____________

WORKSHEET

VISUAL TROUBLESHOOTING

A classmate has just assembled a strobe light and is concerned that something may be wrong; such as a misplaced component, etc. You are asked to check over the project to see if you can find any errors. Refer to the schematic below as a point of reference.



List below the faults you discover while visually troubleshooting the circuit assembly pictured on the following page.

1.

2.

3.

4.

5.

6.

7.

8.

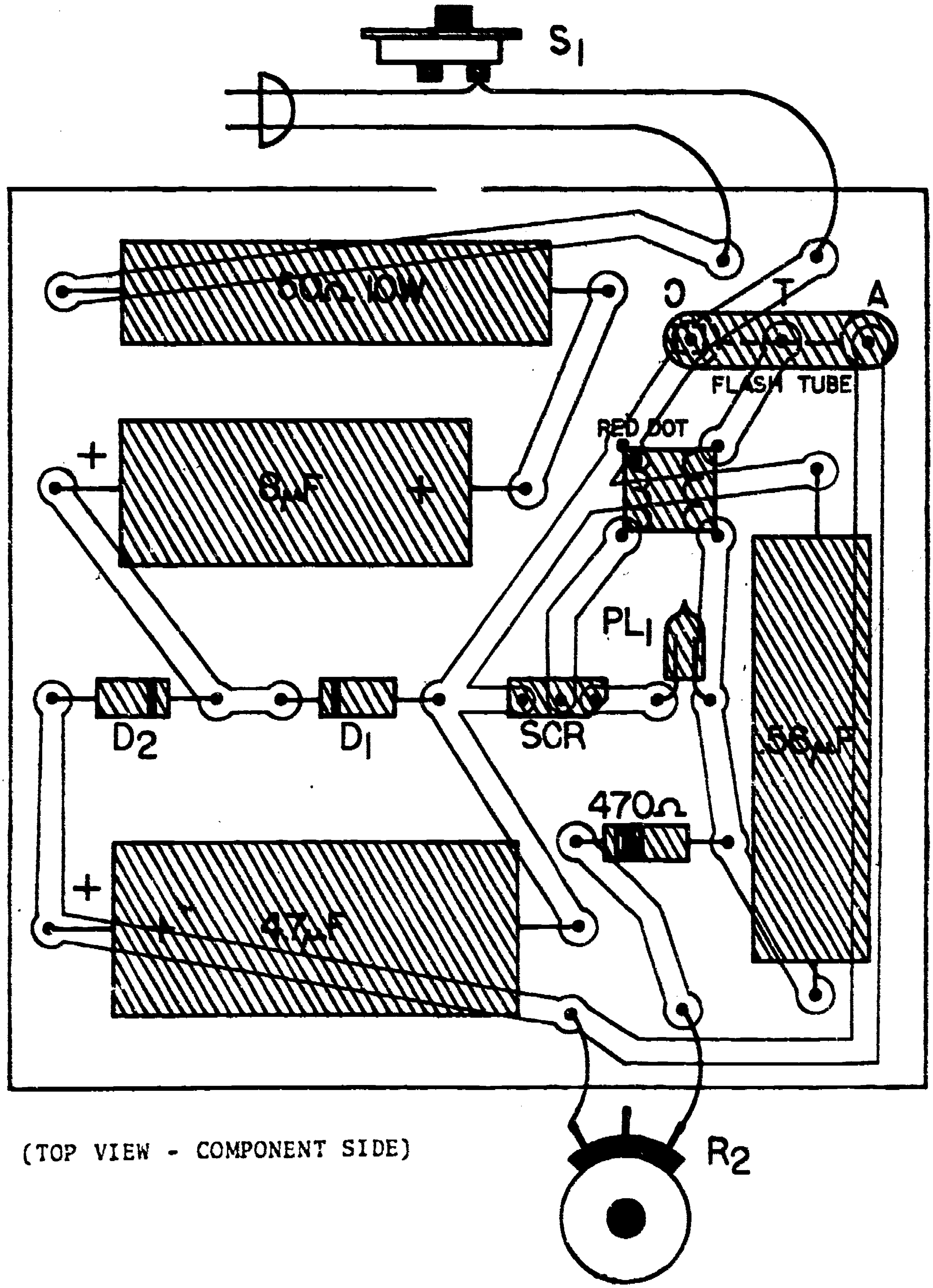
Name: ____________

Date: ____________

Period: ____________

WORKSHEET

VISUAL TROUBLESHOOTING



(TOP VIEW - COMPONENT SIDE)

SCORE:

GRADE:

Name:__________

Date:__________

Period:__________

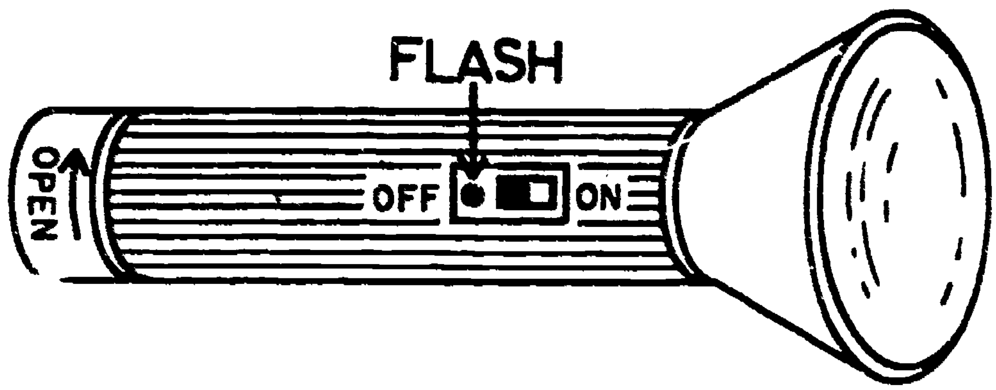
WORKSHEET

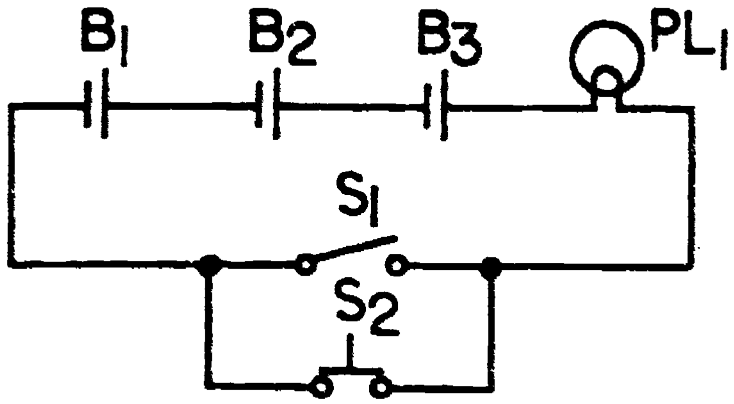
QUEST ACTIVITY

"UNIT 8"

Technical writing encompasses several techniques or processes of communication such as explaining or describing circuit operation, giving procedural or operating instructions, illustrating, and preparing informational charts. This exercise is designed to sharpen your skills in the area of technical writing.

You are a design engineer for a technically advanced electronics company. The president of the company has just designed and prototyped a new style electronic flashlight. He is planning his marketing campaign to appeal to electronic engineers, and wants you to develop the documentation for the product. You are supplied with a schematic and pictorial diagram of the product; develop 1) a description of circuit function, 2) a set of operating instructions and 3) a troubleshooting - repair guide. Submit work in report form.





Name: ________________

Date: ________________

Period: ________________

INFORMATIONAL HANDOUT

HINTS ON PROJECT AND KIT BUILDING

First, select a project that meets your needs; evaluate interest, cost, time, ability, and accessibility of parts and materials.

You may want to inquire by phone to a local electronic part distributor and find out or verify that all components are available for purchase. If cost is a real problem remember that mail-order houses usually are much cheaper in price so check the back of magazines for addresses, but allow enough time (3-4 weeks) for your order to be processed. Now don't overlook the possibility of assistance from electronic firms, many items have been given away as "freebies" just because students wrote letters explaining their needs for project parts. Use common sense when asking for an item and always send a thank you note!!

Next, plan your construction and assembly location carefully and if you choose to work at home it should be quiet, private, and away from your brothers and sisters. Try to obtain a lamp that is movable - maybe there is a high intensity desk lamp that you can borrow. Find an area, or use extension cords, which will allow you to plug several things in at once like a soldering iron, electric drill, lamp, etc. If you are building at school try to use a "pad" at your work area both to protect the school laboratory facility and your project from damage, scratches, or unwanted marks.

Name: ____________

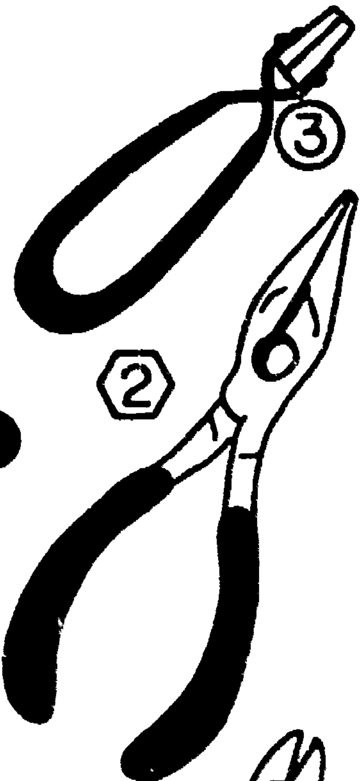
Date: ____________

Period: ____________

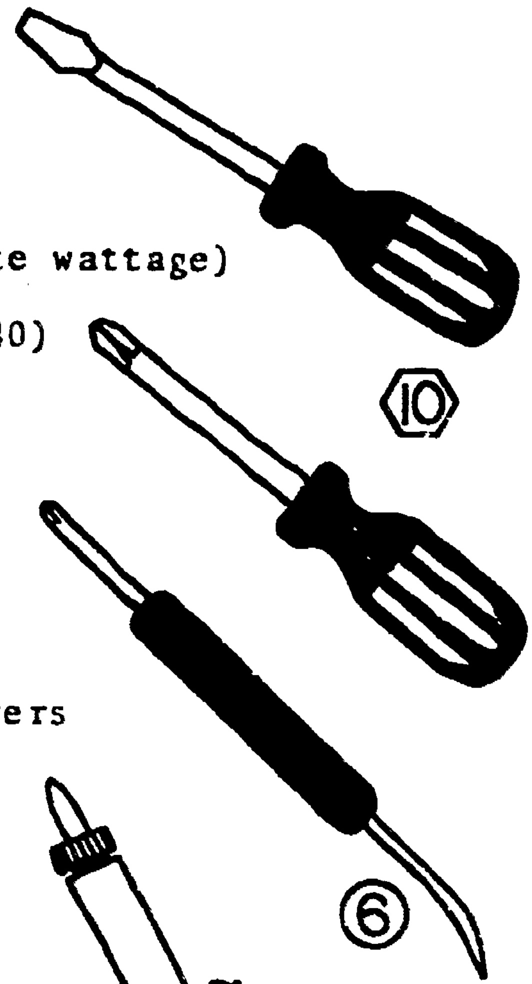
Right from the start, you should be aware that it usually takes more than one day to complete a project or kit, so organize a container, such as a shoe box, to store materials during the construction process. Generally you will sort components into groups (resistors, capacitors, etc.) for storage. To solve your storage problem, consider using small plastic containers, tiny drinking cups, mom's muffin pan, or letter envelopes for ease in location and identification of components.

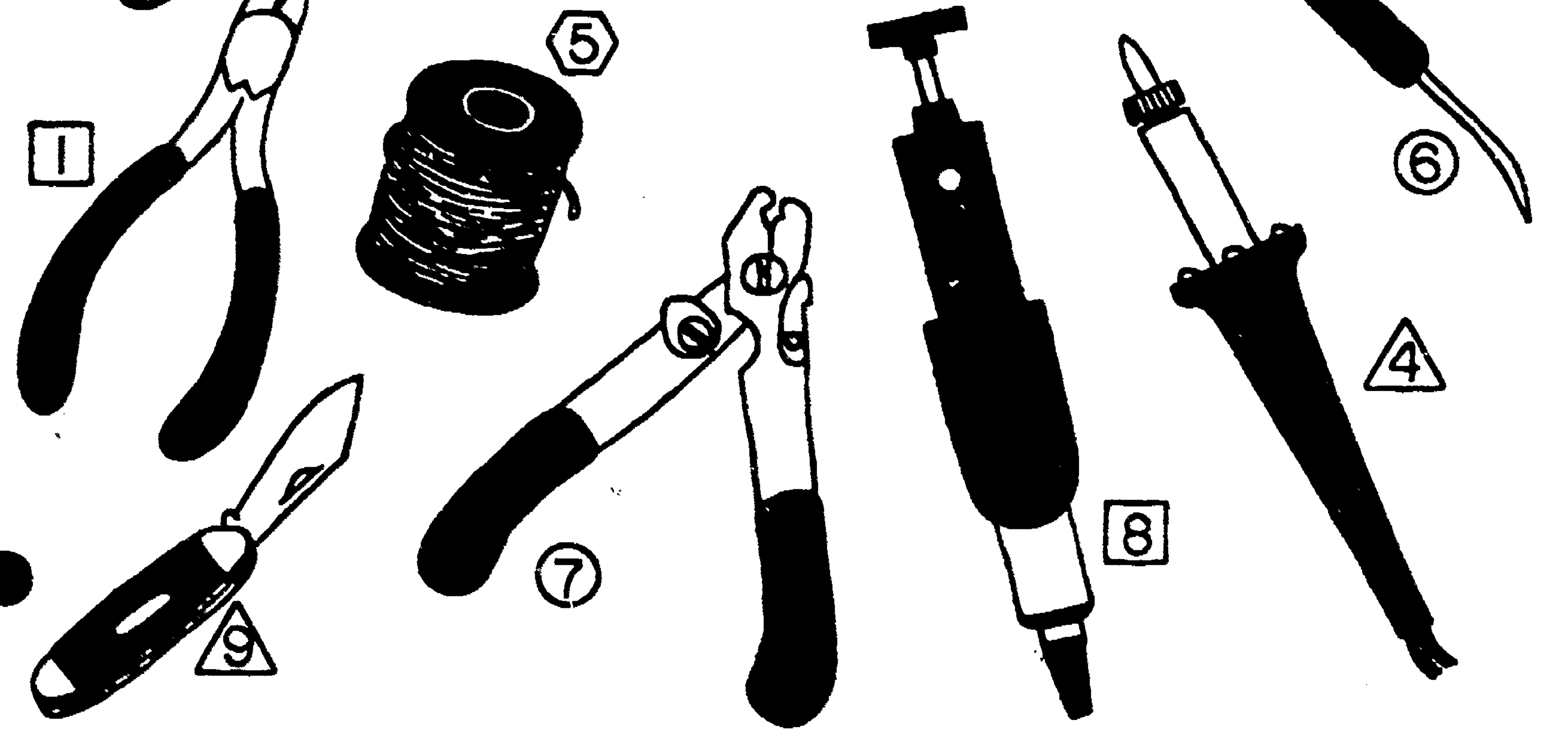
TOOLS AND EQUIPMENT I MAY NEED!!!

The following tools and materials are essential for both mechanical and electrical assembly of any project or kit:



1. Diagonal cutting pliers
2. Long nose pliers
3. Heatsink
4. Soldering device (appropriate wattage)
5. Thin solder (rosin core 60-40)
6. Solder aid
7. Wire stripper
8. Solder "Sucker" remover
9. Knife
10. Assorted type/size screwdrivers





Name: ______________

Date: ______________

Period: ______________

The following items may be needed and should be available in your school laboratory:

1. Portable Electric Drill and Bits
2. Chassis Punch Set
3. Slip Joint Pliers
4. Hex Wrenches
5. Assorted Miniature Files
6. Nut Driver Set
7. Scale or Ruler
8. Vise
9. Center Punch
10. Tin Snips
11. Reamer
12. Sheetmetal Nibbler

Remember selecting the proper tools--using them wisely often makes the difference between a rough, rancid, rookie job and a slick, super, professional one. Each tool works in its own special way so always select tools to fit the construction task. Carrying or keeping all of your necessary project/kit construction tools in one case obviously saves time and effort.

A CONSTRUCTION PROCESS FORMAT TO FOLLOW

An Overview

1. Secure all parts and materials - mark as necessary for future identification. Part substitutions may be necessary in some cases.
2. Reread and study project/kit description or schematic and refer back to them when questions arise.
3. Prior to wiring, review proper soldering techniques and actually practice soldering before tackling the project.
4. Breadboard your project in order to determine mounting location wiring routes, and basic circuit operations.
5. Prepare chassis, printed circuit board, and/or project enclosure as dictated by project.
6. Assemble and double-check all wiring and component connections. Before applying any power, recheck your project for accuracy of component placement, correct wiring of controls, and solder bridges.
7. Occasionally a project encounters a problem in its operation hence requiring troubleshooting by the builder.

Name: ____________________

Date: ____________________

Period: ____________________

8. Perform all adjustments, alignment, and calibration exactly as instructed and in the order prescribed.

9. Add all knobs on controls and label their function respectively.

10. Re-test general operation and then prepare a technical report with schematic.

SOME GENERAL CONSTRUCTION HINTS

SOLDERING

Wear safety glasses at all times.

Use only rosin-core solder. Never use acid-core solder or an acid paste or flux.

Make a good mechanical connection before soldering.

If necessary, thoroughly clean the wire and terminal by scraping away any tarnish which may be present. (sandpaper)

Be sure that the connection is thoroughly heated and that the solder flows around all of the joint.

Let the solder harden before moving any items attached to the joint.

Never use an excessive amount of solder.

Carefully inspect each solder joint after completion.

If semiconductor devices or other sensitive parts are to be directly soldered into a circuit, some type of heat sink should be used.

******

HAND WIRING (point-to-point)

Secure wires and leads so they are positioned neatly and lay flat against the chassis.

Cut the component wires to proper length before installing.

Use insulating tubing (spaghetti) on all wires that may touch each other or could touch the chassis.

Wrap the wire around the terminal before soldering. Merely inserting the wire through the hole or slot does not make a satisfactory connection.

Name: ____________

Date: ____________

Period: ____________

CHASSIS OR ENCLOSURE CONSTRUCTION

Note, use either aluminum or galvanized sheet steel in chassis fabrication. Typically, sheet metals used for chassis are from #14 to #24 USS gauge.

Remember in planning a chassis, to first consider your circuit and component sizes then make a simple chassis layout diagram

Utilize paper "puppets" as an essential part of the trial-and-error process of designing a chassis or enclosure. Make a paper model of your final design.

Some Design Factor to be Considered:

1. Components related to one another should be located in the same general area.

2. All components should be located so that they can be connected with the shortest lengths of wires and with as little crossover of wires as possible.

3. The chassis should be large enough to provide adequate space for the mounting of wiring devices such as terminal strips, grommets and special component mounting devices.

4. The chassis should be deep enough so that components mounted beneath it will not extend below the sides.

5. Switches, indicating lamps, input/output jacks, and receptacles are often mounted on the front or back of the enclosure.

6. The shafts of potentiometers and variable capacitors are brought out at the front of the cabinet.

Safety is of prime concern during all aspects of the fabrication process. Since metal is so sharp be extremely careful when handling at all times.

It is good practice to mount chassis assemblies in a cabinet or enclosure when appropriate.

To eliminate a scratch on a cabinet, or maybe just for the appearance, woodgrain type contact paper makes a unique yet attractive finish.

Name: ____________

Date: ____________

Period: ____________

If the wire is stranded, make sure to twist the individual strands tightly and tin before inserting them into the terminal.

Components should be placed in a manner that allows their value to be read without moving the part around.

Cut off any excess component lead or wire from terminals after they have been mechanically secured.

Resistors are usually color coded so if necessary refer to color code chart and remember that resistors are not polarized.

******

P-C COMPONENT MOUNTING

Clean board by lightly rubbing the copper pattern with fine steel wool or use a soap pad.

Drill all required holes. If drilling large mounting holes for components, it is a good practice to start with a pilot hole.

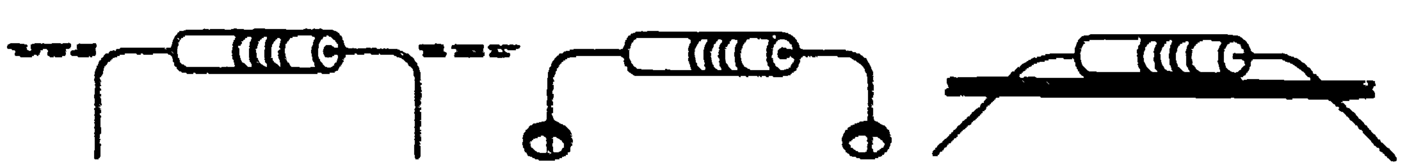
Holes that have been drilled should be slightly larger than wire or component lead to be utilized.

P-C components should be positioned flush against the circuit board when possible.

Insert components or wire to protrude when feasible about 1/16 to 3/32 of an inch on copper side then bend flat and solder. Watch out for heat!

A nice procedure, that enhances the overall looks of your p-c board, is to position all resistors so their coded value can easily be read in a glance from left to right.

DETAIL VIEW OF COMPONENT MOUNTING ON P-C BOARD

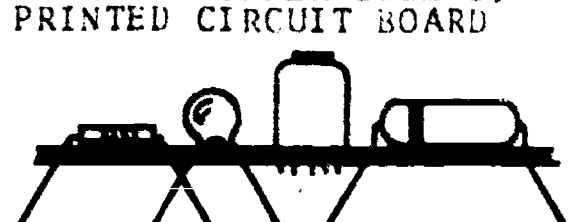


1. BEND LEADS

2. INSERT LEADS THROUGH PROPER HOLES FROM NONCOPPER SIDE OF PRINTED CIRCUIT BOARD

3. POSITION COMPONENT NEXT TO PRINTED CIRCUIT BOARD AND BEND LEADS TO HOLD IN PLACE

4. PROPER PLACEMENT



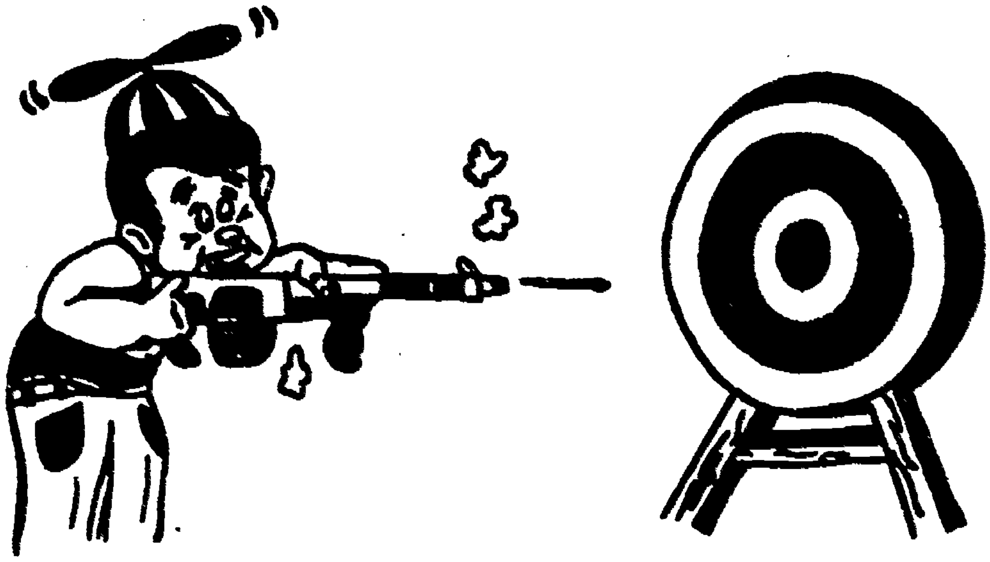
Name: ______________

Date: ______________

Period: ______________

BE A TROUBLESHOOTER

No matter how careful you have been, sometimes, trouble is encountered and your project fails to operate properly! Don't panic-troubleshoot your project/kit and remedy the problem.



Specifically check the following items and generally your project will be as good as new!!

1. Check all wiring and terminations against the pictorial and/or schematic diagrams.

2. Check each solder joint for a "cold" connection.

3. Check the battery and capacitor connections for proper polarity.

4. Be sure that the batteries are in good condition.

5. Check the transistor or I.C. connections including terminals on the socket and the device itself.

6. Check all resistors against the color code chart to make sure that you have the proper value in its proper place.

7. If a fuse within the unit is blown, replace it, then check your circuit once more paying special attention to possible shorts and to the polarity of electrolytic capacitors.

8. Check for an open circuit, faulty soldering, broken wire or a missing connection.

9. Another check is for defective components. Resistors, of course, are easy to check with an ohmmeter. Without a tester of some kind, checking capacitors and semiconductors presents a problem, so see you instructor.

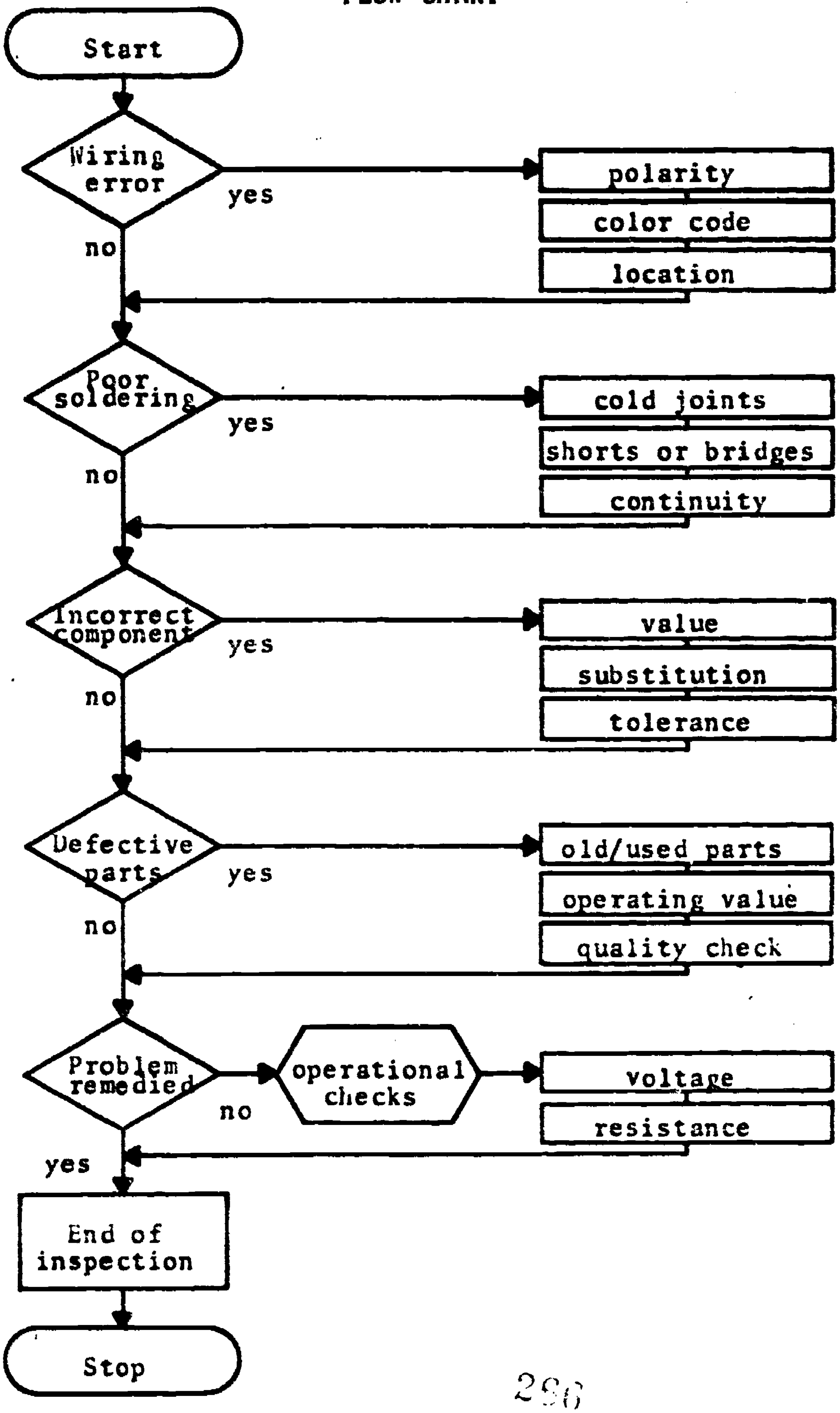
Finally, work carefully, methodically and try to do a professional job and please don't be afraid to periodically recheck your work.

Name: ____________________

Date: ____________________

Period: ____________________

TROUBLESHOOTING RECAP FLOW CHART



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Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

PROJECT REPORT WRITING FORMAT

The format presented below is to be followed when preparing a project report. Include all applicable items below in your write-up, arrange the sections as indicated, type if possible.

PAGE		CONTENT
1.	Title Page	a. Project Title b. Course Title c. Instructor's Name d. Student's Name e. Date
2.	Project Evaluation Sheet.	
3.	Pictorial Drawing or Photograph of Completed Project.	
4.	Description of Circuit Function and Operation	a. Purpose b. Main Circuit Functions (possibly include a block diagram) c. Detailed Analysis
5.	Troubleshooting Guide	a. Calibration Procedure b. Location of Test Points c. Typical Voltage Resistance, or Signal Measurements at each Test Point.
6.	Special Notes:	a. Operating Instructions b. Cautions c. Case Dissassembly Procedure d. Circuit Peculiarities
7.	Schematic Diagram.	
8.	Parts List.	
9.	Printed Circuit Pattern or Component Mounting Plan.	
10.	Parts Placement Diagram.	
11.	Chassis Layout.	

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

PROJECT EVALUATION SHEET

Project ______________ Construction Dates ______________ To ______________

	Excellent	Good	Average	Poor	Offensive
FINISH- (paint labeling, etc.)					
ASSEMBLY (techniques and quality)					
LAYOUT AND DIMENSIONS					
TOOL USAGE					
DESIGN (form/function)					
MATERIALS USED TO BEST ADVANTAGE					
GOOD USE OF TIME					
WORK HABITS					
PROJECT REPORT					
COMMENTS					

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

ANSWER SHEET

EXAM LIII U8

No.	T A	F B	C	D	No.	T A	F B	C	D	No.	T A	F B	C	D	No.	T A	F B	C	D
1.					26.					51.					76.				
2.					27.					52.					77.				
3.					28.					53.					78.				
4.					29.					54.					79.				
5.					30.					55.					80.				
6.					31.					56.					81.				
7.					32.					57.					82.				
8.					33.					58.					83.				
9.					34.					59.					84.				
10.					35.					60.					85.				
11.					36.					61.					86.				
12.					37.					62.					87.				
13.					38.					63.					88.				
14.					39.					64.					89.				
15.					40.					65.					90.				
16.					41.					66.					91.				
17.					42.					67.					92.				
18.					43.					68.					93.				
19.					44.					69.					94.				
20.					45.					70.					95.				
21.					46.					71.					96.				
22.					47.					72.					97.				
23.					48.					73.					98.				
24.					49.					74.					99.				
25.					50.					75.					100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 8

A. VOCABULARY--SPELLING PUZZLE

1. cable
2. lacing
3. connectors
4. fabrication
5. continuity
6. breadboarding
7. layout
8. perforated
9. workmanship
10. harness
11. technical
12. terminal
13. hardware
14. circuit
15. shrinkable
16. chassis
17. ties
18. inspection
19. wiring
20. troubleshoot

B. TROUBLESHOOTING

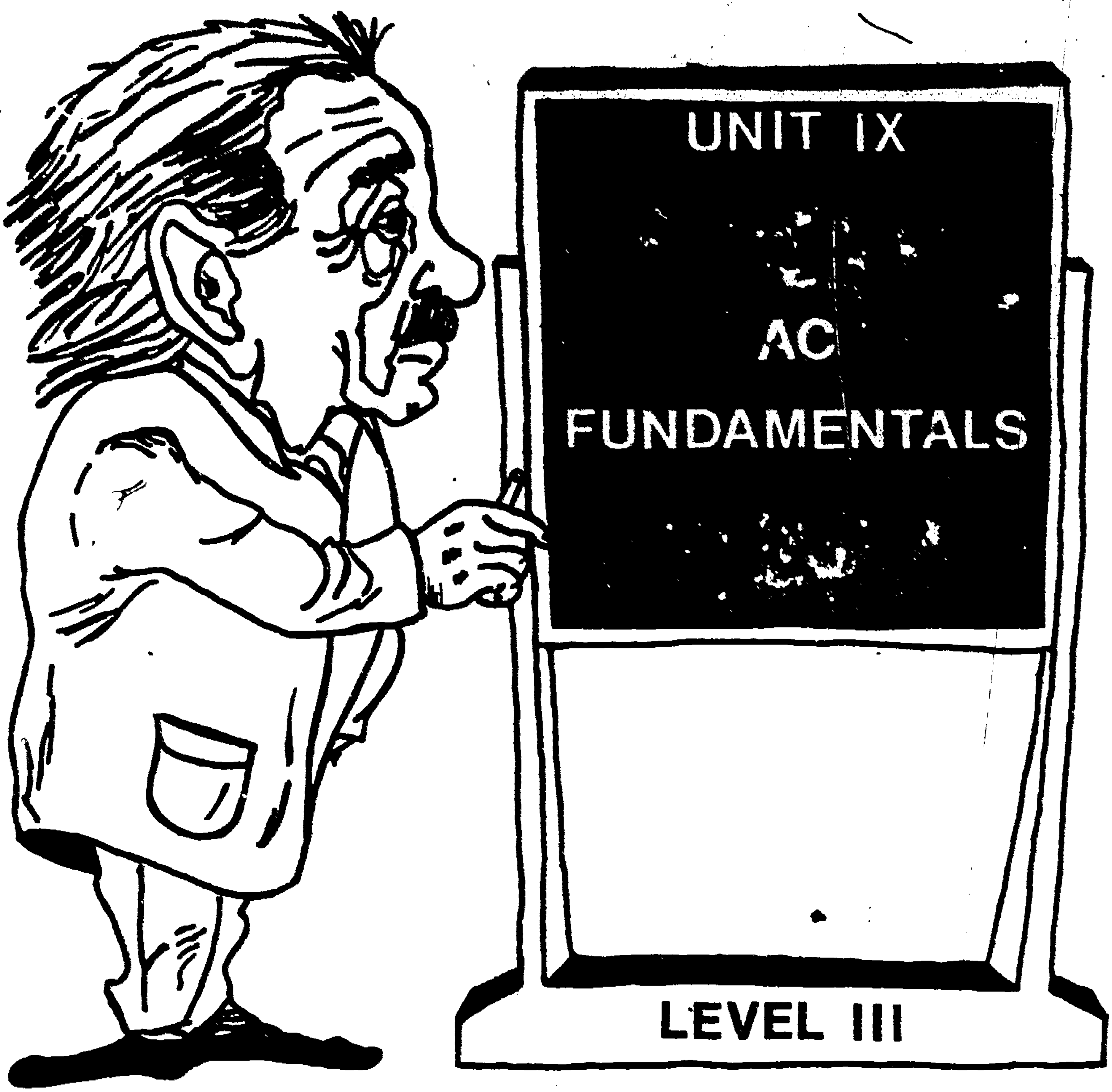
1. Power lead to only one contact of S_1- remove plug wire and solder to other contact. (Switch bypassed)
2. Rotate T_1 one quarter turn clockwise.
3. 8 f capacitor C_1 wrong polarity.
4. 8 f capacitor C_1 wrong position exchange with the 4.7μf capacitor.
5. 4.7μf capacitor wrong position. Exchange with the 8μf capacitor.
6. Reverse D_2
7. Exchange R_3 for a 47KΩ 1/2 W resistor.
8. Install jumper from center lead of R2 to right connector on pictorial schematic.

C. QUEST ACTIVITY

(subjective evaluation)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________

DATE STARTED________

DATE COMPLETED________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: AC Fundamentals

Time Allocation: 2 weeks

Unit Goal:

To disclose and infuse fundamental competencies germane to the generation, terminology, and characteristics of alternating current.

Unit Objectives:

The student will be able to:

1. explain the electrical difference between AC and DC, and describe the operation of a simple AC generator.
2. determine the average and/or effective value of an AC sine wave when its peak or peak-to-peak value is known.
3. compute the period, instantaneous voltage, and wavelength in a given problem utilizing the proper formula and unit of measurement for each quantity.
4. analyze and solve AC circuit problems for E, I, R, or P in circuits which contain only resistance.
5. draw wave forms which depict both "in phase" and "out of phase" relationships between voltage and current in a circuit.
6. identify the audio and radio ranges of frequency within the frequency spectrum, and describe the function that the F.C.C. performs in terms of frequency regulation.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Basic Electronics. Bernard Grob, McGraw-Hill Book Co., 1977. Chapter: 1(

Electrical Fundamentals for Technicians. Robert L. Shrader, McGraw-Hil Book Co., 1977. Chapters: 9 and 28.

Electricity One-seven. Harry Mileaf, Hayden Book Company, Inc., 1976. Chapter: Electricity Three.

Overview:

Several principles from Level II must be reviewed and stressed prior to this unit presentation. It would be wise to emphasize pertinent magnetism and electromagnetism competencies which serve as a foundation in teaching the generation of AC. Technical AC topic coverage which may not be presented in this unit is dedicated for presentation at a more appropriate time conceptionally.

The unit can be introduced by indicating applications where alternating and direct current can or cannot be interchanged. A follow up discussion of similarities and differences between these types of current flow will allow a nice transition into the formal lesson.

Beware that the first formal topics dealing with the sine wave and its method of generation sometimes causes students difficulty, especially the concept of alternations. A simple analysis of AC voltage, as used in the AC power line, indicating the variations and polarity reversals of the power-line voltage can assist student comprehension. Both audio and radio signals are also important examples of AC and should be presented to provide a more meaningful grasp of the complexity of AC. The unit should continue with a thorough discussion of AC terminology, hence a wide variety of terms are given in the accompaning Unit 9 Glossary. This glossary has been prepared to include in depth definitions and examples when appropriate.

The unit concludes with an emphasis on determining various AC values such as; instantaneous, average, effective, peak, and peak to peak. Finally, a variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. This unit can have a tendency to be dry and students can mentally wander during instructor presentations so draw upon the many opportunities to demonstrate principles related to communicating, power, historical AC experiments, motors and generators, and waveforms.
2. Try this activity before a lecture and it will guarantee student excitement about AC. Utilizing a microphone connected to a scope, call up a student to sing into the microphone and then observe the waveform generated with the class. A radio tuned to a popular local station with the scope monitoring the signal at the speaker will serve as a natural "turn on" prior to a discussion on waves, communication, etc.
3. Utilizing the "Spell Down" game strategy previously presented in Unit 6 have students spell and define the words in their glossary.
4. Contact the local electric power company in your area and ask that a representative speak to the class about the reasons for the use of alternating current and to explain how the company meets peak power demand.
5. Formulas can be cumbersome in this unit so concentrate on explaining the function of specific magnitudes when examing AC values in order to accommodate student learning.

Methodology continued:

6. List a variety of appliances on the blackboard or overhead and have the class categorize them according to the type of voltage necessary to operate them. Then examine the possibility that the type of voltage within the appliance may have been converted and the reasons why this may have occured.
7. In addition to formal laboratory experiments, certain laboratory presentations can assist the instructor in vividly illustrating the shape and characteristics of AC sine waves, and the audio frequency band. During an appropriate lecture or discussion use a classroom oscilloscope, signal generator, and signal tracer to enhance the students understanding of technical concepts. Inject signals and observe both the audio/visual affect, then discuss outcomes with the class.

Supplemental Activities and Demonstrations:

1. Construct and discuss on the blackboard a mock electric power transmission system. Include a power plant, a control center, transmission facilities, distribution lines and devices for increasing or decreasing the voltage.
2. A free source for small motors and generators is most retail stores, since they usually have advertising demonstrators or promotional devices which are generally discarded after the promotion, however, if a teacher explained their need it is quite conceivable that they might relinquish it prematurely--try it!
3. There are several simple motor or generator kits that are commercially available, which may be selected as a laboratory supplemental type activity at a very nominal dollar amount.
4. A variety of communication devices in the laboratory should be available for display or demonstration. They could be arranged with labels to indicate the chronological sequence of development such as a; telegraph, telephone, crystal radio, AM radio, etc.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Crossword
5. Worksheet - AC Values
6. Worksheet - Alternating Current Principles
7. Quest Activity
8. Informational Handout (Generating an AC Voltage)
9. Informational Handout (AC Formulas)
10. Informational Handout (Electromagnetic Spectrum)
11. Informational Handout (Radio Frequency Allocations)
12. Unit Module Answer Keys

IX. AC Fundamentals

A. Review induced current theory

B. Simple AC generator

C. The alternating current cycle

D. The sine wave

E. AC terminology
   1. Maximum or peak voltage

   2. Instantaneous voltage

   3. Cycle

   4. Phase angle

   5. Frequency

6. Period

7. Wave/wave form/wavelength

F. AC voltage values
   1. Instantaneous voltage

   2. Average voltage

   3. Effective voltage

   4. Peak voltage

   5. Peak-peak voltage

G. Power in AC circuits

H. Phase relationships

I. Nonsinusoidal wave forms

J. Frequency ranges

LIII-U9

UNIT EXAM

AC FUNDAMENTALS

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question-there is only one correct answer for each question.

1. Moving a piece of wire through a magnetic field will induce a voltage between the ends of the wire. (T-F)

2. If the speed at which a wire cuts the magnetic field is increased, the voltage generated will also be increased. (T-F)

3. You should expect the output voltage of an AC generator to look like a rectangular wave when plotted on graph paper. (T-F)

4. The type of electricity supplied to our homes is DC. (T-F)

5. Radio signals are considered AC type electricity. (T-F)

6. A radio uses both AC and DC type electricity in its operation. (T-F)

7. DC generators and AC generators work by the same electrical principle electromagnetic induction. (T-F)

8. In the left hand rule for generators, the thumb points in the direction of the magnetic field. (T-F)

9. 90 degrees and 270 degrees are the only maximum points on the AC wave. (T-F)

10. An alternation and a half cycle are the same thing. (T-F)

11. One cycle contains 370 degrees. (T-F)

12. The higher the frequency, the closer together the sine waves will appear on the screen of an oscilloscope. (T-F)

13. The period of a DC wave is measured in seconds. (T-F)

14. In an AC resistive circuit, current and voltage are "in phase." (T-F)

15. If two AC waves start and end at the same place on an oscilliscope screen, they are out of phase. (T-F)

16. A factor which does not affect the output voltage of an alternator is (A) the speed of the loop. (B) the number of turns on the loop. (C) the strength of the magnetic field. (D) the size of the slip rings.

17. During one cycle, the peak voltage occurs (A) five times. (B) twice. (C) once. (D) four times.

18. A cycle is made up of two parts called (A) peak voltages. (B) loops. (C) frequencies. (D) alternations.

19. The number of cycles generated in a second is called (A) an alternation. (B) the sine curve. (C) the frequency. (D) an alternating current.

20. Unless otherwise stated, AC meters read the (A) effective (RMS) values. (B) average values. (C) peak values. (D) 3.1416 x peak values.

21. When a graph is drawn of an AC voltage the shape of the resulting curve is called the (A) phase. (B) waveform. (C) frequency. (D) none of the above.

22. A quarter cycle of an AC wave is the equivalent of
(A) 45° (B) 90° (C) 180° (D) 360°

23. Two AC voltages that are always "in phase" must have the same: (A) current value. (B) voltage value. (C) frequency. (D) none of the above.

24. The average value of an AC sine wave voltage is solved by using the formula
(A) .707 x peak (B) .637 x peak (C) 1.414 x peak (D) none of the above.

25. An alternating current wave changes in
(A) direction only. (B) value only. (C) both value and direction (D) frequency and value but not direction.

26. Alternating current is used as
(A) a source of electrical power and as a means of carrying information or intelligence. (B) a source of power only. (C) a means of carrying information only. (D) an AC signal only.

27. A device which utilizes electromagnetic induction as a means of producing an AC voltage is called:
(A) an oscillator. (B) an induction motor. (C) a battery (D) an AC generator.

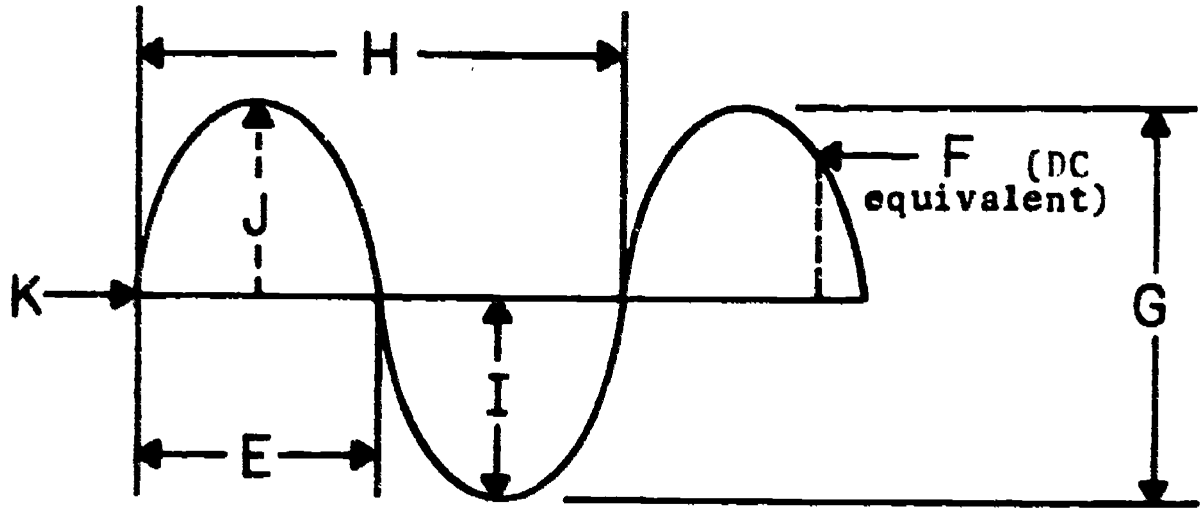
28. The essential elements which are needed to form a basic AC generator are
(A) slip-rings, brushes, and a magnetic field. (B) an armature, slip-rings, and brushes. (C) slip-rings and brushes. (D) an armature, slip-rings, brushes, and a magnetic field.

29. One cycle of an AC sine wave contains
(A) two positive alternations and one negative alternation. (B) two negative alternations. (C) only one alternation. (D) one positive alternation and one negative alternation.

30. The maximum value which occurs during an alternation of a sine wave is called the
(A) peak point. (B) peak value. (C) peak-to-peak value. (D) positive peak-to-peak value.

31. Which of the waveforms listed below is not a nonsinusoidal wave? (A) sawtooth wave. (B) triangular wave. (C) sine wave. (D) square wave.

Match the lettered parts of the graph to their appropriate terms: Write the corresponding letter on your answer sheet.



32. Peak-to-peak _____.

33. Cycle _____.

34. Alternation _____.

35. Maximum negative amplitude _____.

36. Maximum positive amplitude _____.

37. Zero emf _____.

38. Effective value _____.

39. A frequency of 90kHz is located within which band of frequencies? (A) audio band. (B) ultra sonic band. (C) visible light band. (D) radio frequency band.

40. Identify the square wave in the drawings below:
(A)  (B)  (C)  (D) 

41. A voltage sine wave with a peak value of 200 volts will have an average value of
(A) 314.5 volts. (B) 282.8 volts. (C) 127.4 volts. (D) 141.4 volts

42. An AC current with a peak value of 16 amperes would have an effective value of
(A) 10.18 amperes EFF. (B) 11.3 amperes EFF. (C) 22.63 amperes EFF.
(D) 25.16 amperes EFF.

43. An AC voltage has a peak value of 10 volts, hence its peak-to-peak value is
(A) 10 volts p-p. (B) 7.07 volts p-p. (C) 6.37 volts p-p. (D) 20 volts p-p.

44. If you measured an AC voltage with the shop meter that read 10V p-p, what would the peak value be?
(A) $5V_{PK}$. (B) $20V_{PK}$. (C) $10V_{PK}$. (D) $7.07V_{PK}$.

45. Given a value of $40V_{RMS}$, what is the effective AC value?
(A) $20V_{EFF}$. (B) $80V_{EFF}$. (C) $28.28V_{EFF}$. (D) $40V_{EFF}$.

Name: ____________

Date: ____________

Period: ____________

TECHNICAL GLOSSARY

ALTERNATING CURRENT: A flow of electrons which move first in one direction, stop, and flow in the opposite direction. Current, flow begins at zero, increases to a positive maximum, decreases to zero, then increases to a negative maximum and again decreases to zero. The alternating current signal is depicted as a sine wave: Abbrev. AC

ALTERNATION: One-half of an AC wave or cycle, beginning at one zero point, and ending at the next zero point. Consists of the complete rise and fall of an AC voltage or current in one direction. The positive alternation begins at 0° and ends at 180°. The negative alternation begins at 180° and ends at 360°. Graphically or .

ALTERNATOR: An alternating current generator that utilizes a stator, rotor, slip rings, and brushes to produce electricity. Symbol: Letter symbol: GEN

AMPLITUDE: The vertical size or height of an alternating current wave; commonly measured either from the zero line to one maximum point, or from the negative maximum point to the positive maximum point.

ARMATURE: The rotating windings of a generator in which the voltage is produced. Each winding terminates at a commutator segment, or slip rings.

AUDIO FREQUENCY: A group of AC frequencies that can be heard as sound waves by the human ear. The range of audio frequencies is approximately 20 to 20000Hz. Abbrev. AF

AVERAGE VALUE: An arithmetical average of all the values on a sine wave for one alternation. Equivalent to .637 x peak value. Abbrev. AVG

BAND: A group of adjacent frequencies. For example: The AM radio band encompasses frequencies from 535 kHz to 1605 kHz.

BRUSH: A sliding contact, usually made of carbon, used to make connections to a rotating commutator or slip ring.

COMMUTATOR: A ring of copper segments, insulated from each other and used to terminate the armature windings. The brushes ride on the commutator.

CYCLE: One complete alternating current wave from 0° to 360°. One cycle consists of 2 alternations, one positive and one negative.

Name: ________________

DISTORTION: A change in the expected wave shape or form due to a deviation in amplitude, phase, or frequency - usually considered undesirable.

EFFECTIVE VALUE: The most common method of measuring an AC value, and expressed in formula form .707 x peak value. Also known as the root-mean-square value (RMS). Abbrev. EFF

ELECTROMAGNETIC INDUCTION: The process of producing a voltage in a wire by either passing the wire through a magnetic field, or by moving the magnetic field past the wire.

FEDERAL COMMUCICATION COMMISION: A U.S. Government agency which is in charge of regulating and assigning use of the frequency spectrum. Abbrev. FCC

FIELD WINDING: A set of windings in a generator which is supplied with a D.C. voltage to produce an electromagnetic field.

FREQUENCY: The number of complete A.C. waves or cycles which occur during a particular amount of time, usually one second. Measured in the basic unit hertz. Symbol: f

GENERATOR: A machine used to produce electricity by causing one, or a series of interconnecting coils to either cut or be cut by a magnetic field. Symbol:  Letter symbol: GEN or

HARMONIC: A multiple frequency of a base wave or frequency. For example: If 100Hz is the base frequency, then 200Hz is the second harmonic, 300Hz is the third harmonic etc. Harmonic frequencies are generally lower in amplitude than the base frequency.

HERTZ: The basic unit for frequency, and it is the equivalent to the number of complete AC cycles occuring in one second. Also referred to as cycles per second (cps). Example: a frequency of 60 hertz means that 60 complet sine waves occur per second. Abbrev. Hz

INSTANTANEOUS VALUE: The value of an alternating current or voltage at any specific instant in a cycle-commonly expressed in degrees. Instantaneous value = sine x peak value.

INVERTER: An electric or electronic device which converts direct current to alternating current.

LEFT HAND RULE: A method for determining the direction of current flow in a conductor. Extend the thumb, first finger, and second finger of the left hand at right angles to each other. Point the thumb in the direction of conductor motion; the first finger in the direction of the magnetic field (from north to south); then the second finger will indicate the direction of current flow.

Name: ________________

NONSINUSOIDAL: Any wave form that is not a sine wave. For example a square wave () is a nonsinusoidal wave.

OSCILLATOR: An electronic device which converts DC energy into AC energy.

PEAK-TO-PEAK VALUE: The total amplitude or measurement of an AC wave from the positive maximum point to the negative maximum point. Abbrev. p-p

PEAK VALUE: The measurement of an AC wave from the zero line or point to the maximum positive or maximum negative point Abbrev. PK

PERIOD: The time, in seconds, that it takes to complete one AC cycle. Period = $\frac{1}{\text{Frequency}}$. Letter symbol: T

PHASE: An angular comparison of the starting and ending points of two or more AC waves. To be of any significance the waves must be of equal frequency.

PHASE ANGLE: The angular difference between the voltage and current waves of an electronic circuit.

RADIO FREQUENCY: Frequencies located between the audio band and infrared light on the frequently spectrum, generally between 10kHz and 300,000,000kHz. Radio frequencies have the ability to travel or radiate over long distances, and usually cannot be heard. Abbrev. RF

ROTOR: The rotating part within an alternator. Generally, containing a coil of wire terminating at the slip rings and used to provide a magnetic field.

SAWTOOTH WAVE: A waveform resembling the teeth of a saw. The wave represents a voltage or current that slowly increases (at a uniform rate) and then drops sharply to its starting value. Example:  Represents 2 cycles.

SINE WAVE: The waveform produced by an AC generator. The amplitude of the wave is proportional to the sine of the angle between the magnetic field and the positions of the rotating armature. Example:  Represents 1 cycle.

SINUSOIDAL: Referring to a wave or circuit output that follows the shape and form of a sine wave.

SLIP RINGS: Two insulated copper rings used as the sliding contact between the brushes and the rotor winding of an alternator.

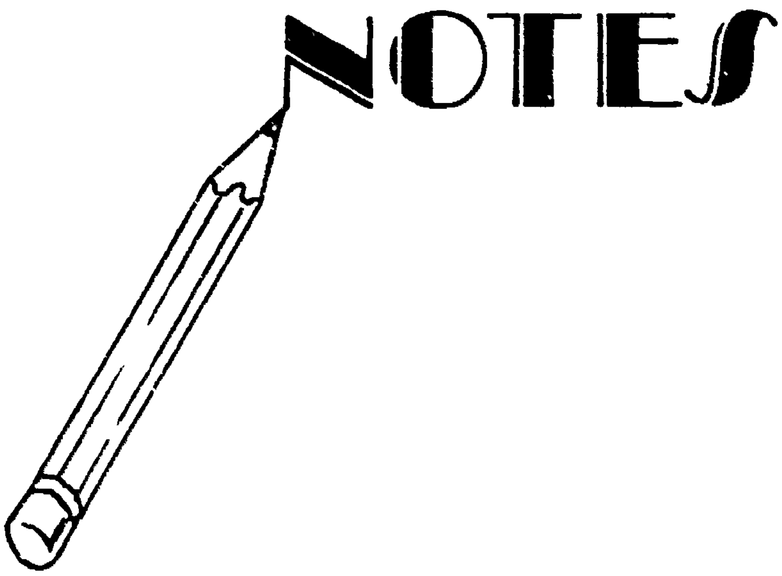
Name: ______________

SQUARE WAVE: A waveform that contains a positive and negative alternation which are square in shape. The square shape indicates that the voltage or current raises immediately to its maximum value and remains at that value for the duration of the alternation. The wave then immediately changes in polarity. Example: Represents one cycle (2 alternations).

STATOR: The stationary coils of an alternator in which the voltage is produced or induced.

WAVEFORM: The pattern or shape of a wave derived from graphing the instantaneous values of a voltage (or current) on an x-y axis. The x axis is designated as "time" while the y axis represents "amplitude."

WAVELENGTH: The distance a wave travels from the beginning point to the end point of one cycle, or the distance between corresponding points on two adjacent waves. Wavelength $= \frac{\text{velocity}}{\text{frequency}}$. Letter symbol:



SCORE:
GRADE:

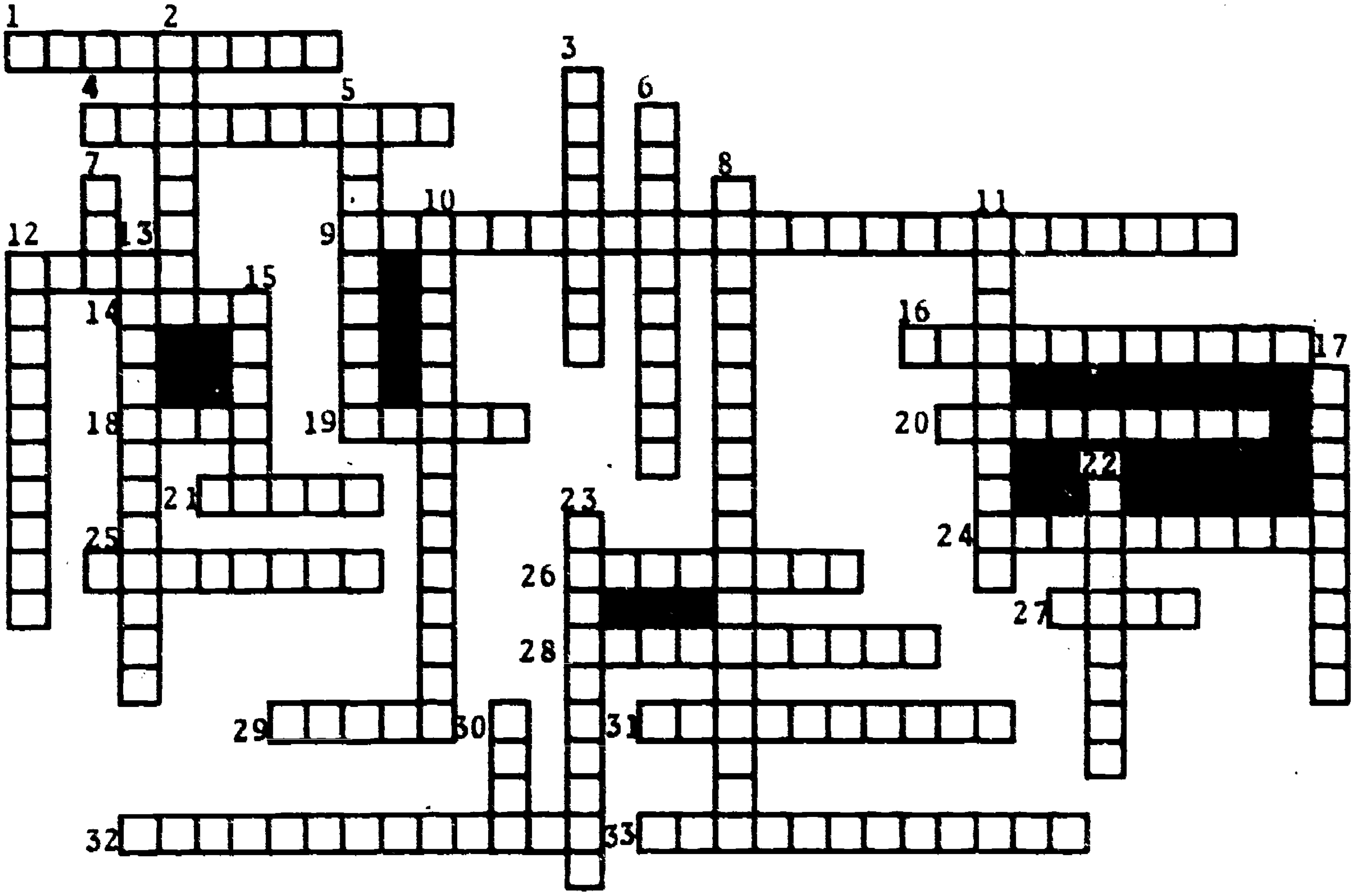
Name: ______________

Date: ______________

Period: ______________

WORKSHEET

VOCABULARY - CROSSWORD PUZZLE



ACROSS

1. The height of an alternating current wave.

4. The distance an AC wave travels in one cycle.

9. Producing a voltage in a wire by moving the magnetic field past a wire. (2 wds)

12. Consists of 2 alternations, one positive and one negative.

14. Abbreviation for root mean square value.

16. Consist of a complete rise and fall of an AC voltage or current in one direction.

18. Basic unit for frequency.

19. The rotating part within an alternator.

20. The number of complete AC cycles produced per second.

21. A sliding contact, usually made of carbon.

24. An electronic device which converts DC energy into AC energy.

Name: ____________________

Date: ____________________

Period: ____________________

25. The windings of a generator in which voltage is produced.

26. A multiple frequency of a base wave or frequency.

27. The measurement of an AC wave from the zero line to the positive maximum point.

28. A wave, or circuit output, that follows the form of a sine wave.

29. An angular comparison of the starting and ending points of 2 or more AC waves.

31. The total amplitude of an AC wave from the positive maximum point to the negative maximum point.(3 wds)

32. Any wave form that is not a sine wave.

33. Is equal to .637 x peak value.(2 wds)

DOWN

2. Converts direct current to alternating current.

3. A wave representing a voltage that slowly increases and then drops sharply to its starting value.

5. A machine that produces electricity by causing a series of interconnecting coils to cut through a magneticfield.

6. A nonsinusoidal wave form that contains a positive and negative alternation.(2 wds)

7. Federal Communication Commission Abbreviation.

8. ____________ = sine x peak value.
(2 wds)

10. Equivalent to the root mean square value.(2 wds)

11. A change in the expected wave shape due to a deviation in amplitude, phase, or frequency.

12. A ring of copper segments used to terminate the armature windings.

13. A method for determining the direction of current flow in a conductor. (3 wds)

15. Part of an alternator which performs the same job as the armature in a generator.

17. Two insulated copper rings used as the sliding contact between the brushes and the rotor winding.(2 wds)

22. Wave form produced by an AC generator.(2 wds)

23. Angular difference between voltage and current waves in an electronic circuit.(2 wds)

30. A group of adjacent frequencies.

SCORE:
GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

AC VALUES

Solve the following conversion problems. Always include the unit of measurement, and the AC value, in your answer. For example: 10V p-p

unit of measurement (10V) — AC value (p-p)

1.

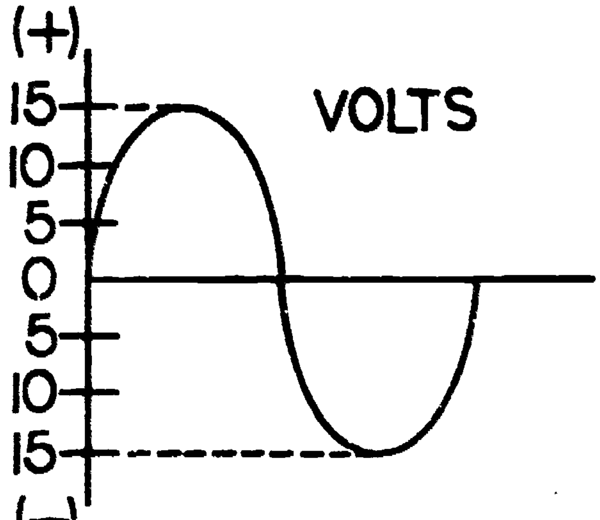


FIGURE 1

A. What is the peak to peak value of the sine wave in figure 1? 1A. ______

B. What is the peak value of sine wave 1? 1B. ______

C. Determine the average value of the sine wave. 1C. ______

D. Compute the effective value of the sine wave. 1D. ______

....

2.

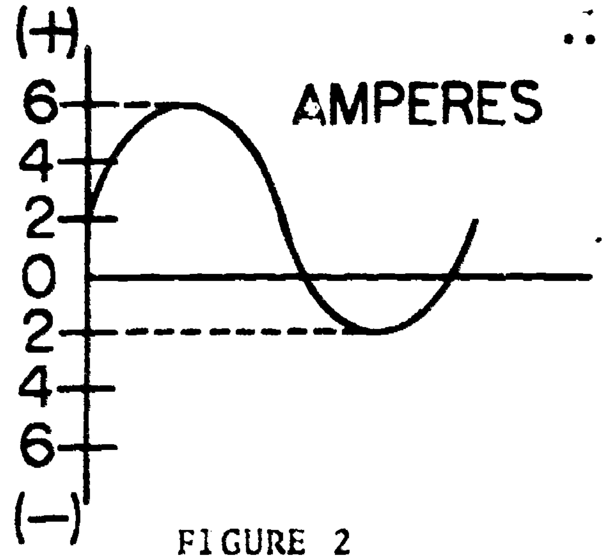


FIGURE 2

A. Determine the peak value of the sine wave in figure 2. 2A. ______

B. What is the average value of the sine wave? 2B. ______

C. Find the peak to peak value of sine wave 2. 2C. ______

D. Compute the RMS value of the wave. 2D. ______

3. E = $30V_{p-p}$--Convert to peak value. 3. ______

Show work

4. E = $40V_{pk}$--Find the peak to peak value. 4. ______

Show work

Name: ____________

Date: ____________

Period: ____________

5. $I = 5A_{PK}$--Find the average value. 5. [ ]

Show work

6. $I = 33mA_{PK}$--Convert to effective value. 6. [ ]

Show work

7. $E = 117V_{RMS}$--Solve for peak value. 7. [ ]

Show work

8. $I = 6A_{EFF}$--Find the RMS value. 8. [ ]

Show work

9. $E = 40mV_{p-p}$--Find the average value. 9. [ ]

Show work

10. $I = 10A_{p-p}$--Find the effective value. 10. [ ]

Show work

11. $E = 20V_{EFF}$--Convert to peak to peak value. 11. [ ]

Show work

12. $I = 7A_{EFF}$--Convert to average value. 12. [ ]

Show work

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

ALTERNATING CURRENT PRINCIPLES

MATCHING

In the exercise below, the lettered answers may be used more than once.

Column 1 (Question)	Column 2 (Answer)	Letter chosen from column 2
1. Direct Current	A. Part of an alternator	1.
2. Alternating Current	B. 90°	2.
3. Inverter	C. Source of alternating current	3.
4. DC Generator	D. Flows in only one direction	4.
5. Solar Cell	E. Left Hand Rule	5.
6. Alternator	F. Cycles per second	6.
7. Oscillator	G. 50 Hertz	7.
8. Battery	H. Radio Frequencies	8.
9. Piezo electric crystal	I. Flows first in one direction stops, and flows in the opposite direction	9.
10. Thermalcouple	J. Source of direct current	10.
11. Most common form of electricity	K. Audio Frequencies	11.
12. Stator	L. AC	12.
13. Field winding	M. Part of a DC generator	13.
14. Brushes	N. 180°	14.
15. Indicates direction of current flow in a conductor	O. Hertz	15.
16. Zero point on the sine wave.	P. Sliding Contact	16.
17. Maximum positive point on sine wave	Q. 60 Hertz	17.
18. Preferred unit for measuring frequency		18.
19. Frequency of AC power in the USA		19.
20. 20-20,000 Hertz		20.

Name: ____________

Date: ____________

Period: ____________

21. What 3 things are required to generate a voltage: 21A.

21B.

21C.

22. One cycle contains two_______, one positive, and one negative. 22.

23. The number of complete AC cycles occuring in one second is referred to as the AC__________. 23.

24. Find the period of an AC wave if the frequency is 15MHz. 24.

Show work

25. Find the wavelength of an AC wave if its frequency is 15MHz. 25.

Show work

26. When comparing an AC voltage to a DC voltage, the equivalent AC value is called the ______ value. 26.

27. Identify the following wave forms.

A.  27A.

B.  27B.

C.  27C.

D.  27D.

28. Label the following frequency bands.

A. 20 - 20,000Hz 28A.

B. 30kHz - 30GHz 28B.

C. 3×10^{19}Hz - 5×10^{20}Hz 28C.

Name: ______________

Date: ______________

Period: ______________

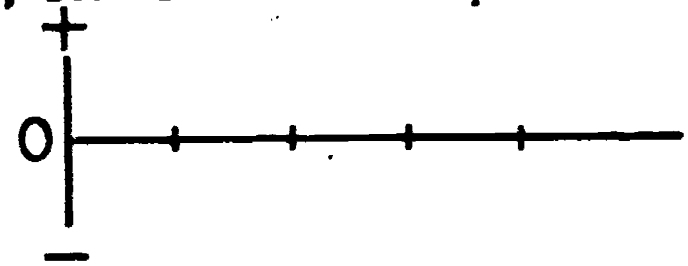
29. Indicate the FCC "allocated use" for each of the radio frequency bands listed below.

A. 535kHz - 1605kHz — 29A. [ ]

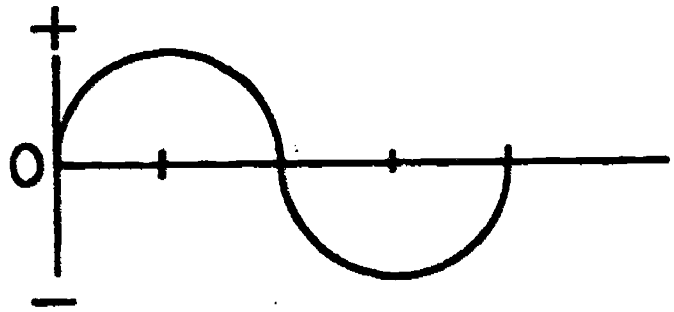
B. 174MHz - 216MHz — 29B. [ ]

C. 88MHz - 108MHz — 29C. [ ]

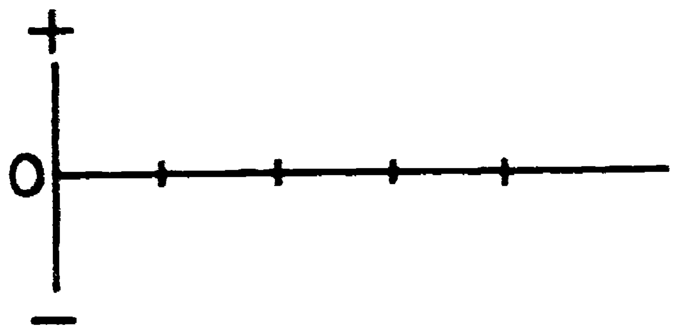
30. On the axis below, draw one cycle of an AC sine wave. Label the 0°, 90°, 180° 270° and 360° points.



31. Utilizing the AC wave below, draw in, <u>and label</u>, arrows to indicate how you would measure A) the peak amplitude, and B) the peak to peak amplitude.



32. Draw a sketch of two AC sine waves that are 90° out-of-phase.



SCORE:	
GRADE:	

Name: ______________

Date: ______________

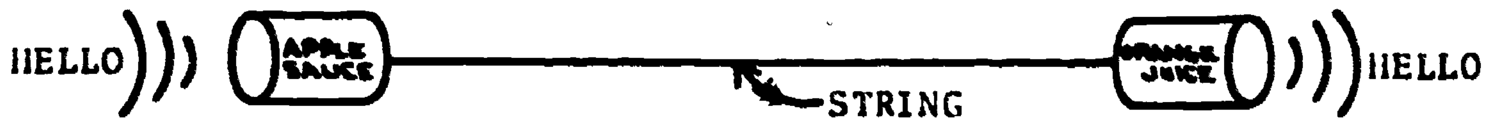
Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 9"

Communication plays a vital role in our existance. The systems developed to transmit information from person to person are consistently being improved, modified, or replaced with a more efficient process. Modern day communication systems employ techniques such as radio wave, microwave, and laser-light beam transmisssion. Below is the beginning of a chronolog of communication systems which you are to complete and document. Follow the examples given below and include a sketch or a block diagram of each system.



A

System and Inventor(s): Can and string communication system invented 1850 by Tommy Primative and Kathy Can (Ha Ha)

Basic Operation: Stretch string taut, then speaking into one can will cause sound to be reproduced in the receiving can

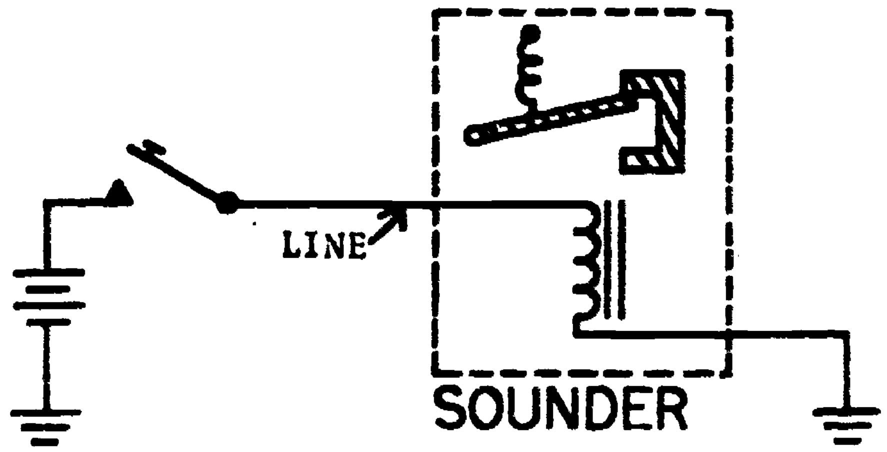
Transmitting Devices: Human voice and can

Message Carrier: String

Receiving Device: Human ear and can

Decoding System: Not necessary as long as languages are similar

B



System and Inventor(s): Telegraph system patented 1843 by Samuel Morse

Name: ______________

Date: ______________

Period: ______________

Basic Operation:	Hand-operated switch (key) controls pulses of current (dots and dashes) which are assigned alphanumeric meaning
Transmitting Device:	Telegraph key
Message Carrier:	Wire
Receiving Device:	Telegraph Sounder
Decoding System:	Electrical pulses converted to sound waves and received by human ear and translated by brain applying Morse Code knowledge

C (Telephone System)

D (Phonograph System)

E (Radio System)

F (Television System)

G (Other see instructor)

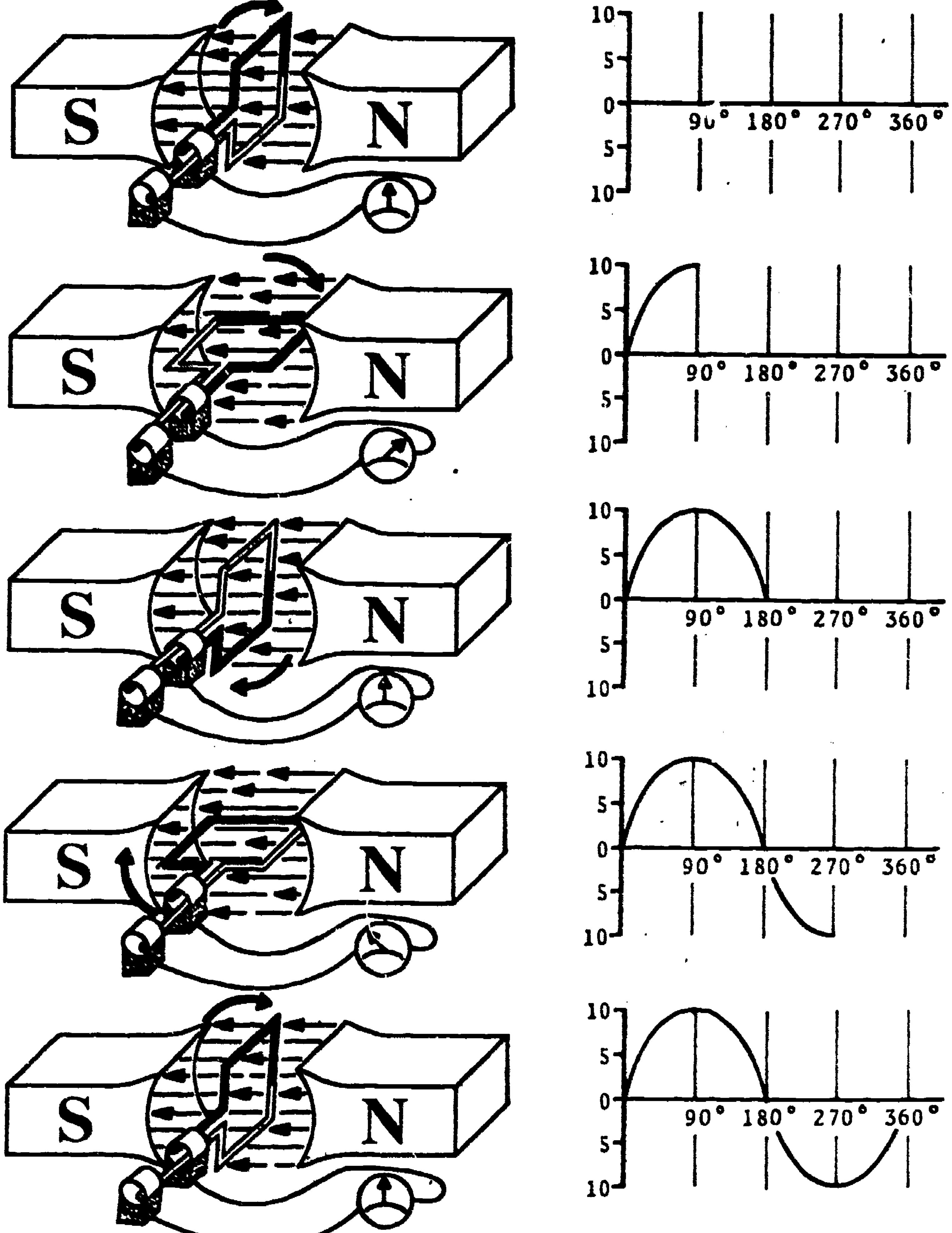
Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

GENERATING AN AC VOLTAGE



Name: ____________

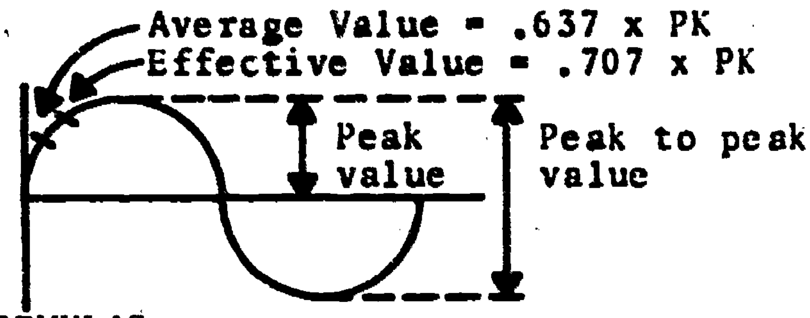
Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

AC FORMULAS

AC VALUES:



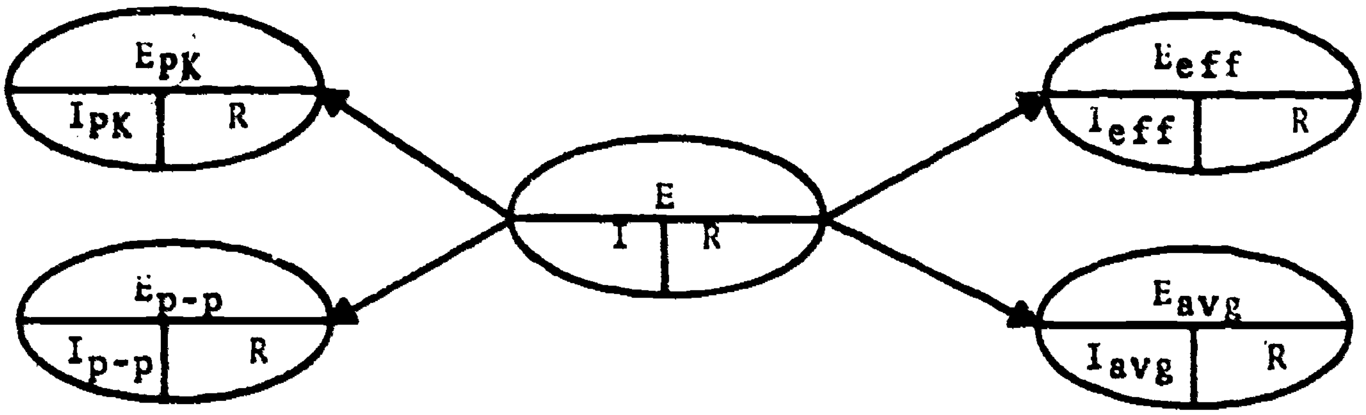
CONVERSION FORMULAS:

Formulas apply equally for AC voltage or current.

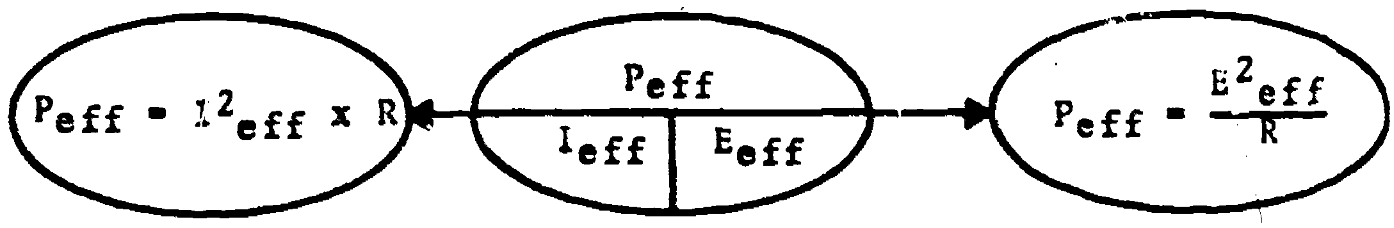
Peak-to-Peak = 2 x peak
Peak = 1/2 x peak-to-peak
Average = .637 x peak
Effective or RMS = .707 x peak
Peak = 1.414 x effective

OHM'S LAW FORMULAS:

AC resistive circuits only.



WATT'S LAW FORMULAS:



NOTICE: To apply either Ohm's law or Watt's Law correctly be sure that the method used for measuring AC voltage and current is similar. That is, if voltage is measured as a peak value, the current must also be measured as a peak value.

Name: ______________

Date: ______________

Period: ______________

PERIOD AND WAVELENGTH:

Period $T = \frac{1}{f}$

WHERE

T = period in seconds

f = frequency in Hz

Wavelength $= \frac{300,000,000}{f}$

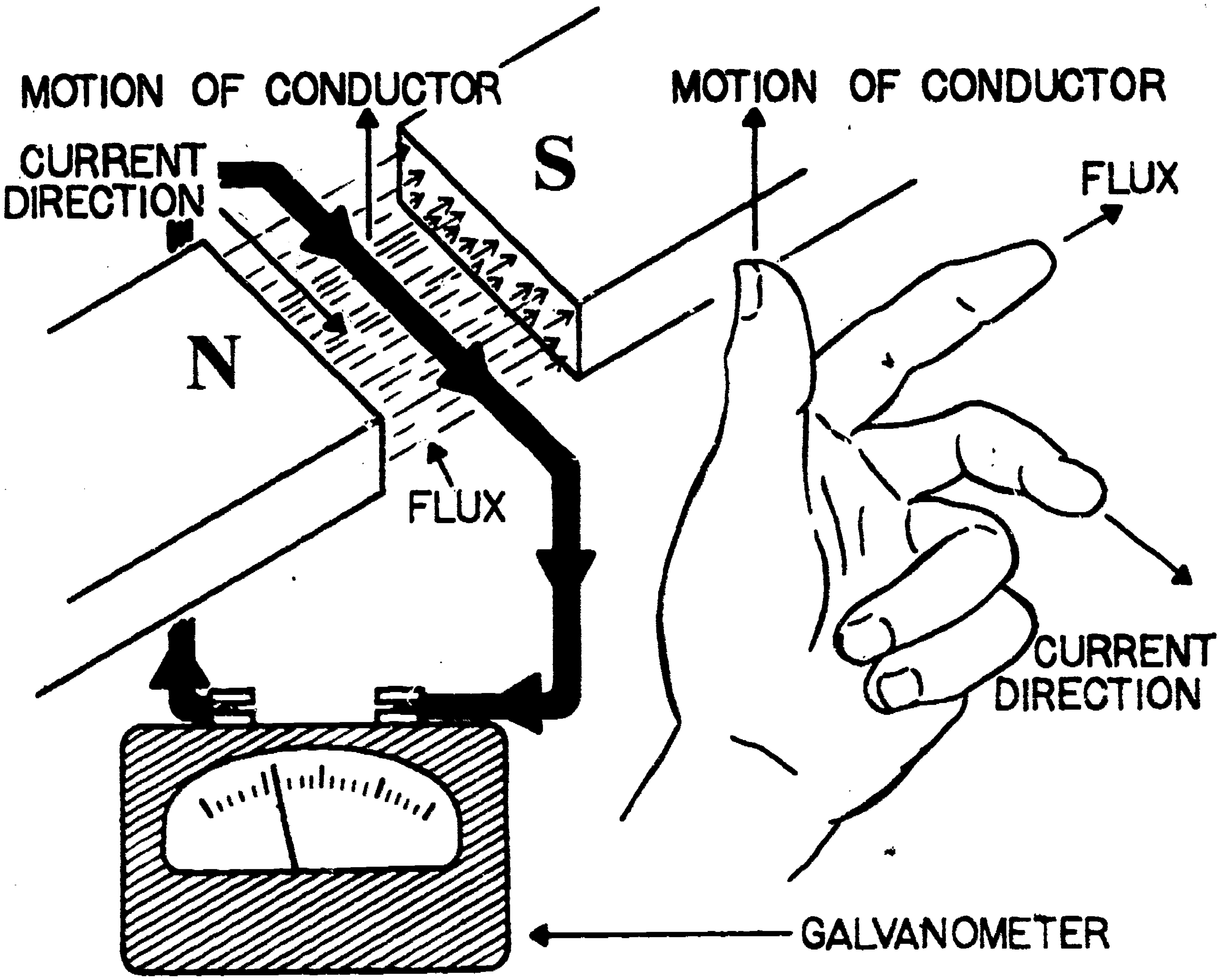
WHERE

= wavelength in meters

300,000,000 = speed of light in meters/sec

f = frequency in Hz.

LEFT-HAND RULE



Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

ELECTROMAGNETIC SPECTRUM

FREQUENCY	NAME	APPLICATIONS
0Hz	Steady direct current or voltage	DC motors, solenoids, relays, electrode voltages for tubes and transistors
20Hz - 20,000Hz	Audio frequencies	60Hz power, ac motors, audio amplifiers, microphones, loudspeakers, phonographs, tape recorders, high-fidelity equipment, public address systems, and intercoms
16kHz-30kHz	Ultrasonic frequencies or very low radio frequencies	Sound waves for ultrasonic cleaning, vibration testing, thickness gauging, flow detection, and sonar; electromagnetic waves for induction heating
30kHz-30GHz	Radio frequencies	Radio communications and broadcasting, including television, radio navigation, radio astronomy, industrial, medical, scientific and military radio
300GHz-430THz	Infared light rays	Heating, infared photography
430THz-1000THz	Visible light rays	Color, illumination, photography
1×10^{15}Hz-6×10^{16}Hz	Ultraviolet rays	Sterilizing, deodorizing, medical
3×10^{19}Hz-5×10^{20}Hz	X-rays	Thickness gauges, inspection, medical
5×10^{20}Hz-8×10^{21}Hz	Cosmic rays	Exist in outer space; can penetrate 70 m of water or 1 m of lead

Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

RADIO FREQUENCY ALLOCATIONS
(30kHz to 300,000 Hz)

MAIN CATEGORIES FOR RADIO FREQUENCIES:

VLF (very-low frequencies) below 30kHz.
LF (low frequencies) 30kHz to 300kHz.
MF (medium frequencies 300kHz to 3MHz.
HF (high frequencies) 3MHz to 30Mhz.
VHF (very-high frequencies) 30MHz to 300MHz.
UHF (ultra-high frequencies) 300MHz to 3GHz.
SHF (super-high frequencies) 3GHz to 30GHz.
EHF (extremely-high frequencies) 30GHz to 300GHz.

FCC FREQUENCY ALLOCATIONS:

BAND	ALLOCATED USE	COMMENTS
30kHz-535kHz	-Includes maritime communications and navigation, aeronautical radio navigation.	-Low and medium radio frequencies
535kHz-1605kHz	-Standard radio broadcast band.	-AM broadcasting
1605kHz-30MHz	-Includes amateur radio, loran, government radio, international shortwave broadcast, fixed and mobile communications, radio navigation, industrial, scientific, and medical.	-Amateur bands 3.5-4.0MHz and 28-29.7MHz; industrial, scientific, and medical band 26.95-27.54MHz; citizen's band class D for voice is 26.965-27.225MHz, 27.255MHz, and 27.230-27.470MHz.
30MHz-50MHz	-Government and nongovernment, fixed and mobile.	-Includes police, fire, forestry, highway, and railroad services; VHF band starts at 30MHz
50MHz-54MHz	-Amateur	-6-m band (Ham Radio)
54MHz-72MHz	-Television broadcast channels 2 to 4.	-Also fixed and mobile services
72MHz-76MHz	-Government and nongovernment services	-Aeronautical marker beacon on 75MHz.
76MHz-88MHz	-Television broadcast channels 5 and 6.	-Also fixed and mobile services
88MHz-108Mhz	-FM broadcast	-Also available for facsimile broadcast; 88-92MHz educational FM broadcast
108MHz-122MHz	-Aeronautical navigation	-Localizers, radio range, and air port control
122MHz-174MHz	-Government and nongovernment, fixed and mobile, amateur broadcast	-144-148MHz amateur band
174MHz-216MHz	-Television broadcast channels 7 to 13	-Also fixed and mobile services
216MHz-470MHz	-Amateur, government and non-government, fixed and mobile aeronautical navigation, citizen's radio	-Radio altimeter, glide path, and meteorological equipment; citizens' radio band 462.4-465MHz; civil aviation 255-400MHz; UHF band starts at 300MHz.
470MHz-890MHz	-Television broadcasting	-UHF television broadcast channels 14 to 83
890MHz-3000MHz	-Aeronautical radio navigation, amateur broadcast, studio-transmitter relay, government and nongovernment, fixed and mobile	-Radar bands 1300-1600MHz
3000MHz-30,000MHz	-Government and nongovernment, fixed and mobile, amateur broadcast radio navigation	-Super-high frequencies (SHF); 8400-8500MHz satelite communications
30,000MHz-300,000MHz	Experimental, government amateur	-Extra-high frequencies (EHF)

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

ANSWER SHEET

EXAM LIII U9

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.	■				26.	■				51.					76.				
2.	■				27.				■	52.					77.				
3.		■			28.				■	53.					78.				
4.		■			29.				■	54.					79.				
5.	■				30.		■			55.					80.				
6.	■				31.			■		56.					81.				
7.	■				32.	G				57.					82.				
8.		■			33.	H				58.					83.				
9.	■				34.	E				59.					84.				
10.	■				35.	I				60.					85.				
11.		■			36.	J				61.					86.				
12.	■				37.	K				62.					87.				
13.		■			38.	F				63.					88.				
14.	■				39.				■	64.					89.				
15.		■			40.			■		65.					90.				
16.				■	41.			■		66.					91.				
17.		■			42.		■			67.					92.				
18.				■	43.				■	68.					93.				
19.			■		44.	■				69.					94.				
20.	■				45.				■	70.					95.				
21.		■			46.					71.					96.				
22.		■			47.					72.					97.				
23.			■		48.					73.					98.				
24.		■			49.					74.					99.				
25.			■		50.					75.					100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 9

A. VOCABULARY - CROSSWORD PUZZLE

ACROSS

1. amplitude
4. wavelength
9. electromagnetic induction
12. cycle
14. erms
16. alternation
18. hertz
19. rotor
20. frequency
21. brush
24. oscillator
25. armature
26. harmonic
27. peak
28. sinusoidal
29. phase
31. peak to peak
32. nonsinusoidal
33. average value

DOWN

2. inverter
3. sawtooth
5. generator
6. square wave
7. FCC
8. instantaneous value
10. effective value
11. distortion
12. commutator
13. left hand rule
15. stator
17. slip rings
22. sine wave
23. phase angle
30. band

B. AC VALUES

1A. 30 V P-P
1B. 15 V PK
1C. 9.555 V AVG
1D. 10.605 V RMS
2A. 4 A PK
2B. 2.548 A AVG
2C. 8 A P-P
2D. 2.828 A RMS
3. 15V PK
4. 80 V P-P
5. 3.185 A AVG
6. 23.331 MA Eff
7. 165.438 V PK
8. 6 A RMS
9. 12.74 MV AVG
10. 3.535 A Eff
11. 56.56 V P-P
12. 6.305 A AVG

C. ALTERNATING CURRENT PRINCIPLES

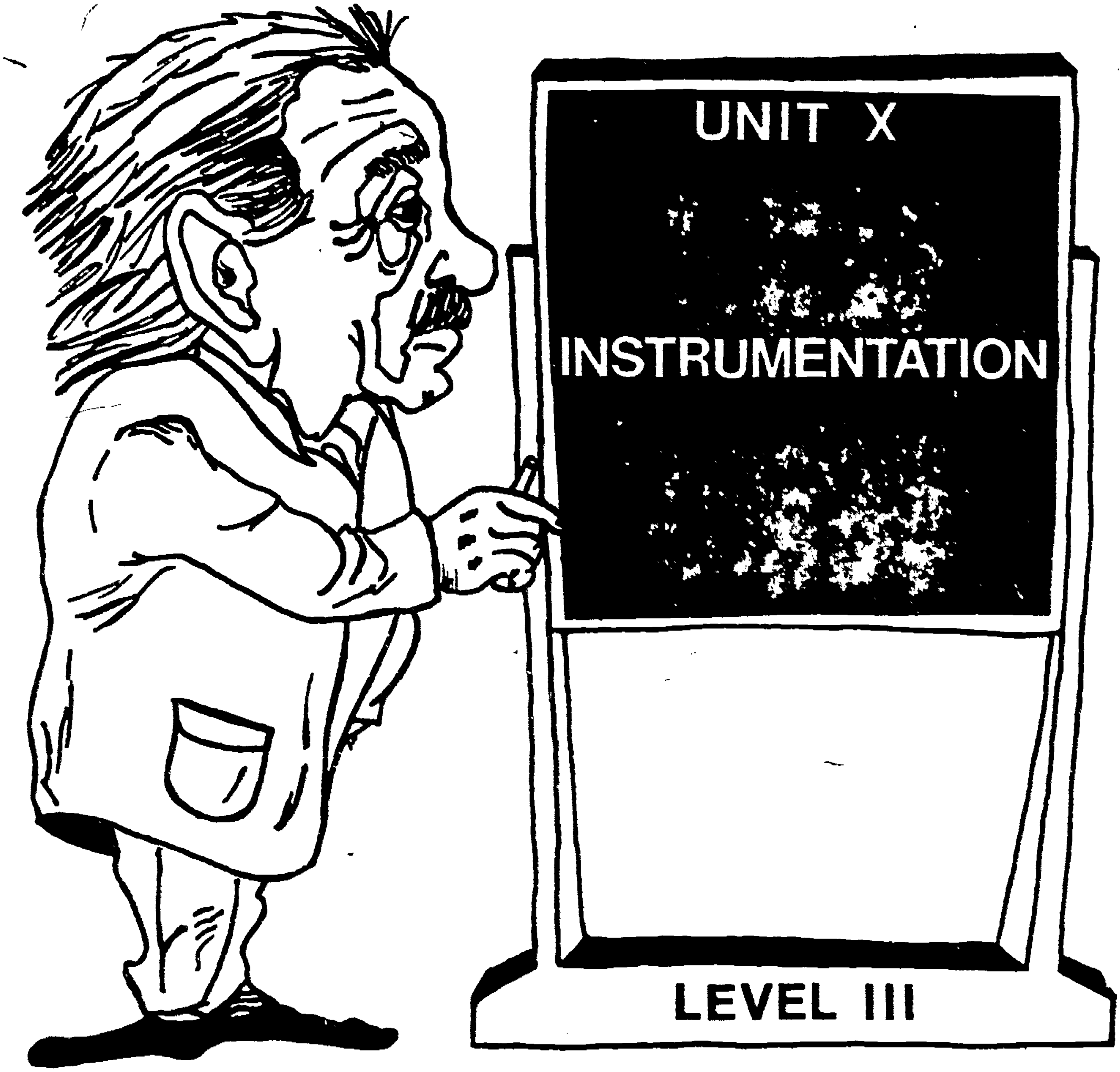
1. D
2. I or L
3. C
4. J
5. J
6. C
7. C
8. J
9. C
10. J
11. L
12. A
13. M
14. P
15. E
16. N
17. B
18. O
19. Q
20. K
21A. magnetic field
21B. conductor
21C. motion
22. alternations
23. frequency
24. .066 micro sec.
25. 20 meters
26. RMS
27A. sawtooth
27B. sinewave
27C. square wave
27D. pulsed wave
28A. AF
28B. RF
28C. x-rays
29A. standard AM radio
29B. television CH 7-13
29C. FM
30. (subjective answer)
31. (subjective answer)
32. (subjective answer)

D. QUEST ACTIVITY

(subjective evaluation)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME____________________

DATE STARTED____________

DATE COMPLETED__________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Instrumentation

Time Allocation: 2 weeks

Unit Goal:

To stimulate and instil student competence in utilizing basic test equipment, including knowledge related to operating techniques, limitations, and purpose of instrumentation.

Unit Objectives:

The student will be able to:

1. differentiate and identify the following meter abbreviations; VOM, VTVM, TVM, and DMM.

2. list at least two examples of simple display indicators and explain their specific function.

3. demonstrate basic operational skills and indicate corresponding electronic testing techniques when manipulating the following major test instruments: oscilloscope, audio generator, radio frequency generator, and any other instrumentation presented by the instructor.

4. explain and apply the proper safety and care procedures for each piece of test equipment given, and this would imply the ability to prevent misuse of the same equipment.

5. select and connect the appropriate test lead accessories for each test equipment item operated.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Basic Electricity/Electronics Book 2. Training and Retraining, Inc., Howard W. Sams and Co., Inc., 1974. Volume 4

Fundamentals of Electricity. Robert G. Seippel, American Technical Society, 1974. Chapter 11.

Technical Electricity and Electronics. Peter Buban and Marshall L. Schmitt, McGraw-Hill Book Co., 1977. Units 25, 26, and 27.

Overview:

In Unit 4 of this level some initial exposure to test equipment was presented partially as a foundation for this and succeeding units. Utilize this past unit on basic meters as a resource for review.

The unit should be introduced by examining the function of indicating devices, and stressing that the most basic of indicating devices are display indicators that react to either voltage or current.

Next, more sophisticated laboratory type testing instruments should be introduced, however for each item emphasized a detailed demonstration should ensue. This demonstration can include; equipment purpose, features/or controls, operating techniques, measurement procedures, leads and accessories, troubleshooting, and safety.

The unit outline concentrates on three standard test equipment items but the instructor can select any additional laboratory instruments utilizing personal discretions and a partial equipment listing given within item (F) in the accompanying outline.

The unit should conclude with a lesson on troubleshooting or testing techniques. Which troubleshooting methods and what techniques are to be taught will depend upon what is to be tested, equipment available, and test conditions. However, the fundamental competencies of testing are similiar for most applications. This unit will acquaint the student with both fundamental testing instruments and testing techniques, and the student should be constantly encouraged to practice these competencies whenever the opportunity presents itself.

A variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. LED's and other indicating devices are fast becoming popular in all aspects of electronics. Illustrate different varieties to your students and have them go through additional research to find out some of the more dramatic applications.
2. When making a presentation on different pieces of test equipment it is advantageous to take slides of the shop items to be discussed and project them on the screen while discussing various technical features.
3. Have a specific shop location, with student access, where all the laboratory instrumentation manuals are stored for student/instructor reference as needed, and periodically ask students to check certain procedures or functions by referring back to the equipment manuals.
4. Teachers often do not allow a significant amount of time or attention to the process of signal <u>injection</u> and <u>extraction</u>. A review of basic concepts like input/output will assist in establishing students with logical priorities in signal tracing. This particular competency will enable students to perform efficiently in all phases of troubleshooting work.
5. Because time and space does not permit instruction on all types of test equipment, concentrate on introducing and demonstrating the test equipment used most frequently in your laboratory.

Methodology continued:

6. Instructors periodically find special funding as a major obstacle in securing additional test equipment, however, a stop gap procedure is to purchase test equipment in kit form and allow advance students to build. This will enable students to experience project construction, increase laboratory inventory and reduce financial expenditure on ready - made test equipment.

Supplemental Activities and Demonstrations:

1. Demonstrate the technique of signal tracing utilizing the oscilloscope. Stress that loss of signal requires tracing in order to recover proper operation, and that the procedure is to trace the signal from its point of origin to the point where the signal encountered difficulty.
2. Demonstrate the cause and remedy of circuit loading when using test equipment to take measurements in an operating circuit. Emphasize that this is due to unavoidable disturbance of the circuit when the test leads from the equipment are applied to the circuit under test. Conclude by giving examples of ways to typically minimize this condition - special probes and/or special test equipment.
3. When demonstrating standard test equipment it is helpful to have advance students or shop managers assist the instructor in watching students operate their bench test equipment. When seeking help on equipment operation some students are more comfortable with fellow students than their instructor — so take advantage of this kind of assistance.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Scrambled Word Puzzle
5. Worksheet - Oscilloscope Controls and Inputs
6. Worksheet - Audio Frequency Generator
7. Worksheet - Radio Frequency Generator
8. Quest Activity
9. Informational Handout (Test Equipment and Applications)
10. Unit Module Answer Keys

X. Instrumentation

A. Review VOM, VTVM, TVM, DMM, etc.

B. Simple display indicators
   1. Neon lamp as a voltage indicator

   2. Light emitting diode (LED) as a current indicator

C. The oscilloscope
   1. Oscilloscope function

   2. Types of oscilloscopes

   3. Oscilloscope features and controls

   4. Basic operating techniques

   5. Measurement procedures

6. Probes and cables

D. The audio signal generator
   1. A.F. generator function

   2. Using the low frequency signal source

   3. Generator features and controls

   4. Basic operating techniques

E. The radio frequency generator
   1. Description of the RF generator

   2. RF signal generator applications

   3. Generator features and controls

4. Basic operating techniques

5. Probes and cables

F. Other laboratory test instruments
   1. Signal tracer

   2. Transistor and diode tester

   3. Tube tester

   4. Capacitor checker

   5. Impedance bridge

   6. Grid dip meter

   7. Frequency counter

F. (Continued)

8. Function generators

9. Sweep generators

10. RF power meter

Test Number ________

LIII-U10

UNIT EXAM

INSTRUMENTATION

IMPORTANT:

Indicate your responses on the answer sheet <u>only</u>. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. A multimeter is a test instrument used to measure AC/DC volts and DC current only. (T-F)

2. A VOM contains an ohmmeter scale which is nonlinear and the scale generally reads from zero to infinity. (T-F)

3. A DMM is a test instrument which displays its measurement with a pointer deflecting on a continuous scale. (T-F)

4. Light emitting diodes produce light from energy released, during normal operation, and most LED's emit a red light. (T-F)

5. The beam of electrons within a Cathode-Ray Tube is often called a cathode stream. (T-F)

6. Audio-signal generators produce output signals that have a frequency range from approximately 10Hz to 400kHz. (T-F)

7. There is a built-in signal in most scopes which is used to calibrate the instrument. (T-F)

8. A loudspeaker will respond to signals that are above the audio range of frequencies. (T-F)

9. The primary purpose of an oscilloscope is to show a picture or waveform on a screen in order that it may be measured or observed.

10. When the electron beam within a Cathode-Ray Tube strikes the phosphor coating on the screen of the tube it causes the phosphor to glow. (T-F)

11. The process by which the electron beam in the Cathode-Ray-Tube of an oscilloscope is made to move is called dejection. (T-F)

12. That circuit of an oscilloscope which causes the electron beam to move across the screen in a horizontal direction is called the horizontal sweep circuit. (T-F)

13. An audio generator usually generates either a sine or square-shaped output voltage. (T-F)

14. The signal to be observed by means of an oscilloscope is usually applied to the instrument at the vert. input jacks or terminals. (T-F)

15. The brightness control of an oscilloscope is most often referred to as the focus control. (T-F)

16. The assembly known as the "electron gun" is contained in the CRT of a scope. (T-F)

17. An RF signal generator is similar in operation to a common transmitter. (T-F)

18. Signal generators are classified in terms of the type of amplitude signal generated. (T-F)

19. Specific information in regards to test instruments is contained in the individual instruction or operating manuals. (T-F)

20. A good technique in locating a problem is a systematic process called logical faultfingering. (T-F)

21. Which of the following controls may cause damage to the screen on the scope if it is incorrectly adjusted?
(A) intensity (B) focus (C) vertical position (D) power switch

22. The vertical gain control on a scope may also be called a:
(A) height control (B) width control (C) sawtooth wave (D) none of the above.

23. The amount of vertical deflection on a scope indicates the:
(A) peak value of voltage applied. (B) peak-to-peak value of voltage applied. (C) RMS value of voltage applied. (D) none of the above.

24. To convert an RMS AC sine wave voltage to its peak-to-peak equivalent, we multiply it by:
(A) 1.414 (B) 2.83 (C) .707 (D) .636

25. The part of a Cathode-Ray Tube which produces the electron beam is the:
(A) vertical deflection plates. (B) horizontal deflection plates. (C) electron gun. (D) none of the above.

26. Which of the following controls is used to adjust the clarity of the wave on an oscilloscope?
(A) intensity (B) focus (C) vertical gain (D) horizontal position

27. The output level control is used to adjust the ____________ of the signal generator output.
(A) frequency (B) period (C) magnitoad (D) amplitude

28. Which of the following frequencies would be a typical output for an RF signal generator?
(A) 200kHz (B) 600MHz (C) 10MHz (D) 500Hz

29. The typical RF generator is not capable of producing an:
(A) audio signal. (B) high amplitude signal. (C) radio frequency signal. (D) modulated wave.

30. Special probes or leads are required for the:
(A) RF generator. (B) tube tester. (C) capacitor checker. (D) grid dip meter.

31. The oscilloscope is able to measure which of the following electrical characteristics?
(A) AC voltage (B) frequency (C) phase relation (D) all of the above.

32. Which of the following scope controls contributes to the stabilization of the displayed wave?
(A) brightness (B) fine frequency adjustment (C) horizontal positioning (D) vertical gain.

33. Of the instruments listed , which has the ability to directly measure DC current?
(A) VTVM (B) frequency counter (C) DMM (D) oscilloscope

34. Which piece of test equipment is designed to produce a test signal which can be injected into a circuit for troubleshooting?
(A) audio signal generator (B) signal tracer (C) radio frequency generator (D) both A and C

35. Of the pieces of test equipment listed below, which contains an oscillator circuit?
(A) oscilloscope (B) audio generator (C) RF generator (D) all of the above

Name: ____________

Date: ____________

Period: ____________

TECHNICAL GLOSSARY

AUDIO GENERATOR: A piece of test equipment designed to produce a continuous output signal - sine or square wave - which has a selectable output frequency generally between 20Hz to 200kHz.

BRIGHTNESS CONTROL: Oscilloscope control used to control the brightness or intensity of the trace on the screen.

CAPACITOR CHECKER: Test instrument designed to check capacitors for shorts, opens, leaks, and farad value.

CATHODE RAY TUBE: The visual display tube on the oscilloscope. A sweeping electron beam illuminates fluorescent atoms, coated on the inner face of the tube, to produce visible light. Abbrev. CRT

DIGITAL MULTIMETER: A multimeter whose input or measured value is displayed directly as illuminated digits or numbers. Abbrev. DMM

FINE FREQUENCY ADJUSTMENT: An oscilloscope control which is used as a fine adjustment for the horizontal sweep oscillator. This control will stabilize or "lock in" a slowly drifting signal.

FOCUS: An oscilloscope control used to adjust the trace into a sharp, clear image.

FREQUENCY COUNTER: A piece of test gear designed to accurately count or measure AC frequencies. Modern frequency counters have a digital display.

FREQUENCY RANGE CONTROL: A signal generator control used in conjunction with the main tuning dial as a frequency multiplier. Typical range control markings would be X1, X10, X100, etc.

FUNCTION GENERATOR: A type of signal generator capable of providing sine, square, triangle, ramp, and pulse output waves.

GRATICULE: The major markings on the oscilloscope screen. The graticules are used when measuring a voltage or frequency.

GRID DIP METER: An instrument used primarily to tune transmitters or oscillators to a designated frequency.

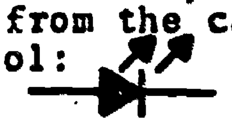
Name: ______________

HORIZONTAL GAIN: An oscilloscope control which increases the length (left to right) of a scope trace. Many scopes utilize two controls, one to adjust gain in large steps, and a variable resistor to provide fine adjustment.

HORIZONTAL INPUT: An oscilloscope input which is used to apply an external signal to the horizontal deflection plates of the CRT.

HORIZONTAL POSITIONING: An oscilloscope control which will move the trace across the screen in a horizontal direction.

IMPEDANCE BRIDGE: An instrument used to accurately measure or determine resistance, capacitance, or inductance values, using a ratio-comparitive process.

LIGHT EMITTING DIODE: A two element semiconductor device which produces visible light when current flows from the cathode to the anode terminal. Graphic symbol: 
Abbrev. LED

MAIN TUNING DIAL: A signal generator control used to "adjust for" or "tune in" a specific frequency.

NEON LAMP INDICATOR: A voltage sensitive glow lamp which requires approximately 55 volts to ionize and produce light. Graphic symbol:  Letter symbol: LP

OSCILLOSCOPE: A basic piece of test equipment used to display voltage waveshapes on the screen of a cathode ray tube. The oscilloscope can also be used to measure AC or DC voltages and AC frequencies.

OUTPUT LEVEL CONTROL: A signal generator control used to adjust the output voltage or amplitude of the generated output wave.

PROBES: Special test lead designed to be used only with particular pieces of test equipment. Typical examples RF probes, high voltage probes, etc.

RADIO FREQUENCY GENERATOR: A piece of test equipment which is designed to produce a continuous sinusoidal output signal that is adjustable over a range of approximately 150KHz to 150MHz. Most instruments also include a fixed audio frequency which can be mixed (modulated) with an RF signal.

RF POWER METER: A test instrument used to measure output power of a transmitter. One type of RF power meter will connect in series between the transmitter and a dummy load. Also referred to as an RF wattmeter.

SIGNAL TRACER: A test instrument that is useful in troubleshooting radio and audio circuits. It basically consists of a widerange amplifier and detector circuit.

Name: ______________

SWEEP FREQUENCY:	An oscilloscope control used to select the frequency band over which the internal oscillator operates. The higher the sweep frequency, the faster the electron beam moves across the face of the scope.
SWEEP GENERATOR:	A piece of test equipment utilized mainly in tuning or aligning FM radios and television receivers. The instrument produces a sinusoidal signal that continually varies in frequency, above and below a tuned center frequency.
SYNC AMPLITUDE:	An oscilloscope control used to adjust the triggering or sync circuit within the scope. It will assist in locking the input signal and the horizontal sweep in order to obtain a stationary pattern.
SYNC SELECTOR:	An oscilloscope control or switch used to select the method of signal synchronization - internal, external or 60Hz sync mode.
TRANSISTOR-DIODE TESTER:	A test instrument designed to check semiconductor diodes and transistors. Test modes may include; leakage test, gain test, and short or open test.
TRANSISTORIZED VOLTMETER:	A basic measuring instrument which utilizes a transistorized circuit to drive a meter movement. Abbrev. TVM
TRIGGERED SWEEP:	An oscilloscope circuit which allows you to view a signal as a stationary pattern.
TUBE TESTER:	A test instrument designed to check vacuum tubes. Most tube testers will evaluate filament continuity, shorts, and the ability to amplify a signal.
VACUUM TUBE VOLTMETER:	A test instrument able to measure voltage and resistance, with the meter circuit designed around vacuum tubes. The instrument is usually not portable, requiring a source of 117V AC. Abbrev. VTVM
VERTICAL GAIN:	An oscilloscope control which will adjust the instruments sensitivity to a vertical input. It has a similar function to the range switch on a voltmeter. Many scopes utilize two controls for this purpose, one to adjust gain in large steps, and a variable resistor to provide fine adjustment.
VERTICAL INPUT:	The most commonly used oscilloscope input terminals and this input will allow the beam to deflect in the vertical direction when a voltage is applied.
VERTICAL POSITIONING:	An oscilloscope control which will move the beam up or down on the screen. It is used to locate the beam on a graticule line.
VOLT-OHM-METER:	A portable, battery powered meter designed to measure voltage, current, and resistance. Abbrev. VOM

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

VOCABULARY - SCRAMBLED WORD PUZZLE

Unscramble the letters below to uncover the electronic terms.

EXAMPLE:

A. GNREETARO — A. GENERATOR

1. POBRES — 1. ______

2. CUSFO — 2. ______

3. UETB RESTTE — 3. ______

4. NNOE ALPM — 4. ______

5. SOLSLOCEPICSO — 5. ______

6. IDUAO EENGARROT — 6. ______

7. GINSAL RCATRE — 7. ______

8. SARRNTOZIISTDE TLMEVORET — 8. ______

9. IIDGATL MITLEMURET — 9. ______

10. TERICVLA NAGI — 10. ______

11. HLTGI TEMGNIIT ODEDI — 11. ______

12. NESTSHIGRB ROOTLNC — 12. ______

13. RITZALNOOHI TINUP — 13. ______

14. QEENUFRYC TRENCUO — 14. ______

15. NSYC IPMALDUET — 15. ______

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

OSCILLOSCOPE CONTROLS AND INPUTS

Many manufacturers, such as Eico, Heathkit, Leader, Sencore, Tektronix, Lectrotech, Hewlett-Packard, Viz, Hickok, B&K Precision, etc., produce oscilloscopes. These companies unfortunately do not use common control designations; thus, while a scope control has a similar function on both an Eico and an Lectroteck scope they are labeled differently. For example, the vert attenuator control on the Eico-460 and the volts/div control on the Lectroteck - 55 scope have a similar function - that of adjusting vertical gain - but a different designation.

This exercise is designed to familiarize you with the name of the various scope controls, and their function. The chart below lists 1) control designation, 2) other common control names, 3) a column for you to indicate the name of the control, on your shop scope, which provides a similar adjustment and 4) a column for you to indicate the function of that control.

CONTROL DESIGNATION	OTHER COMMON CONTROL NAMES	NAME OF CONTROL ON YOUR SCOPE	CONTROL FUNCTION
BRIGHTNESS	BRIGHTNESS, INTENSITY		
FOCUS	FOCUS		
VERTICAL POSITIONING	VERTICAL POSITION, VERTICAL CENTERING		
HORIZONTAL POSITIONING	HORIZONTAL POSITION, HORIZONTAL CENTERING		
VERTICAL GAIN*	VERTICAL GAIN, VERTICAL AMPLITUDE, VERTICAL SENSITIVITY, VERTICAL ATTENUATOR, VERTICAL RANGE		

Name: ____________

Date: ____________

Period: ____________

HORIZONTAL GAIN*	HORIZONTAL GAIN, HORIZONTAL AMPLITUDE HORIZONTAL SENSITIVITY HORIZONTAL ATTENUATOR, HORIZONTAL RANGE		
SWEEP FREQUENCY	SWEEP FREQUENCY, COURSE FREQUENCY, FREQUENCY RANGE, SWEEP SELECTOR		
FINE FREQUENCY	FINE FREQUENCY, FREQUENCY VERNIER		
SYNC SELECTOR	SYNC SELECTOR, HORIZONTAL SELECTOR, SYNC INPUT		
SYNC AMPLITUDE	SYNC AMPLITUDE SYNC ADJUST LOCKING		
VERTICAL INPUT	V-INPUT INPUT		
HORIZONTAL INPUT	H-INPUT EXT./SYNC EXT. HORIZ. SYNC/HORIZ.		

* Many scopes utilize two gain controls, one to adjust gain in large steps, and a variable resistor to provide fine adjustments.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

AUDIO FREQUENCY GENERATOR

In the space provided, make an accurate drawing of the shop audio frequency generator. Label all controls and terminals.

AUDIO FREQUENCY GENERATOR

Utilizing the reference materials available:

1) describe the purpose of the AF generator.

2) list the controls found on the generator and indicate their function.

3) briefly describe the operating procedures, and precautions to be observed when using the signal generator.

Name: ______________

Date: ______________

Period: ______________

PURPOSE:

CONTROLS AND FUNCTION:

OPERATING PROCEDURES AND PRECAUTIONS:

SCORE:

GRADE:

Name: ____________

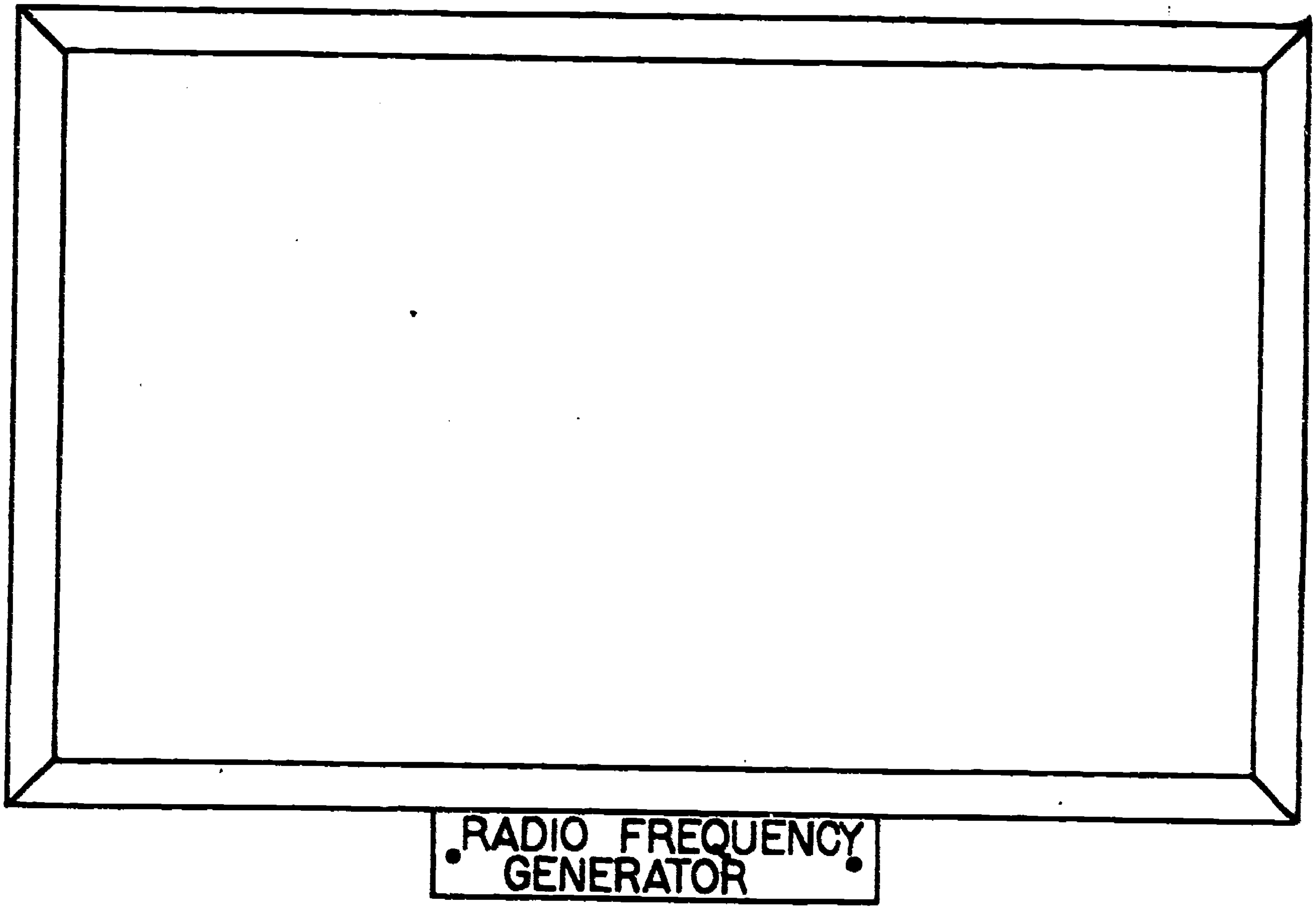
Date: ____________

Period: ____________

WORKSHEET

RADIO FREQUENCY GENERATOR

In the space provided, make an accurate drawing of the shop radio frequency generator. Label all controls and terminals.



Utilizing the reference materials available:

1) describe the purpose of the RF generator.

2) list the controls found on the generator and indicate their function.

3) briefly describe the operating procedures, and precautions to be observed when using the signal generator.

Name: ______________

Date: ______________

Period: ______________

PURPOSE:

CONTROLS AND FUNCTION:

OPERATING PROCEDURES AND PRECAUTIONS:

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

QUEST ACTIVITY

"UNIT 10"

Assume you were planning to start a small shop in your garage for hobby and repair purposes. You are interested in purchasing some test equipment and discovered that the following pieces of equipment are considered to be basic items necessary for troubleshooting circuit failures, and measuring circuit performance. (Items listed in general order of importance.)

1. VTVM or other accurate multimeter (TVM, DMM, ICVM, etc.)

2. Isolation transformer

3. RF signal generator

4. AF signal generator

5. Oscilloscope

6. R/C substitution box

7. Semiconductor tester

8. Variable output power supply (0-30V regulated)

On a separate piece of paper. List each item, and describe why you would need that particular piece of equipment in your shop. (What job will the test instrument perform?) Also, using the catalogs available in the room, look up, and price, the various pieces of equipment. Record the model, manufacturer, and price noting whether the equipment is assembled or in kit form.

Name: ____________

Date: ____________

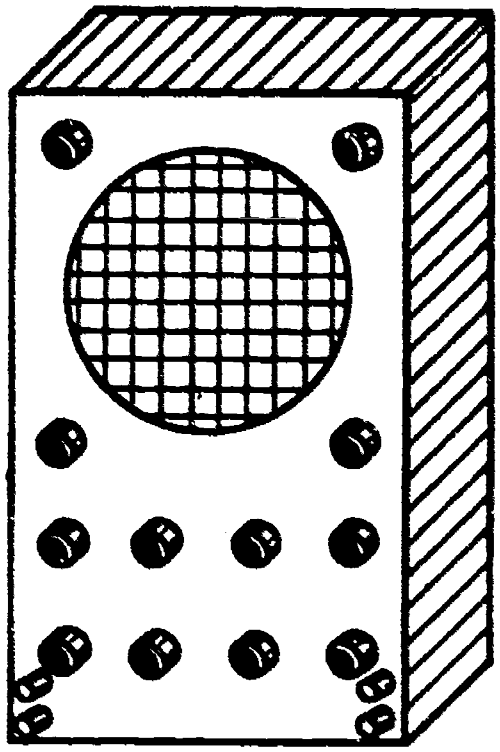
INFORMATIONAL HANDOUT Period: ____________

TEST EQUIPMENT AND APPLICATIONS

THE OSCILLOSCOPE

GENERAL INFORMATION:

When examining an electronic circuit, it's important to know the voltage present at a test point, or the current flow through a particular component, but that's only half the story. You will also want to know what type of signal is flowing from point to point in the circuit. This is particularily important when checking audio, RF, SYNC or timing circuits. To SEE what's happening in your circuit you will use an oscilloscope. The scope allows you to visually examine and measure circuit signals or waveforms.



The heart of the oscilloscope is a cathode-ray tube, which is in many ways similar to the picture tube of a black-and-white television set. At the rear of the CRT is an electron gun. This assembly produces a narrow beam of electrons which are focused on to the screen of the CRT. When the electrons strike the phosphor atoms, which are coated on the inner face of the cathode-ray tube, light is produced. Internal circuitry is designed to sweep the beam horizontally across the face of the screen. When a signal is applied to the vertical input terminals, the beam is caused to deflect in the vertical direction, in proportion to the input voltage; that is, the larger the input voltage, the higher the beam will move in the vertical direction.

Name: ____________

Date: ____________

Period: ____________

To summarize, the beam is affected by two forces - 1) the internal horizontal sweep, and 2) the external input signal. These two forces, in combination, allow the beam to "trace-out" a picture of the input signal.

APPLICATIONS:

Besides providing a visual display of a waveform, an oscilloscope can perform other important functions or jobs. One of the simplest applications for the oscilloscope is the measurement of AC or DC voltages. Voltage measurements are indicated by the vertical amplitude of the wave, as compared to a graticule scale on the face of the scope. The scope can indirectly measure circuit current - that is if you are measuring the voltage across a resistor of known value, current can be computed by applying OHM's Law. The oscilloscope can also be used to measure the frequency of an AC wave. This measurement is a function of the horizontal length of the wave, and the sweep frequency. In the hands of a knowledgable individual, the oscilloscope can also be used to roughly check the sensitivity of a radio receiver, isolate distortion in an audio circuit, measure the bandwidth of a filter circuit, determine phase relationships between signals, and perform signal tracing operations.

SIGNAL GENERATORS

GENERAL INFORMATION:

Signal generators are test instruments used to supply an output signal at various frequencies and amplitudes. Generally, the outputs are either sinusoidal, square wave or amplitude modulated. The basis for a typical signal generator is an oscillator circuit. Such a circuit produces an AC output through the interaction of an (inductor-capacitor) or (capacitor-resistor) circuit, and an amplifier. The circuit design allows the operator to select the output frequency (over a certain range) and the output amplitude or voltage. Signal generators are divided into two major types: audio frequency and radio frequency generators.

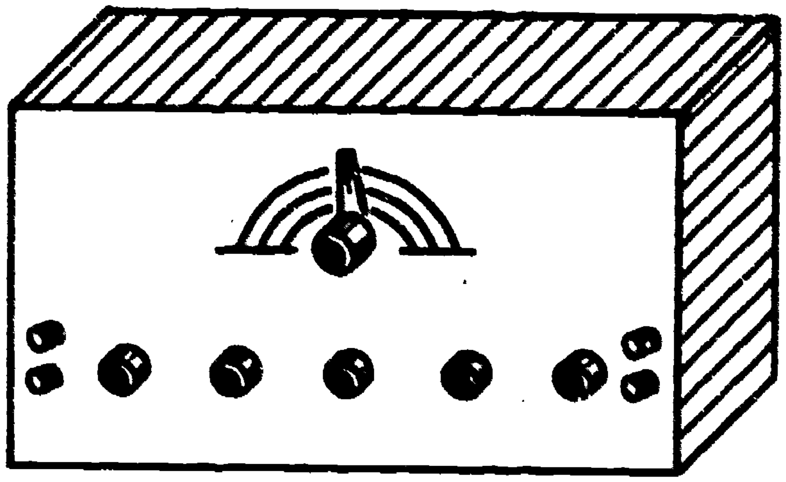
AUDIO FREQUENCY GENERATOR:

AF generators are designed to produce output signals which have a frequency range of approximately 20Hz to 200Hz. The particular output frequency is selected by using both a range switch or multiplier and a tuning dial. The amplitude of the output wave is adjusted by using a gain control. General-purpose AF generators are capable of producing both a sine wave and square wave output.

Name: ______________

Date: ______________

Period: ______________



APPLICATION:

An AF generator is used in testing and locating faulty stages in audio equipment. A typical tactic would be to inject an audio signal (using the AF generator) into a circuit and monitor that signal with a scope or signal tracer. Lack of output, or distortion of the signal would indicate a faulty stage.

RADIO FREQUENCY GENERATOR:

RF generators are designed primarily to produce a sinusoidal output signal that ranges from approximately 150kHz to 100MHz, again selectable by using a multiplier or band switch and tuning dial. In addition, the generator usually contains a fixed audio oscillator circuit. The addition of this circuit allows the output to be modulated (AF and RF signals mixed together) for testing of radio and TV circuits. The signal output level can be adjusted using the gain control. Typically, the output amplitude of an RF generator is low when compared to its audio frequency counterpart. The RF generator also requires special shielded probes to prevent the radiation of high frequency waves.

APPLICATIONS:

Alignment and adjustment, for maximum output, of a tuned circuit, in a radio, television, transmitter, or receiver.

SCORE:
GRADE:

Name: ______________________

Date: ______________________

Period: ______________________

ANSWER SHEET

EXAM LIII U10

	A (T)	B (F)	C	D
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*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 10

A. VOCABULARY - SCRAMBLED WORD PUZZLE

1. probes
2. focus
3. tube tester
4. neon lamp
5. oscilloscopes
6. audio generator
7. signal tracer
8. transistorized voltmeter
9. digital multimeter
10. vertical gain
11. light emmitting diode
12. brightness control
13. horizontal input
14. frequency counter
15. sync amplitude

B. OSCILLOSCOPE CONTROLS AND INPUTS.

(subjective evaluation)

C. AUDIO FREQUENCY GENERATOR

(subjective evaluation)

D. RADIO FREQUENCY GENERATOR

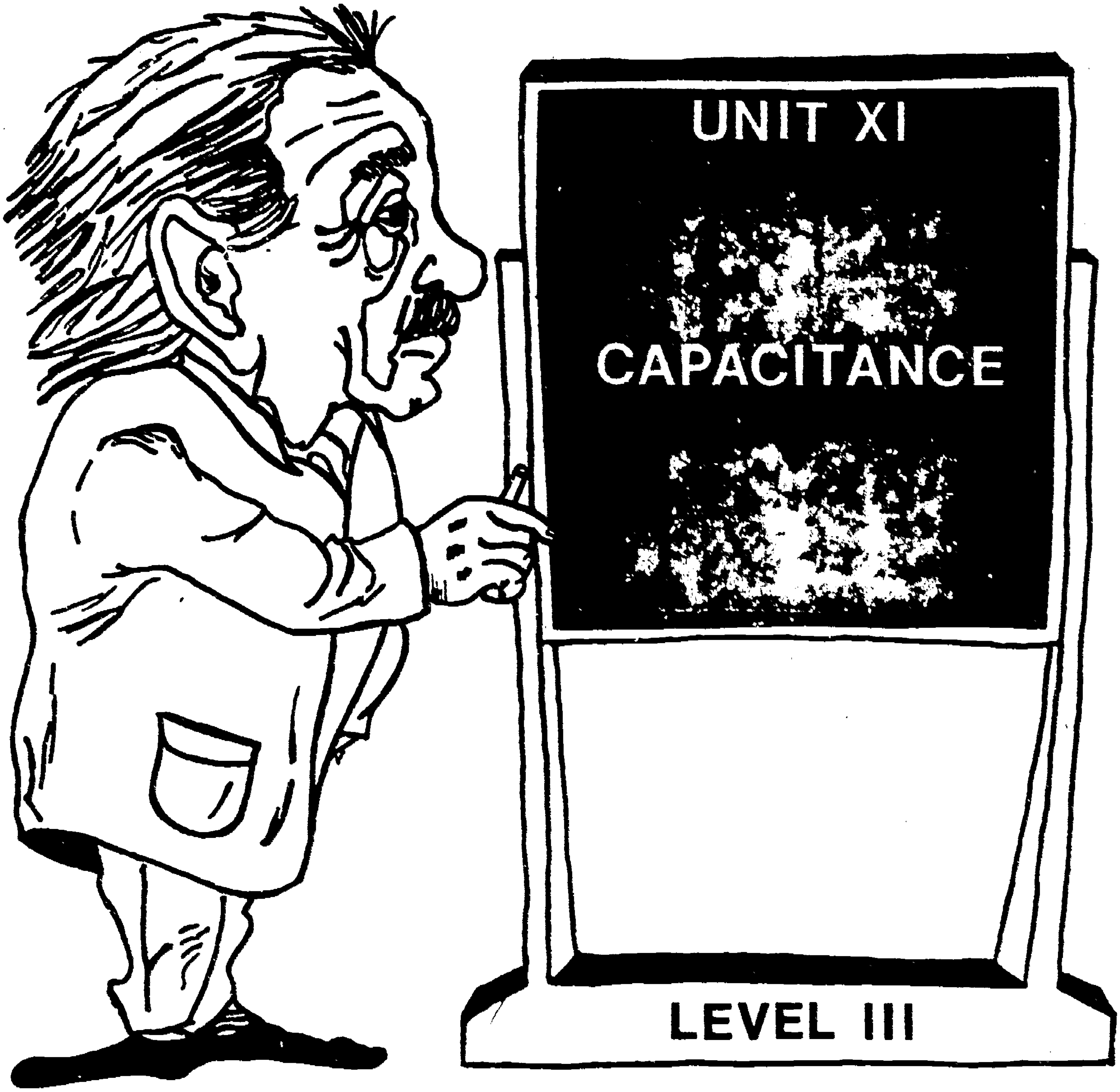
(subjective evaluation)

E. QUEST ACTIVITY

(subjective evaluation)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________

DATE STARTED________

DATE COMPLETED________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Capacitance

Time Allocation: 2 weeks

Unit Goal:

To impart and implant those competencies which allow an extensive evaluation of capacitors in respect to construction, characteristics, and problems analysis.

Unit Objectives:

The student will be able to:

1. describe safety precautions to be observed to prevent electrical shock when handling capacitors in electrical circuits.

2. write the names and abbreviations of the various units of measurements for capacitance, and draw the schematic symbols for both fixed and variable capacitors.

3. define the term capacitance and list three factors which affect this property in a capacitor.

4. indicate, on a schematic drawing of a battery and a capacitor in series, the direction of the charging current and the polarity of the charge on the capacitor.

5. solve for total capacitance of capacitors either in series or parallel utilizing the proper formula and units of measurement

6. explain and compute problems involving RC time constants and capacitive reactances while utilizing the values given and solving for the unknown.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Basic Electronics. Bernard Grob, McGraw-Hill Book Co., 1977. Chapters 21-25.

Elements of Electronics. Henry V. Hickey and William M. Villines, McGraw-Hill Book Co., 1970. Chapters 20-22.

Essentials of Electricity-Electronics. William Osterheld and Morris Slurzberg, McGraw-Hill Book Co., 1965. Chapter 9.

Overview:

Unit 11 and succeeding units in Level III contain technical data and mathematics which must be carefully presented in order that students do not become overwhelmed by the abstract nature of the subject matter.

In this unit the central theme is that a capacitor consists basically of two conductors separated by an insulator, yet, this physically simplistic component is considered a remarkable control device.

Upon this kind of introduction the topics of capacitance, units of measurement, reaction to AC/DC, capacitor types, ratings, and other pertinent concepts on the effects of capacitance can be explored.

Next, the testing techniques of capacitors offers an opportunity to break up the normal unit presentation with demonstrations on both condition and value testing.

An appreciable amount of unit time should be allocated to RC time constants, phase relationship, and capacitors in series or parallel circuits. However, the relationship between Ohm's Law and capacitive reactance is sometimes difficult to present and is reserved as part of the concluding topic in this unit. Reactance is an important concept that should be stressed through extensive problem solving situations and will also be handled as a topic in future units of Level III.

Before departing from this unit the student should be cognizant of many of the technical characteristics of capacitors, however, further explanation of capacitor applications at this point will allow even greater student comprehension.

A variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. The instructor should not forget to preface the presentation on capacitors with a thorough coverage of capacitor safety. In addition to stressing the possibility of capacitors causing a severe electrical shock, explain that this voltage can seriously damage test instruments as well.
2. Remember to point out during a presentation that the formulas for adding capacitors in series or in parallel are exactly opposite to those for adding resistors in series or in parallel. To avoid formula confusion point out that capacitance is the ability of a device to store an amount of electrons at a given voltage, while resistance is the measure of a device to oppose current as a result of its internal structure, hence formula inconsistency.
3. Mathematics used in solving X_C problems presents a stumbling block for some students. At this point, they start to panic in regards to why they took this course so take some extra time and effort to show the importance of these concepts and their future applications—be patient.
4. When discussing capacitor construction it is easy to tear apart, in front of the class, a discarded capacitor and describe the contents; foil, waxed paper, and covering material. A little theatrics will be far more impressive than a textbook definition.

Methodology continued:

5. After the class has mastered basic capacitor principles, accompanied by appropriate problem exercises, it is a good opportunity to lay the foundation for reactance. Impress on the students that reactance is AC resistance caused by a capacitor and when solving for simple electrical quantities just substitute "X_C" for "R" in the Ohm's Law equation. Remember a successful program of constant formula repetition and problem solving will pay off.

Supplemental Activities and Demonstrations:

1. Instructor can assemble a large demonstration capacitor in class by utilizing several plate glass mirrors taped together with the silver backing on the outside. The backing acts as the conductor, and the glass as the dielectric. This simple visual aide, however is an effective means of illustrating the physical characteristics of capacitors.
2. When explaining the charging aspect of capacitors in DC circuits an interesting method for students to vividly see the voltage and current relationship is to use a power supply with both a voltmeter and ammeter display panel. Students may then observe the rapid increase/decrease of current under charging.
3. To show the characteristics of capacitors in both direct and alternating circuits a simple demonstrator can be used. Take a number 44 lamp, and a 150 MFD capacitor at 25 WVDC and wire them in series. Inject a 6.3 VAC source first and observe results at the lamp then inject a 6.0 VDC source and again note the results. Ask the class to explain the reasons for this electrical behavior.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Know Your Definitions
5. Worksheet - Capacitors and Capacitance
6. Worksheet - Capacitive Reactance
7. Quest Activity
8. Informational Handout (Capacitors - What they are and how they function.
9. Informational Handout (Capacitance Formulas)
10. Unit Module Answer Keys

XI. Capacitance

A. What is capacitance?

B. Construction of a capacitor

C. Units of capacitance

D. Factors which determine capacitance

E. Capacitor action to DC and AC

F. Types of capacitors

G. Capacitor replacement

1. Handling precautions

2. Capacitor ratings

3. Capacitors in series and parallel

4. Capacitor testing techniques

H. R-C time constants

I. Voltage and current phase relationships

J. Uses of capacitors

K. Capacitive reactance

Test Number ______

LIII-U11

UNIT EXAM

CAPACITANCE

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. An AM radio receiver can be tuned with a variable capacitor. (T-F)

2. In the past, capacitors were called or referred to as condors. (T-F)

3. A variable capacitor consists of stationary plates called stator plates and rotating plates called rotor plates. (T-F)

4. Air separates the plates within a mica capacitor. (T-F)

5. In a capacitor, the conducting surfaces are called the dielectrics and the insulating material is called the plate. (T-F)

6. A capacitor is an energy source, the operation of which is similar to that of a voltaic cell. (T-F)

7. One microfarad is equal to one-millionth of a farad. (T-F)

8. One picofarad is equal to one-millionth of a microfarad. (T-F)

9. As a general rule, all capacitors having a capacitance of more than one microfarad are electrolytic capacitors. (T-F)

10. The charging time period of a capacitor can be decreased by the addition of a large value of resistance in series with the capacitor. (T-F)

11. Total capacitance is increased by connecting capacitors in series. (T-F)

12. Capacitive reactance is measured in terms of the basic unit ohms. (T-F)

13. It can be said that a capacitor blocks AC but passes DC. (T-F)

14. Increasing the plate area of a capacitor increases its capacitance. (T-F)

15. A potentially dangerous voltage may exist across some capacitors for many hours after their circuits have been turned off. (T-F)

16. A capacitor can, but seldom does, become open. (T-F)

17. Increasing the spacing between the plates of a capacitor increases its capacitance. (T-F)

18. All capacitors that are in good condition will have a relatively low resistance between their plates. (T-F)

19. The letter symbol for capacitive reactance is "RC". (T-F)

20. The time required for the voltage across a capacitor to reach 63.2 percent of the applied voltage is known as the time constant of the capacitor circuit. (T-F)

21. A capacitor is composed of:
(A) two or more metal plates separated by a dielectric. (B) one metal plate and one layer of insulation. (C) one plate and one conductor. (D) two plates separated by a conductor.

22. While a capacitor is discharging:
(A) the amount of charge stored on the plates increases. (B) the voltage across it is decreasing. (C) the voltage across it is increasing. (D) electrons are building up on the negative plate.

23. The unit of capacitance is:
(A) ohm. (B) volt. (C) farad. (D) none of the above.

24. The term DIELECTRIC STRENGTH means:
(A) the ability of an insulator to withstand electric stress across it without breaking down. (B) the ability of a conductor to store large voltage values. (C) the ability of a conductor to handle high voltages. (D) none of the above.

25. In a parallel circuit, if $C_1 = 10\mu F$ and $C_2 = 2\mu F$, the total capacitance would be:
(A) $2\mu F$. (B) $8\mu F$. (C) $12\mu F$. (D) $10\mu F$.

26. A $.022\mu F$ capacitor is connected in series with a $.066\mu F$ capacitor. The total capacitance is :
(A) .088 pF. (B) $.0165\mu F$. (C) $60.6\mu F$. (D) $.088\mu F$.

27. The term in phase indicates that the:
(A) current lags the voltage. (B) current leads the voltage. (C) current and voltage reach given values simultaneously. (D) voltage is always higher than the current.

28. The formula for capacitive reactance is:
(A) $C = Q/E$. (B) $X_C = 1/6.28FC$. (C) $X_R = 6.28FL$. (D) $X_{eff.} = X_1 - X_($

29. Alternating current can flow in a capactive circuit with AC voltage applied because:
(A) of the high peak value. (B) varying voltage produces charge and discharge current. (C) charging current flows when the voltage decreases. (D) discharge current flows when the voltage increases.

30. With higher frequencies, the amount of capacitive reactance:
(A) increases. (B) stays the same. (C) decreases. (D) increases only when the voltage increases.

31. At a given frequency, substituting a larger capacitance results in: (A) more reactance. (B) the same reactance. (C) less reactance. (D) less reactance if the voltage amplitude decreases.

32. The capacitive reactance of a 0.1μF capacitor at 1,000Hz equals: (A) 1,000 ohms. (B) 1,600 ohms. (C) 2,000 ohms. (D) 1,590 ohms.

33. The type of capacitor which may be damaged if the applied voltage reverses polarity is the: (A) electrolytic capacitor. (B) ceramic capacitor. (C) mica capacitor. (D) paper capacitor.

34. If a capacitor only circuit has an applied voltage of 100 AC volts and a capacitive reactance of 500 ohms, the circuit current is: (A) 5 amps. (B) 4 amps. (C) 2 amps. (D) .2 amps.

35. If a short circuit occurs when a breakdown voltage is applied to a capacitor, but the capacitor returns to normal operating conditions when the voltage overload is removed, the capacitor is said to be: (A) in need of replacement. (B) off tolerance. (C) self-healing. (D) variable.

36. It is found that a capacitor, when charged, loses its charge in a few minutes. This is most likely owing to: (A) leakage across the dielectric. (B) leakage withing the anode. (C) leakage within the cathode. (D) leakage through the surrounding air.

37. The capacitive reactance of a 0.01 farad capacitor at 159Hz is: (A) 0.1 farad. (B) 0.1 ohm. (C) 0.01 ohms. (D) 159 ohms.

38. The current flow in a capacitive circuit __________ the voltage by __________°. (A) lags, 45° (B) lags, 90° (C) leads, 0° (D) leads, 90°

39. What is the reactance of a .05 mfd capacitor at 400Hz? (A) 7960 ohms. (B) 15920 ohms. (C) 31840 ohms. (D) 63680 ohms.

40. What is the equation for finding the total capacitance of a circuit with four parallel capacitors?

(A) $\frac{C_1 \times C_2}{C_1 + C_2}$ (B) $C_1 + C_2 + C_3 \cdots$ (C) $\frac{C}{N}$ (D) $\frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots}$

Name: ____________________

Date: ____________________

Period: ____________________

TECHNICAL GLOSSARY

BREAKDOWN VOLTAGE: A voltage, applied across the plates of a capacitor, which will cause the stored charges to puncture through the dielectric. Once this occurs, the capacitor is referred to as "leaky" and is considered functionally destroyed.

CAPACITANCE: The ability of a device, usually a capacitor, to store a charge, and oppose a change in voltage. Capacitance is measured in the basic unit farads. Abbrev. C

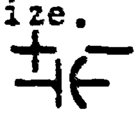
CAPACITIVE REACTANCE: The AC resistance of a capacitor, measured in ohms, and computed by the formula $X_C = \frac{1}{2\pi fc}$. Abbrev. X_C

CAPACITOR: A device consisting of two metal plates separated by an insulator, or dielectric. A capacitor has the ability to store a charge and provides capacitance in a circuit. Symbol:  Letter symbol: C

DIELECTRIC: The insulating material between the plates of a capacitor

DIELECTRIC STRENGTH: A measurement of a dielectric materials ability to withstand high voltages without breaking down. The rating is based upon the specific thickness of the insulator.

DISCHARGE: The process of removing or neutralizing stored charges from the plates of a capacitor.

ELECTROLYTIC CAPACITOR: A fixed value capacitor which utilizes a thin oxide layer on the surface of one of the plates, as a dielectric. The advantage of this design is that it allows for large capacitance values and relatively small case size. These capacitors are generally polarized. Symbol:  Letter symbol: C

ELECTROSTATIC FIELD: A field of force that exits between positively and negatively charge surfaces. It is the presence of this force that allows a capacitor to charge and remain charged for an amount of time.

FARAD: The basic unit of measurement for capacitance. One farad is a large unit, therefore more practical units of capacitance are the microfarad and the picofarad. Abbrev. F

NONPOLARIZED: Many capacitors may be connected into a circuit regardless of plate polarity. This type of capacitor is designated as a nonpolar or nonpolarized capacitor. Disc, paper, mica, and mylar capacitors fall into this category.

PLATE: The conducting surfaces of a capacitor, upon which charges accumulate and/or are stored.

Name: ____________

Date: ____________

Period: ____________

POLARIZED: Capacitor whose plates have a particular polarity assigned to them. When connecting a polarized capacitor, the + plate must be connected to the positive side of the circuit, while the - plate is connected to the negative side of the circuit.

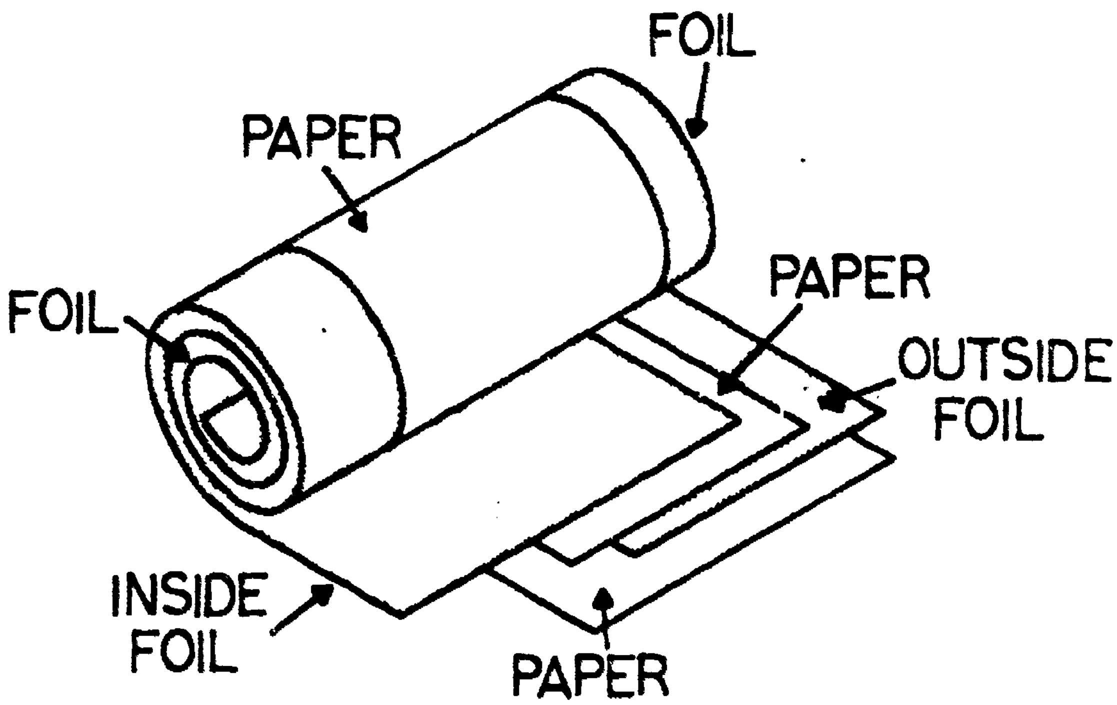
RC TIME CONSTANT: Measurement of the time, in seconds, that it takes for a capacitor to charge to 63.2 percent of the source voltage. This time is a function of the circuit resistance and capacitance, as expressed by the following formula: $T = R \times C$. It requires 5 time constants for a capacitor to be considered fully charge.

REACTANCE: The opposition to AC current flow due to capacitance or inductance.

TEMPERATURE COEFFICIENT: A capacitor rating which designates the change in capacitance due to variations in operating temperature. It is usually expressed as a change in capacitance per degree celsius.

VARIABLE CAPACITOR: A type of capacitor whose capacitance can be varied by some mechanical means. Symbol: Letter symbol: C

WORKING VOLTAGE: Generally designated as WVDC (working voltage direct current), and is a measure of the maximum DC voltage that may be applied continuously to a capacitor without risking breakdown, or permanent damage. To compute WVAC simply multiply .707 time the WVDC rating. Abbrev. WV, WVDC, or VDC.



CAPACITOR

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

VOCABULARY - KNOW YOUR DEFINITIONS

Below you will find short definitions for a number of electrical terms. Your job is to find the term that best fits the definition. If your're imaginative you might refer to your technical glossary.

DEFINITION	TERM
EXAMPLE:	
A. The basic unit for measuring voltage.	A. volt
YOUR TURN:	
1. Two metal plates separated by a dielectric.	1.
2. A measure of an insulators ability to withstand high voltages.	2.
3. Employs an oxide layer as a dielectric.	3.
4. Basic unit of measurement for capacitance.	4.
5. The AC resistance of an inductor or capacitor.	5.
6. The normal DC operating voltage of a capacitor.	6.
7. The metal surfaces of a capacitor upon which charges are stored.	7.
8. A device whose capacitance can be changed by mechanical means.	8.
9. The ability of a device to store a charge and oppose a change in voltage.	9.
10. The voltage at which dielectric damage begins.	10.
11. The general category of capacitors which must be connected into a circuit according to polarity.	11.
12. Must be connected into the circuit observing positive and negative potentials.	12.
13. Time required to charge a capacitor to 63.2% of its full charge.	13.

Name: ____________

Date: ____________

Period: ____________

14. A rating of the change in capacitance due to temperature. 14. [ ]

15. A characteristic of a capacitor which allows it to be connected into a circuit in either direction. 15. [ ]

16. "AC resistance" of a capacitor. 16. [ ]

17. Electrical force which exists between two charged bodies. 17. [ ]

18. Insulating material between the two plates of a capacitor. 18. [ ]

19. Combining of positive and negative charges to produce a net charge of zero. 19. [ ]

20. A more common unit of capacitance equivalent to .000001 farads. 20. [ ]

SCORE:

GRADE:

Name: ____________

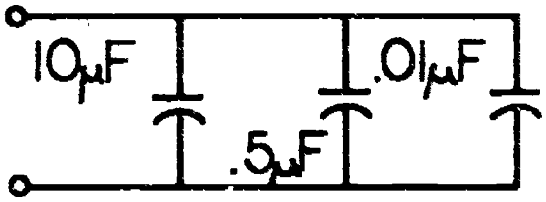
Date: ____________

Period: ____________

WORKSHEET

CAPACITORS AND CAPACITANCE

1. Find the total capacitance in the following circuit. — 1. [ ]

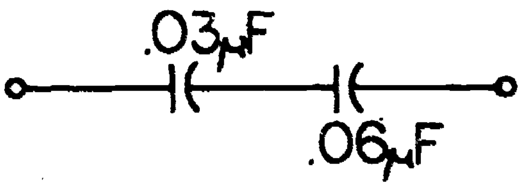


Show work

2. Find the total capacitance when .01µF, .02µF, .05µF, and a .1µF capacitor are connected in parallel. — 2. [ ]

Show work

3. Solve for C_T in the following circuit. — 3. [ ]

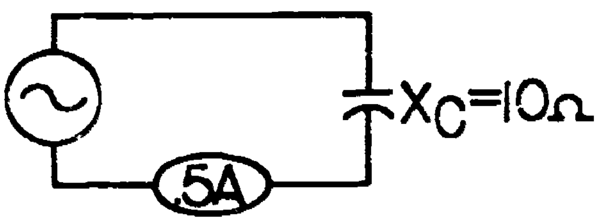


Show work

4. Find the total capacitance when a 24µF, 8µF, and a 12µF capacitor are connected in series. — 4. [ ]

Show work

5. Find E in the following circuit. — 5. [ ]



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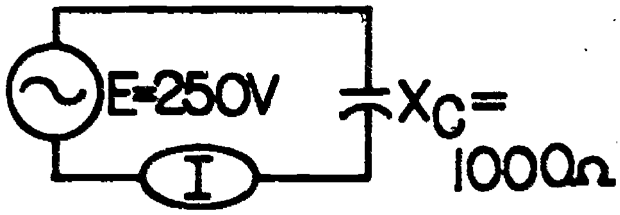
Name: ______________

Date: ______________

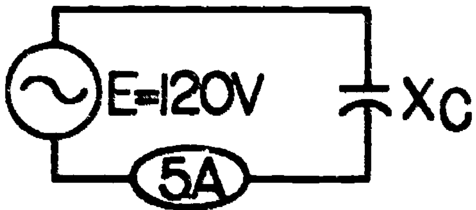
Period: ______________

6. Find the current in the following circuit. 6. [ ]



Show work

7. Find the capacitive reactance in the following circuit. 7. [ ]



Show work

8. Complete the following chart:

A. After 1T, the capacitor is charged to _____% of full charge. 8A. [ ]

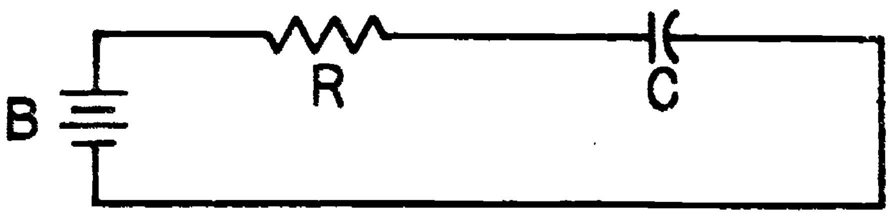
B. After 2T, the capacitor is charged to _____% of full charge. 8B. [ ]

C. After 3T, the capacitor is charged to _____% of full charge. 8C. [ ]

D. After 4T, the capacitor is charged to _____% of full charge. 8D. [ ]

E. After 5T, the capacitor is charged to _____% of full charge. 8E. [ ]

9. Find the capacitive time constants in the following problems: (Remember R in ohms, C in micro farads, then T is in μsec).



A. Find T if R = 1M ohm and C = .05μF. ____________ 9A. [ ]

B. Find T if R = 270 ohms, C = 47μF. ____________ 9B. [ ]

C. Find T if R = 91k ohms, C = .2μF. ____________ 9C. [ ]

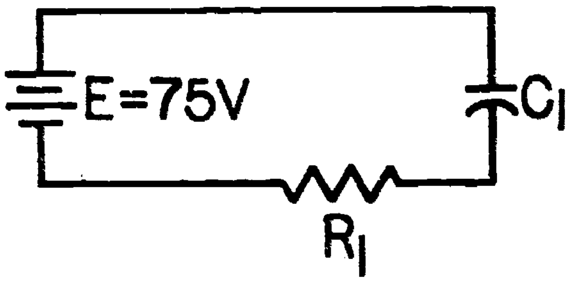
Name: ____________________

Date: ____________________

Period: ____________________

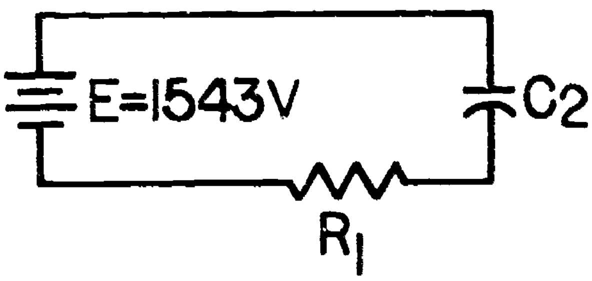
10. Find the state of charge (the charge across the capacitor) for the following capacitors circuits.

A. Find the state of charge across C_1 after 3T. ____________ 10A. [ ]



Show work

B. Find the state of charge across C_2 after 5T. ____________ 10B. [ ]

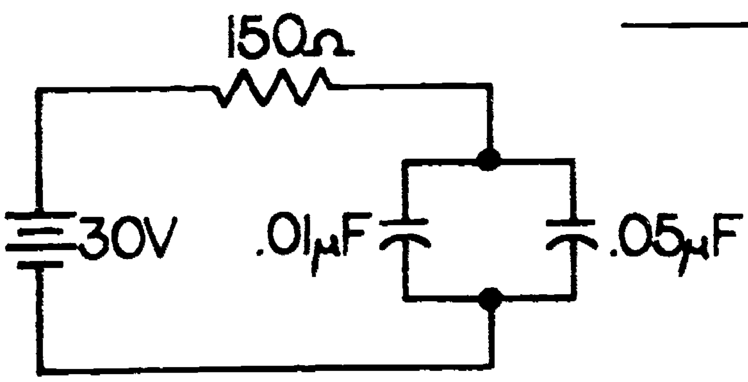


Show work

11. A. Find T; ____________ 11A. [ ]

B. How long will it take in micro seconds, for C to be fully charged? ____________ 11B. [ ]

C. What is the state of charge of C after 4T? ____________ 11C. [ ]



Show work

SCORE:
GRADE:

Name: ______________

Date: ______________

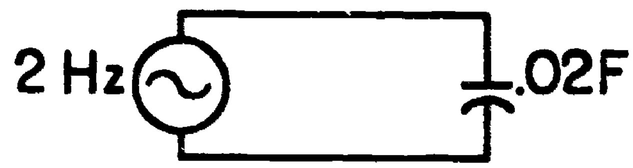
Period: ______________

WORKSHEET

CAPACITIVE REACTANCE

Solve the following problems for the capacitive reactance (X_C) of the circuit. Remember to change frequency and capacitance to their basic unit.

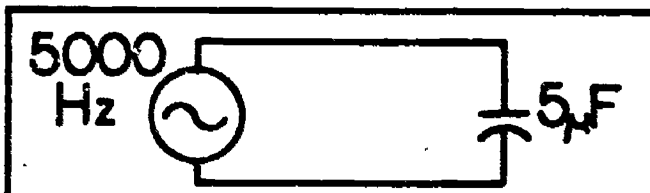
Round all answers to include two decimal places only. Example: 65.78521 = 65.79.

1. 

Find X_C

Show work

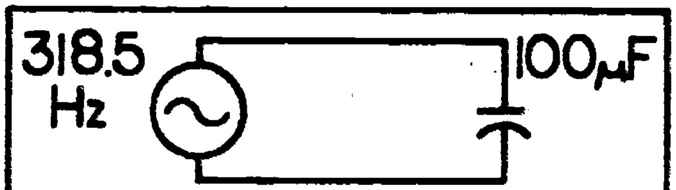
1. [ ]

2. 

Compute X_C

Show work

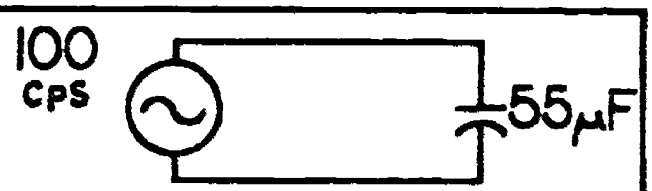
2. [ ]

3. 

Calculate X_C

Show work

3. [ ]

4. 

Find X_C

Show work

4. [ ]

5. A coupling capacitor in a radio transmitter has a capacitance of .0025μF. What is the reactance at a frequency of 980kHz.

5. [ ]

Show work

Name: ______________

Date: ______________

Period: ______________

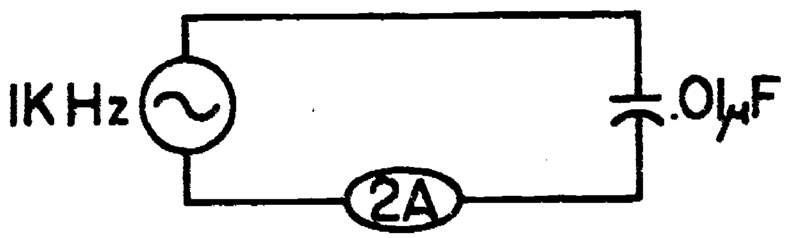
6. What is the reactance of a capacitor of 50pF at a frequency of 565kHz.

6. [ ]

Show work

7. Find the voltage in the following circuit.

7. [ ]



Show work

Hint: Find X_C first

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

QUEST ACTIVITY

"UNIT 11"

1. The basic purpose of all capacitors is to store a __________ and release that charge back into the circuit at the appropriate time. 1. [ ]

2. Air is used as a dielectric in capacitors. True or False? 2. [ ]

3. Electrons pass through the dielectric of a capacitor during the charging process. True or False? 3. [ ]

4. It can be said that a capacitor (4A) ______ AC but (4B) ______ DC. 4A. [ ] 4B. [ ]

5. Since electrons do not pass through the dielectric of a capacitor, it is impossible to have a flow of electrons in a circuit containing a capacitor. True or False? 5. [ ]

6. The basic unit of capacitance is the farad. Usually, it is more convenient to use a smaller unit equal to one-millionths of a farad, called a __________. 6. [ ]

7. An even smaller unit of capacitance equal to one-trillionths of a farad, called a __________. 7. [ ]

8. Convert .00005μF to pF. 8. [ ]

9. Convert 1800pF to μF. 9. [ ]

10. Increasing the plate area of a capacitor increases its capacitance. True or False. 10. [ ]

11. Increasing the space between the plates of a capacitor increases its capacitance. True or False? 11. [ ]

12. The maximum voltage that can be steadily applied to a capacitor is called __________. (Breakdown voltage, or working voltage.) 12. [ ]

13. A capacitor can hold a charge only for a short time. True or False? 13. [ ]

Name: ____________

Date: ____________

Period: ____________

14. Write the formula for finding total capacitance in a series circuit. 14. [ ]

15. Write the equation for finding total capacitance in a parallel circuit containing 3 or more unequal value capacitors. 15. [ ]

16. When capacitors are connected in series, the total capacitance increases. True or False? 16. [ ]

17. What type of dielectric does a tubular paper capacitor use? 17. [ ]

18. Capacitor manufacturers usually stack or roll the plates and dielectric in order to reduce _______. 18. [ ]

19. Mica and ceramic capacitors generally share the property of high stability, but relatively low farad value. True or False? 19. [ ]

20. The dielectric in an electrolytic capacitor consists of an oxide layer formed on the positive plate. True or False? 20. [ ]

21. List three characteristics of electrolytic capacitors that differ from other capacitors. 21A. [ ] 21B. [ ] 21C. [ ]

22. In what two ways may the capacitance of a variable capacitor be changed? 22A. [ ] 22B. [ ]

23. In terms of time constants, how much time is required for a capacitor to charge to 94.9% of full charge? 23. [ ]

24. It requires 6T for a capacitor to just reach a fully charged state. True or False? 24. [ ]

25. If R = 15kΩ and C = .1μF then the time constant must equal ____________ sec. 25. [ ]

Show work

Name: ______________

Date: ______________

Period: ______________

26. If the source voltage in an RC circuit is 50V, what is the "state of charge" of the capacitor after 2T?

26. [ ]

Show work

27. Give the formula for computing the reactance offered by a capacitor in an AC circuit.

27. [ ]

28. What two factors effect the AC resistance of a capacitor?

28A. [ ]

28B. [ ]

29. Find X_C given that the circuit frequency is 10kHz, and the total capacitance is 20 micro farads.

29. [ ]

Show work

30. Explain the phase relationship between voltage and current in a purely capacitive circuit.

30. [ ]

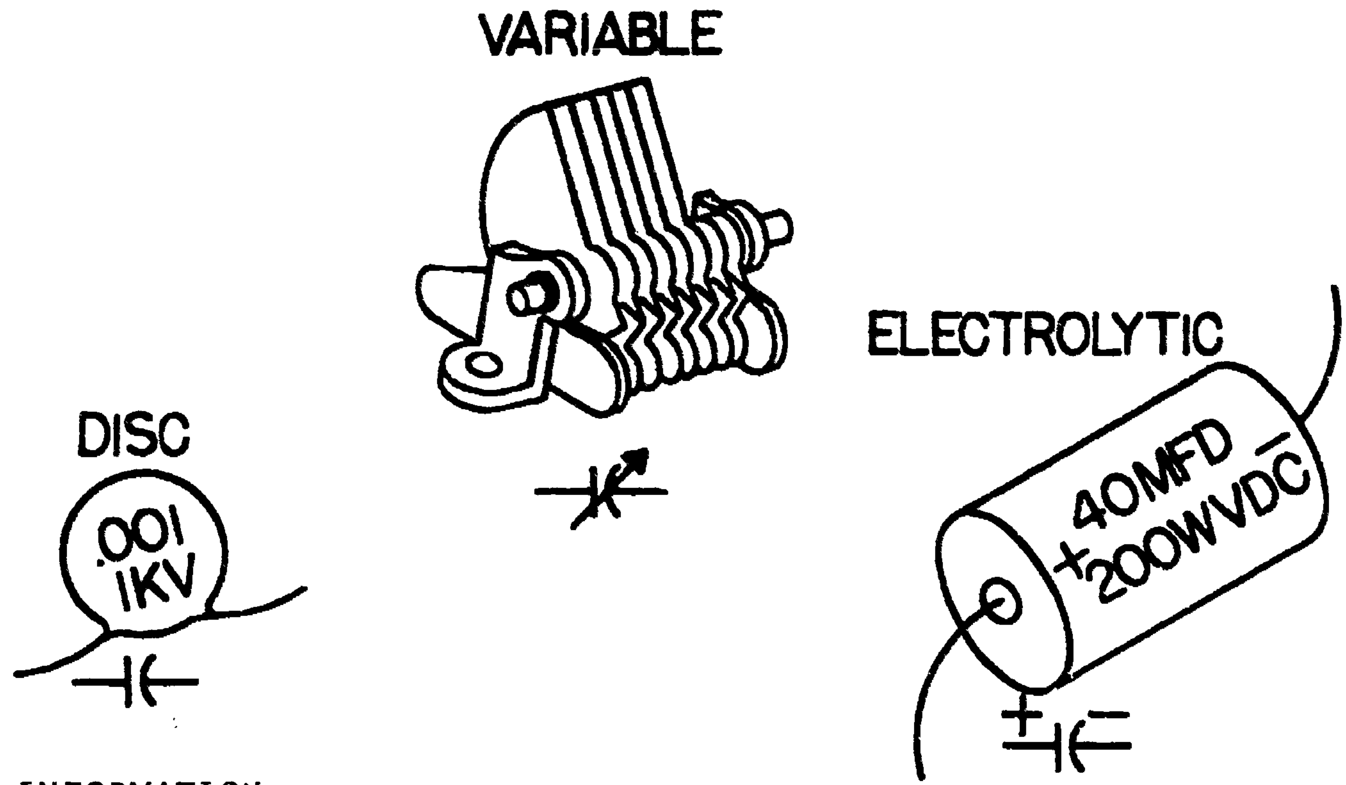
Name: ________________

Date: ________________

Period: ________________

INFORMATIONAL HANDOUT

CAPACITORS - WHAT THEY ARE AND HOW THEY FUNCTION



GENERAL INFORMATION:

In its basic form, the capacitor consists of two conducting areas, such as two metal plates or foil sheets, separate by an insulator, such as air, paper, or plastic. The insulator is called a dielectric. A capacitor has the "capacity" for storing an electrical charge, hence its name. Years ag capacitors were sometimes called condensers and you still might encounter this name in older magazines and books.

Capacitors can serve as filters, and are utilized for DC blocking and AC signal coupling. Combined with coils to form resonant circuits, they are used for tuning to specific signal frequencies. They are available in botl fixed and variable form, with the latter used principally for tuning RF circuits in receivers and transmitters.

Fixed capacitors generally are identified by the type of dielectric used, or their basic shape. Variable capacitors may be designed for varying plate area, or varying distance between the plates, with the latter called trimmer or padder capacitors, and the former (plate area) called a rotary capacitor.

Here are the basic capacitor specifications with which you should be familiar:

TYPE: Refers to the type of dielectric used in the capacitor's construction. Fixed capacitors may be paper, mylar, ceramic, or electrolytic, etc. Occasionally, type also refers to the physical shape of the capacitor. For example, one might refer to a disc (shape) ceramic (dielectric) capacitor. As a general rule, a capacitor's physical shape is not critical from an electrical viewpoint, but may be a factor in circuits where space is at a premium.

Name: ____________

Date: ____________

Period: ____________

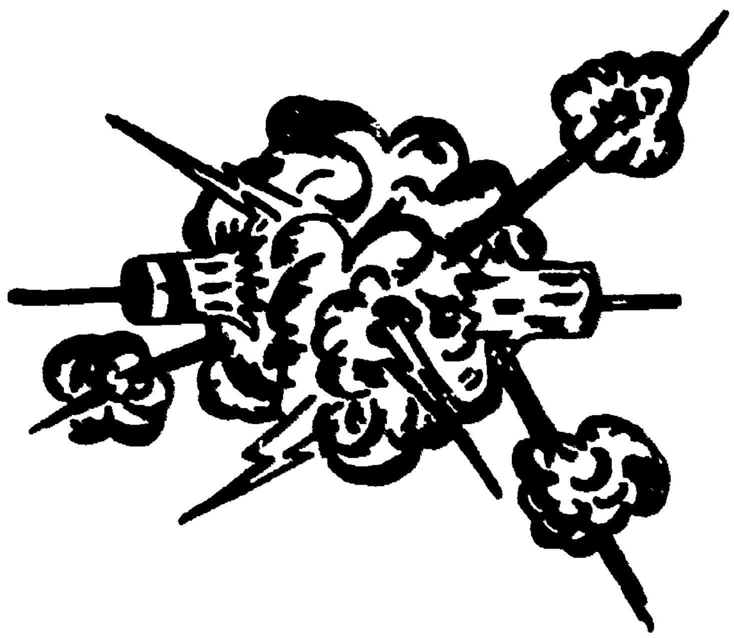
Capacitors utilize two electrical ratings, one the capacity rating in farads and the other a working voltage rating.

CAPACITY: The actual electrical value of the capacitor is specified either in microfarads (Abbreviated as μF, MF, mfd, or MFD) or picofarads (pF, Pf, or pFd). A picofarad is one-millionth of a microfarad and was once designated micromicrofarad (mmf, Mmf, or mmF). You can convert microfarads into picofarads and vice-versa simply by moving the decimal point 6 digits to the left or right, as appropriate. For example, 0.001 μF is the same as 1000 pF. Many times disc capacito[illegible] ive capacity rating as just a number with no indication of unit (μF or p[illegible], generally the rating will be in picofarads.

WORKING VOLTAGE: Indicates the maximum DC operating voltage to which the capacitor may be subjected. A capacitor of higher working voltage can be substituted for one with a lower voltage of the same value (capacity). Thus, a 600-volt mylar capacitor may be used as a direct replacement for a 200-volt unit of the same value.

TOLERANCE: Given as a percentage figure, indicates the possible variation in a capacitor's actual value from its specified nominal value. Most capacitors have a tolerance of 20%. Thus, a 10 μF electrolytic capacitor with a 20% tolerance might have an actual value of from 8 to 12 μF.

LEADS: The principal designations are: axial, which means the leads extend at opposite ends along the length of the device; parallel or PC, which means the leads extend together from one end of the unit.



CAPACITOR SAFETY:

Many capacitors, especially electrolytic capacitors used as filters, retain their charges for many hours after the circuit is turned off. Because a potentially dangerous voltage may exits across the capacitor plates a few simple precautions should be observed:

1. Always treat a capacitor as if it were charge.
2. Never grab a capacitor by the leads, handle by the case only.

Name: ______________

Date: ______________

Period: ______________

3. When working with circuits which contain high voltage capacitors, discharge them immediately before the circuit is handled.
4. When discharging a capacitor use an insulated wire to briefly short the leads of the capacitor together. Handle your shorting wire by the insulation only. To reduce sparking, a 10,000 ohm resistor can be connected in series with the wire, the discharge will take a little longer in this case.
5. In many older style television receivers, the picture tube is used as a giant capacitor, with 20,000 volts or more stored on its plates. Discharge by connecting a shorting wire between the metal chassis and the outer surface of the picture tube. Move the shorting wire to touch several spots on the tube surface.

Capacitors are also prone to another danger, that of exploding. Two conditions will cause a capacitor to explode with dangerous results 1) too high of a voltage applied across the plates, and 2) connecting an electrolytic capacitor into a circuit with reverse polarity. After assembling or repairing a circuit double check to:

1. Be sure electrolytic capacitors are connected correctly into the circuit, with the + terminal connected to the positive side of the circuit and the - terminal to the negative side of the circuit.
2. Compare the circuit voltage with the WVDC rating of the capacitor. It is a good practice to allow a 100% safety margin. That is, if the circuit voltage is 50V the capacitor should have at least 100 WVDC rating.

CAPACITOR TESTING:

There are two basic types of capacitor checks - a condition test, and a value test. The condition tests are used to check the physical condition of the capacitor - shorts, leakage, or opens. The value test is used to determine the electrical - farad - value of the capacitor. An instrument called a capacitor tester or analyzer can perform both condition and value tests, but these instruments are not always readily available.

Your ohmmeter may be used to perform condition tests as outlined below:

1. Testing for shorts using an ohmmeter. A simple continuity test can be used to test for shorts. Isolate the capacitor from the circuit by disconnnecting at least one of the leads. As a precaution, the capacitor should first be discharged to prevent possible damage to the meter, or a dangerous shock to the technician. When testing a nonelectrolytic capacitor an extremely high resistance value should be indicated when the test leads are connected across the capacitor. Procedure: adjust the ohmmeter to a high range position and connect the leads across the terminals of the capacitor. Good nonelectrolytic capacitors will exhibit extremely high resistance or no continuity, if zero ohms, or low resistance is indicated the capacitor is shorted and should be replaced. When testing electrolytic capacitors for shorts you must first learn the polarity assigned to the leads of your ohmmeter, then connect the

Name: ______________

Date: ______________

Period: ______________

meter across the capacitor observing polarity. Electrolytic capacitors will have a measurable, high resistance between their terminals, even if they are in good condition, as a rule of thumb, electrolytic capacitors with a WVDC rating of 100 volts or more usually have a resistance in excess of 300,000 ohms, while capacitors with a WVDC rating of less than 100 volts will have a resistance of from 100,000 to 500,000 ohms. Variable capacitors are checked in a similar manner to nonelectrolytic capacitors, the meter response should be similar. When testing a rotary style capacitor, begin with the plates fully meshed, and slowly unmesh the plates, watching the meter for indications of shorts. In some cases, a shorted condition can be corrected by carefully bending the shorted plates away from each other.

2. Checking for open capacitors. The capacitor tester may be used to perform an open test on a capacitor. If a capacitor checker is not available, the simplist way to accurately check a suspected capacitor is by substitution. Because of the characteristics of open circuits, this can be done simply by connecting a good capacitor in parallel with the existing circuit capacitor. There is no need to remove the suspect capacitor from the circuit, and a simple technique is to use alligator clip leads for "connecting in" the test capacitor. If that eliminates the problem, you know the original should be replaced.
3. Leakage test. This test is reserved almost exclusively for a capacitor checker, although special circuits can be built for checking leakage. If neither of these possibilities are feasible, direct substitution can be used. This will involve removing and replacing a suspect capacitor with a good capacitor of like value.
4. Value test. Used to determine the farad value of the capacitors, and requires the use of a capacitor tester.

USES FOR CAPACITORS:

After all this discussion on capacitors, it might be a good idea to find out what they are used for. The capacitor is an extremely versatile device and can be used to perform a number of different circuit functions. For example:

1. The ability of a capacitor to store a charge at one time, and release that charge at a later time, makes the capacitor useful in the operation of a photostrobe, welding units, and capacitive discharge ignition systems for automobiles.
2. The ability to control the timing of the charging and discharging cycles makes the capacitor applicable for precise timing circuits such as used in oscillators and strobe lights.
3. Capacitors are also used to block the flow of DC current, and couple signals from one circuit to another. This process is used commonly in multistage amplifiers where the coupling capacitor allows the AC signal to flow to the next stage, but blocks the DC current flow into that succeding stage. If the DC current were allowed into the next stage, operating points would change, and distortion would occur.
4. Capacitors are used as filtering elements in DC power supplies to smooth out and flatten the output current and voltage.

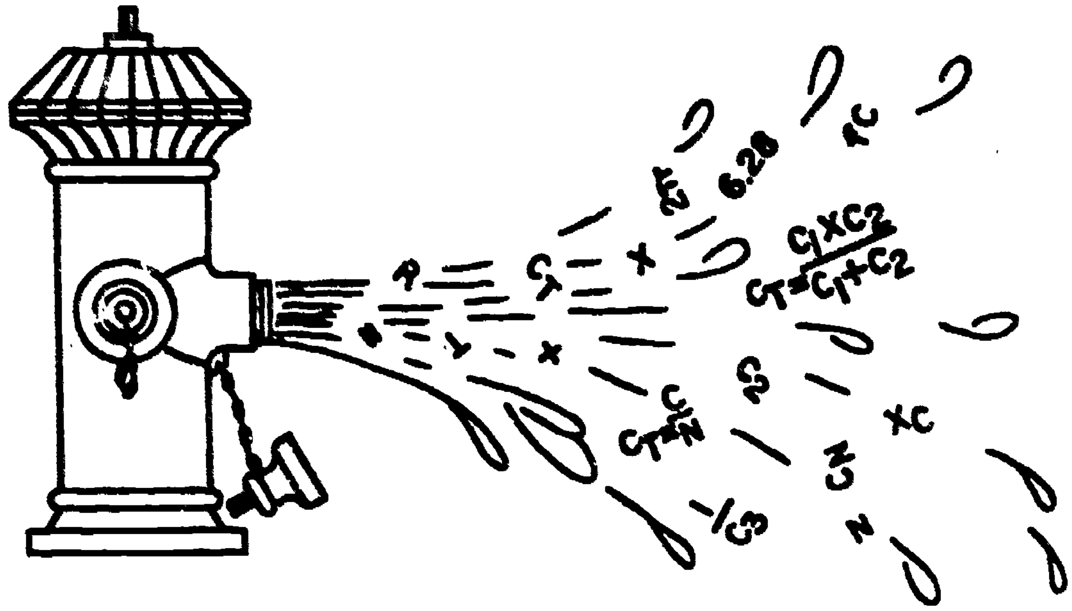
Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

CAPACITANCE FORMULAS



CAPACITORS IN SERIES AND PARALLEL:

SERIES FORMULAS:

When capacitors are connected in series the total effective capacitance decreases, thus C_T will always be lower than the value of the smallest "farad value" capacitor in the series string.

Total Capacitance - (Equal capacitor values)

$$C_T = \frac{C}{N} \quad \frac{\text{capacitance of one capacitor}}{\text{number of capacitors}}$$

- (Two capacitors unequal value)

$$C_T = \frac{C_1 x C_2}{C_1 + C_2}$$

- (General formulas)

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_N}$$

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_N}}$$

Note the similarity of these formulas to the parallel resistance. formulas.

Series connections may be used to increase the effective working voltage of a block of capacitors, or to obtain special values, but, this requires special considerations and/or techniques.

Name: ____________

Date: ____________

Period: ____________

PARALLEL FORMULA:

When capacitors are connected in parallel the total effective capacitance increases, thus C_T will always be larger than the largest "farad value" capacitor.

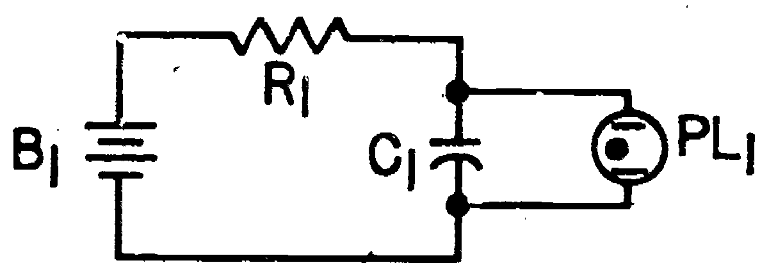
Total Capacitance - $C_T = C_1 + C_2 + C_3 + \cdots + C_N$

Note the similarity of this formula to the series resistance formula.

Parallel connections may be used to obtain special values. Use similar types of capacitors with the same working voltages.

R-C TIME CONSTANTS:

An R-C network contains a resistor connected in series with a capacitor. This basic circuit forms a simple timing or oscillator circuit.



RELAXATION OSCILLATOR

The rate at which the capacitor charges or discharges is dependent upon the capacitance and resistance present in the circuit. The higher the resistance or capacitance, the longer the charge time.

TIME CONSTANT FORMULA:

$T = R \times C$ Where T = time in seconds

R = resistance in ohms

C = capacitance in farads

Recall that one time constant (1T) is the time required to charge the capacitor to 63.2% of full charge. To fully charge a capacitor in an RC network requires 5 time constants. Capacitors charge at the rate listed in the chart below.

Time Constant	Percent of Maximum Voltage
1T	63.2%
2T	86.4%
3T	94.9%

Name: ____________________

Date: ____________________

Period: ____________________

4T 98.1%
5T . . . . 100% Effectively

After each time constant the voltage increases to a value 63.2% closer to its maximum value.

Recall the maximum voltage is equivalent to the source voltage.

CAPACITIVE REACTANCE:

Capacitors block direct current, but permit alternating current to "flow." Capacitors have a unique resistance to the flow of alternating current; this resistance is called capacitive reactance.

FORMULA:

$$X_C = \frac{1}{2\pi \times f \times C}$$

Where X_C = capacitive reactance in ohms

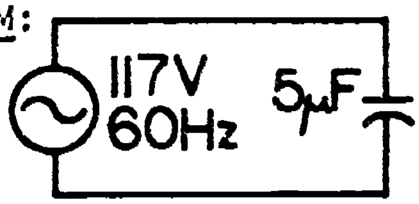
2π = 6.28, a mathematical constant

f = frequency in hertz

C = capacitance in farads

From the formula one can readily see that an increase in either frequency or capacitance will decrease the capacitive reactance.

SAMPLE PROBLEM:



At a frequency of 60Hz what is the capacitive reactance of a 5μF capacitor?

Note 5 mfd equals .000005 farad

Step 1: $X_C = \frac{1}{6.28\ fC}$ This is the formula.

Step 2: $X_C = \frac{1}{6.28 \times 60 \times .000005}$ Here we have substituted actual values for f and C. f in hertz, C in farads.

Step 3: $X_C = \frac{1}{.0018840}$ Here we have multiplied all the figures together.

Name: ______________

Date: ______________

Period: ______________

Step 4: X_C = 530.7 ohms

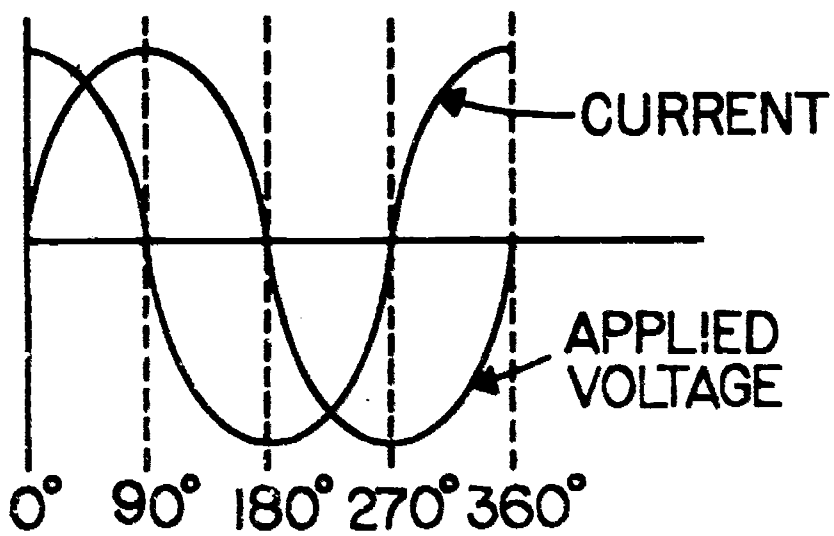
To solve the fraction in Step 3, we divided 1, the figure above the line by the figure .0018840, and adding seven zeroes after the figure 1 to compensate for moving the decimal point seven places to the right in converting the number .0018840 to a whole number.

$$\text{Divide } \frac{1}{.0018840} = \frac{10,000,000}{18,840}$$

PHASE RELATIONSHIP:

Recall that phase relations deal with a comparison between the voltage and current waves in an AC circuit. In an AC resistive circuit you learned that voltage and current are in-phase, that is the voltage wave follows directly the current wave, in a capacitive AC circuit this condition does not occur.

When an AC voltage is applied across a capacitor, maximum current flows in the circuit the instant the source is energized. (Remember what you learned about the charging of a capacitor in a DC circuit) thus, we will find that current will lead the applied voltage by 90°.



SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

ANSWER SHEET

EXAM <u>LIII</u> U11

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*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 11

A. VOCABULARY

1. capacitor
2. dielectric strength
3. electrolytic capacitor
4. farad
5. reactance
6. working voltage
7. plates
8. variable capacitor
9. capacitance
10. breakdown voltage
11. polarized
12. electrolytic capacitor
13. RC time constant
14. temperature coefficient
15. nonpolarized
16. capacitive reactance
17. electrostatic field
18. dielectric
19. discharge
20. micro farad

B. CAPACITORS AND CAPACITANCE

1. 10.51μf
2. .18μf
3. .02μf
4. 4μf
5. 5 V
6. .25 A
7. 24 ohms

8A. 63.2%
8B. 86.4%
8C. 94.9%
8D. 98.1%
8E. 100%
9A. .05 sec
9B. 12690μsec or .0127 sec or 12.69 m sec
9C. .018200 sec or 18200μsec.
10A. 71.175 V
10B. 1543 V
11A. 9μsec
11B. 45μsec
11C. 29.43 V

C. CAPACITIVE REACTANCE

1. 3.98 ohms
2. 6.37 ohms
3. 4.99 ohms or 5 ohms
4. 28.95 ohms
5. 64.99 ohms
6. 5636.66 ohms
7. 31.84 KV or 31847.14 V

D. QUEST ACTIVITY

1. charge
2. true
3. false

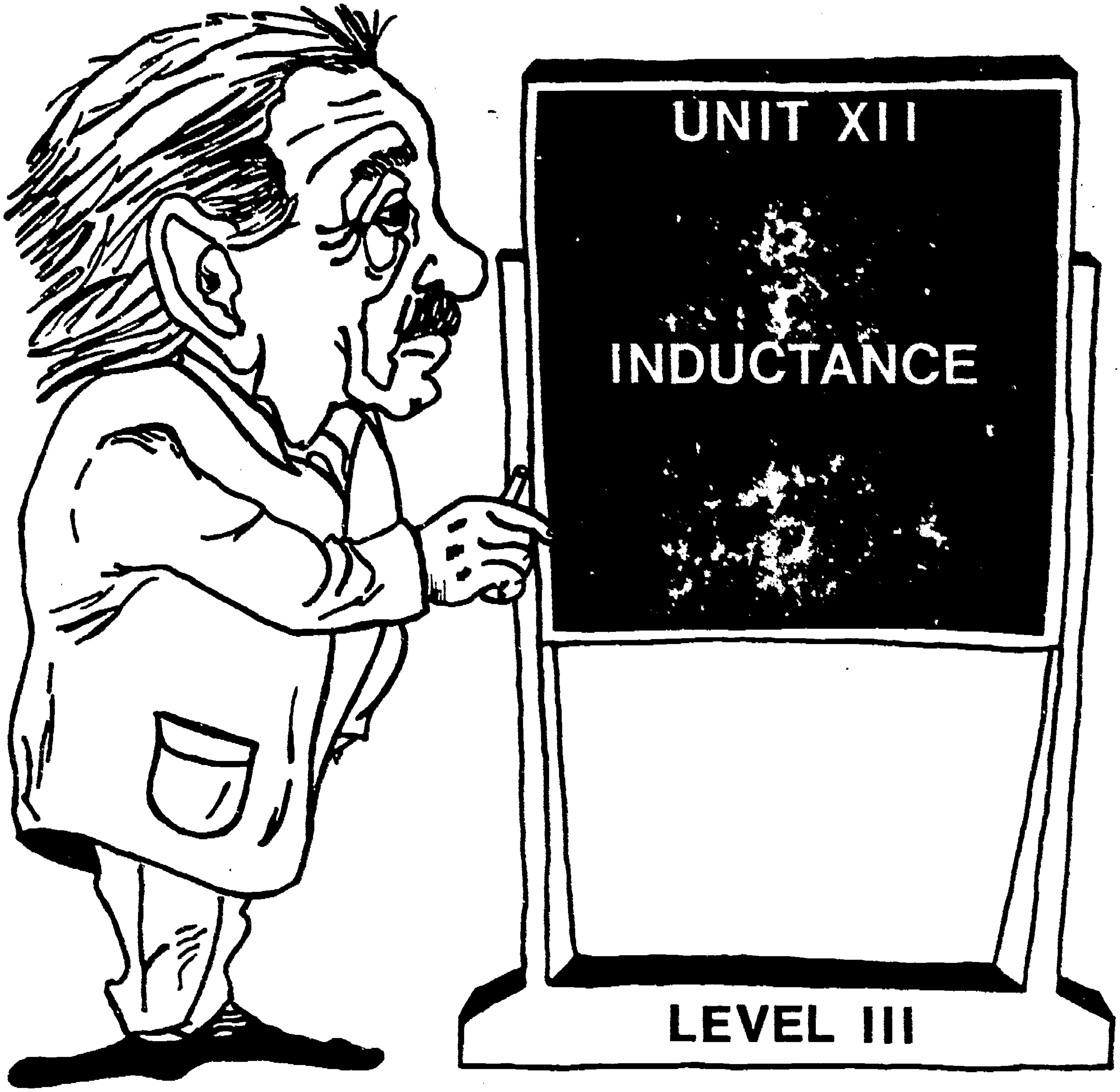
4A. passes
4B. blocks
5. false
6. microfarad
7. picofarad
8. 50 pf
9. .0018μf
10. true
11. false
12. WVDC or VDC or WV
13. false
14. $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots \frac{1}{C_N}$
15. $C_T = C_1 + C_2 + C_3 + \cdots C_N$
16. false
17. paper
18. size
19. true
20. true

21A. polarity
21B. size
21C. value
22A. change plate area
22B. change distance between plates
23. 3 RC times
24. false
25. 1.5 m sec or .0015 sec
26. 43.2 V
27. $C = \frac{1}{2\pi FC}$

28A. frequency
28B. value
29. .796 ohms
30. I leads E by 90° or 

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME____________________

DATE STARTED____________

DATE COMPLETED__________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Inductance

Time Allocation: 3 weeks

Unit Goal:

To communicate and inculcate those competencies which permit a comprehensive evaluation of inductors and transformers in respect to construction, characteristics, and problem solving techniques.

Unit Objectives:

The student will be able to:

1. write the names and abbreviations of the various units of measurements for inductance, and draw the schematic symbols for both fixed and variable inductors.

2. define the terms inductance, self inductance, and mutual inductance.

3. solve for total inductance of inductors either in series or parallel utilizing the proper formula and units of measurement.

4. explain and compute problems involving RL time constants and inductive reactance while employing the values given and solving for the unknown.

5. state the function, construction, and characteristics of transformers, and draw the proper schematic symbol for this component.

6. when given the number of turns in the primary and secondary coils, and either, the voltage or current in the primary and secondary coil, solve for the remaining unknown.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Basic Electricity. Abraham Marcus and William Marcus, Prentice-Hall, Inc., 1974. Chapters: 10 and 11.

Electricity One-Seven. Harry Mileaf, Hayden Book Company, Inc., 1976. Chapters: Electricity 3.

Electronics in Action Book 1. George H. Delpit and Stephen Johnson, Chas. A. Bennett Co., Inc., 1975. Circuits: 17 and 18.

Overview:

Unit 12 is similiar in both technical structure and methodology to the previous unit on capacitance except for the obvious topical difference in subject matter.

The unit should be presented, initially, with a review of magnetism an electromagnetism theory, hopefully this will serve as an adequate curriculum foundation for this inductance unit.

The main thrust of this unit is that inductors, like capacitors, are simple to construct, yet they, too, are important circuit control devices.

Upon this kind of introduction the topics of inductance, units of measurement, reaction to AC/DC, inductor types, ratings, and other pertinent concepts on the effects of inductance can be explored.

The next topics dealing with RL time constants, phase relationship, testing techniques, component applications, and inductors in series or parallel circuits will need a significant amount of unit instructional time for adequate explanation and student comprehension.

Inductive reactance and its relationship to Ohm's Law can be presented rather quickly since the fundamental concepts were given in the prior unit.

This unit terminates with an informative yet practical topic enabling students to grasp the characteristics and applications of transformers. Technically transformers represent an important aspect of inductive device theory and they tie in easily with this unit of instructio

A variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. The secret to the understanding of ideas related to inductance lies with the mastery of basic magnetism principles, explain or review those that are essential to the subject matter of this unit.
2. Remember to point out during a presentation that the formulas for adding inductors in series or in parallel are exactly the same as those for totaling resistors in series or in parallel. Explain that coils may interact depending on physical placement and that this characteristic can necessitate slight formula modification.
3. Once the fundamental concepts have been absorbed by the class, it is appropriate to concentrate on reactance. Impress on the students the similarity between "X_C" and "X_L", and even the concept of impedance may be introduced informally as a quantity which allows the solving for total opposition of any combination of R, X_C, and X_L.
4. A description on transformer operation is generally easily digested by students, however, many students incorrectly believe that transformers produce power. It is advantageous then to stress that power in equals power out and that there really is no gain in total power within a transformer.

Methodology continued:

5. In addition to formal laboratory experiments, certain laboratory exploration can assist the instructor in vividly illustrating procedures for testing inductors and transformers. Have students list the most common defects that they feel might occur with these components, then elaborate on various testing techniques such as; continuity, voltage checks, component performance observation, etc.

Supplemental Activities and Demonstrations:

1. Instructor can demonstrate the principle of inductance by dramatizing the action of a series circuit containing a coil, ammeter, and lamp connected to an AC source. Immediatly exchange a DC sqource for the AC and observe both the ammeter reading and the brightness of the lamp. Discuss various observations with the class and elicit basic inductance principles
2. Illustrate the use of transformers as related to consumer products which are familiar to students, then disunite internally a large transformer while identifying parts and purpose. These kinds of activities will help promote a comprehension of the relative importance of transformers and remove some of the mystic associated with this common electrical device.
3. When defining the term "inductance" one may be at a loss to describe this characteristic in a simple manner. First compare inductance with the property of inertia and then use the analogous situation of pushing a car uphill and then trying to stop it on its downhill flight. Inertia is the property of an object to oppose any change in its direction of motion while inductance opposes any change in current flow.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Word Decoding
5. Worksheet - Inductance and Inductors
6. Worksheet - Transformers
7. Quest Activity
8. Informational Handout (Inductor and Transformer Formulas
9. Informational Handout (Inductors-Transformers-What They Are And How They Function)
10. Unit Module Answer Keys

XII. Inductance

A. What is inductance?

B. Construction of an inductor

C. Units of inductance

D. Factors which determine inductance

E. Inductor action to DC and AC
   1. Self induction

   2. CEMF

F. Types of inductors

G. Inductor replacement

1. Inductor ratings

2. Inductors in series and parallel

3. Inductor testing techniques

H. R-L time constant

I. Voltage and current phase relationships

J. Uses of inductors

K. Inductive reactance

L. Transformers
   1. Construction

a. Mutual induction

b. Action in AC and DC circuits

3. Types

4. Turns ratio

5. Uses

6. Ratings

7. Transformer testing techniques

Test Number ________

LII-U12

UNIT EXAM

INDUCTANCE

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question there is only one correct answer for each question.

1. A voltage is induced in a wire anytime it cuts through a magnetic field, or the magnetic field moves through the wire. (T-F)

2. A transformer consists of two or more coils wound around a common core. (T-F)

3. The inductance of a coil is effected by the amount of current flowing through it. (T-F)

4. Total inductance increases when inductors are connected in parallel. (T-F)

5. An inductor opposes a change in current flow. (T-F)

6. A CEMF and a self-induced voltage are one and the same. (T-F)

7. The counter-electromotive force produced in an inductor opposes the applied current. (T-F)

8. If the motion of the magnetic field were reversed, the CEMF produced in the inductor would also reverse polarity. (T-F)

9. A transformer will not produce an output in a circuit utilizing pure DC current. (T-F)

10. Mutual inductance is the magnetic effect which explains the operation of a conductor. (T-F)

11. The inductive time constant is a measure of how rapidly an inductor allows current to rise to its steady value. (T-F)

12. The opposition to AC current provided by a transformer is called inductive reactance. (T-F)

13. If the primary winding of a transformer contains more turns of wire than the secondary winding, the transformer will act as a step-up transformer. (T-F)

14. Inductive reactance increases as frequency increases. (T-F)

15. The input and output voltages of a transformer are in-phase. (T-F)

16. Power transformers may contain more than one secondary winding. (T-F)

17. Iron-core inductors are often called chokes. (T-F)

18. The winding of a transformer which provides the output is called the second winding. (T-F)

19. The letter symbol for an inductor is I. (T-F)

20. The maximum power that the secondary winding of a step-up transformer can deliver to its load is always slightly less than, or equal to the power in the primary winding. (T-F)

21. Inductance is the property of an electric circuit that opposes a change in:
(A) current, (B) applied voltage, (C) induced voltage, (D) magnetic field.

22. The basic unit for inductance is the:
(A) ohm, (B) reactance, (C) farad, (D) henry.

23. The thin sheets of metal used to make up the core of an iron-core inductor or transformer are called:
(A) pieces, (B) laminations, (C) strips, (D) sheets.

24. The basic unit of inductive reactance is the:
(A) hertz, (B) ohm, (C) volt, (D) watt.

25. When the current through an inductor starts to change, the applied current is prevented from instantly reaching its final value by the:
(A) counter emf, (B) resistance of the coil, (C) eddy currents, (D) applied emf of the circuit.

26. Energy is stored in the magnetic field around an inductor. When the current flow decreases, the collapsing magnetic field:
(A) returns energy to the circuit, (B) takes energy from the circuit, (C) increases the flux, (D) does not induce a voltage.

27. In a transformer, energy is transfered from the primary to the secondary winding by means of a:
(A) core, (B) magnet, (C) winding, (D) magnetic field.

28. A transformer that has more turns in the secondary than in the primary
(A) steps-up voltage, (B) steps-up current, (C) steps-down voltage, (D) steps-up power.

29. Transformers are rated in which of the following ways?
(A) Turns ratio, (B) input voltage verse output voltage, (C) input impedance verse output impedance, (D) all of the above.

30. A transformer consisting of one continuous winding with several taps for taking off different voltages is called:
(A) an isolation transformer, (B) a power transformer, (C) a current transformer, (D) an autotransformer.

31. Since a transformer operates because of a magnetic linkage between its windings, the device is said to possess the property of mutual:
(A) operation, (B) inductance, (C) magnetism, (D) links.

32. A transformer that has a turns ratio of 1:1 is used for:
(A) impedance matching, (B) changing frequency, (C) isolation, (D) stepping-up voltage.

33. The transformer turns ratio is the ratio of:
(A) secondary voltage to secondary current, (B) primary windings to secondary voltage, (C) secondary windings to primary windings, (D) primary current to secondary current.

34. Iron core transformers have the operating characteristic that the power in the secondary is equal to:
(A) $E_p \times I_s$, (B) $E_s \times I_s$, (C) $E_p \times I_p$, (D) both B and C.

35. When two coils, one 5 henrys and the other 3 henrys, are connected in series and are so far apart that they cannot influence each other, the total inductance will be:
(A) 2 henrys, (B) 15/8 henrys, (C) 8 henrys (D) 8/15 henrys.

36. The opposition of an inductor to current flow (X_L):
(A) depends on the magnitude of the applied voltage, (B) varies directly with frequency, (C) varies inversely with frequency, (D) depends only on the resistance of the coil.

37. The inductive reactance of a 4-henry coil at 100Hz is:
(A) 400 ohms, (B) 628 ohms, (C) 2,512 ohms, (D) 5,024.

38. When two inductors are connected in parallel: one a 30mh choke and the other a 60mh choke, the total inductance will be:
(A) 90 mh, (B) 30mh, (C) 180mh, (D) 20mh.

39. A transformer used on a 120-volt line has a primary with 60 turns and provides 720 volts output. The secondary winding should have:
(A) 240 turns, (B) 10 turns, (C) 360 turns, (D) 720 turns.

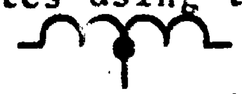
40. If a 1:4 step-up ideal transformer has a primary voltage of 100 volts, the secondary voltage is:
(A) 25 volts, (B) 400 volts, (C) 60 volts, (D) 141 volts.

Name: ______________

Date: ______________

Period: ______________

TECHNICAL GLOSSARY

AUTOTRANSFORMER: A type of transformer utilizing only one tapped coil of wire. It operates using the principle of self inductance. Symbol:  Letter symbol: T

CENTER-TAPPED: A type of transformer or inductor which has an additional lead connected to the center of the secondary coil. A center-tapped transformer provides the option of a second output voltage between the center-tapped lead and one of the secondary leads.

CHOKE: Another expression for indicating an inductor. A choke is used to oppose or "choke off" the flow of alternating current.

CORE: The magnetic path within an inductor or transformer. Usually a core forms the center of a coil or transformer, supporting wire turns and concentrating magnetic flux lines. Two basic core designations are air core or iron core.

COUNTER ELECTROMOTIVE FORCE: A voltage produced in a wire by self-induction. This induced voltage opposes, or has the opposite polarity, of the applied circuit voltage. This phenomenon is common in inductors and transformers, sometimes called "back EMF". Abbrev CEMF

EDDY CURRENTS: Circular currents induced in the core of generators or transformers caused by a varying magnetic field. These currents do not serve a useful purpose, but rather represent a loss.

FLUX LINES: Lines of force produced by a magnetic field.

HENRY: The basic unit of inductance. The henry is a relatively large unit, thus the more common inductance units are the millihenry and microhenry. Letter symbol: H

HYSTERESIS: A "loss" in an iron-core device due to remaining (residual) magnetism in the iron-core after each cycle. This residual force must be removed before the core material can be remagnetized in the reverse direction.

INDUCTANCE: The property of an electric circuit which opposses a change in current flow. This opposition to current change is produced by an expanding or collapsing magnetic field within a coil or wire. Inductance is measured in the basic unit henrys.

Name: ____________________

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INDUCTIVE REACTANCE: The AC resistance offered by an inductor. Inductive reactance is computed by the following formula: $X_L = 2\pi fL$. Abbreviation X_L and its basic unit of measurement is the ohm.

INDUCTOR: A coil of wire wrapped around an air or iron core. Symbol:  Letter symbol: L

LAMINATIONS: Thin layers or sheets of iron stacked together to form the core for iron-core transformers or inductors. Cores are made with laminations to reduce eddy currents.

LENZ'S LAW: A law which states that the induced EMF in any circuit is always in such a direction as to oppose the force which "generated" that EMF.

MUTUAL INDUCTION: The transfer of energy from one coil to an adjacent coil by means of a varying magnetic field. Transformers operate on this principle; so that, as the magnetic field in the primary winding expands and collapses, a voltage is induced in the secondary winding.

PERMEABILITY: A measure of the ease with which a material will conduct magnetic line of force.

PRIMARY WINDING: The winding of a transformer which receives the <u>input</u> energy. Abbrev. P

RL TIME CONSTANT: The time required for an inductor to allow 63.2% of maximum current to flow when a DC voltage is applied. Formula: $T = \frac{L}{R}$

SATURATION: In the iron core of an inductor or transformer, saturation describes the condition when the maximum number of flux lines possible are established in the core.

SECONDARY WINDING: That winding of a transformer whose energy is produced by electromagnetic induction from the primary winding. The secondary winding provides the output of the transformer, and many transformers are designed with more than one secondary winding.

SELF INDUCTANCE: The process by which a varying current (causing a varying magnetic field), induces a voltage in the adjacent conductor or coil of an inductor.

SLUG: A powdered iron core, in an inductor, which can be moved to vary inductance.

STEP-DOWN: A type of transformer that has fewer windings in the secondary than in the primary, hence a decrease in voltage from primary to secondary.

Name: ____________

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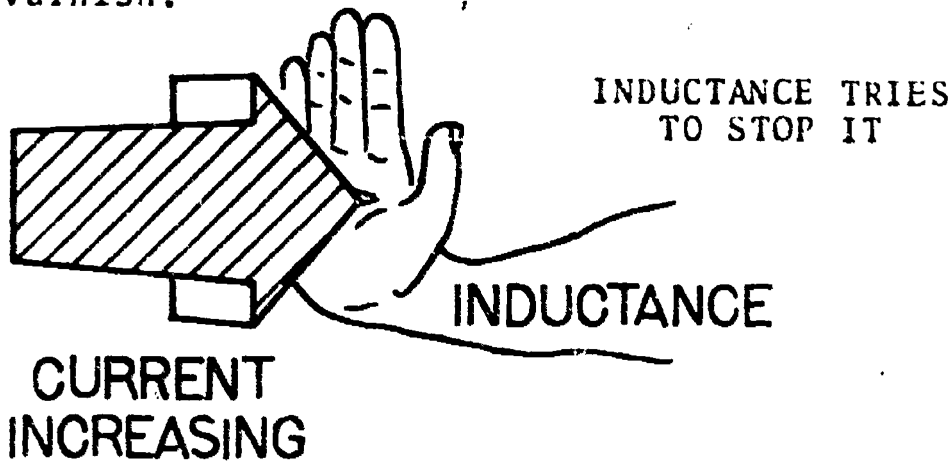
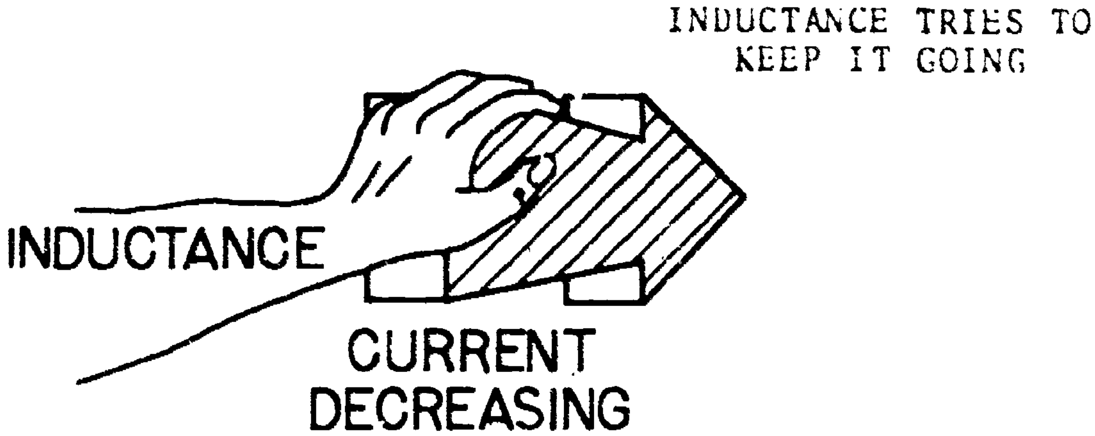
STEP-UP: A type of transformer that has more windings in the secondary than in the primary, thus allowing an increase in voltage from primary to secondary.

TRANSFORMER: A device consisting of two or more coils wound around a common core. Energy is transferred from one coil (primary winding) to another coil (secondary winding) by means of mutual induction. A transformer is used to step up or step-down AC voltage or current. Symbol:
Letter symbol: T

TURNS RATIO: The ratio of the number of turns in the secondary of a transformer to the number of turns in the primary.

WINDING: A turn (one revolution) of insulated wire, wrapped aroun an air or iron core. The insulating material on inductor or transformer windings is generally enamel or varnish.





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WORKSHEET

VOCABULARY WORD DECODING

The words below have little meaning until they are decoded. Each letter actually represents another letter in the alphabet. Your task is to break the code and decode each word. The example will get you started by providing four decoded letters. The code remains the same through out the worksheet.

EXAMPLE: A. C H J M

Z E R O

A. ZERO

1. L M J H

_ _ _ _

1. ______

2. L Z M V H

_ _ _ _ _

2. ______

3. Z H U J I

_ _ _ _ _

3. ______

4. B S U Q S U T

_ _ _ _ _ _ _

4. ______

5. S U Q R L A P U L H

_ _ _ _ _ _ _ _ _ _

5. ______

6. F P X S U P A S M U D

_ _ _ _ _ _ _ _ _ _ _

6. ______

7. D P A R J P A S M U

_ _ _ _ _ _ _ _ _ _

7. ______

8. G H J X H P N S F S A I

_ _ _ _ _ _ _ _ _ _ _ _

8. ______

9. W F R E F S U H D

_ _ _ _ _ _ _ _ _

9. ______

10. X R A R P F S U Q R L A S M U

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _

10. ______

SCORE:

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Name: ______________

Date: ______________

Period: ______________

WORKSHEET

INDUCTANCE AND INDUCTORS

1. Inductance is the property of an electric circuit, or device, which opposes a change in circuit __________. 1. [ ]

2. An inductor utilizes an expanding and collapsing __________ __________ to provide inductance. 2. [ ]

3. The basic unit of measurement for inductance is the __________. 3. [ ]

4. Other common sub-units of inductance are the (A) __________ and (B) __________. 4A. [ ] 4B. [ ]

5. Basically, an inductor consists of a coil of insulated wire wrapped around an air or iron __________. 5. [ ]

6. If the number of turns of wire are increased, the inductance of the inductor will __________. 6. [ ]

7. The letter symbol for an inductor is __________. 7. [ ]

8. Draw the schematic symbol for an air core inductor. 8. [ ]

9. As __________ is passed through a conductor, a magnetic field appears about the conductor forming a circular field. 9. [ ]

10. As the magnetic field expands around a conductor, a voltage is developed in that conductor by a process called __________ - __________. 10. [ ]

11. As the current flow through an inductor increases a voltage is developed within the coil which opposes the applied voltage. This induced voltage is called the __________. 11. [ ]

12. A CEMF is produced in an inductor only when the applied voltage is increasing or decreasing. (True - False) 12. [ ]

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13. In order for an inductor to operate functionally in a DC circuit, the DC voltage must ________ or pulsate. 13. [ ]

14. The formula $L_T = \frac{L_1 x L_2}{L_1 + L_2}$ is used to find the total inductance of two inductors connected in ________. 14. [ ]

15. To obtain the greatest total inductance, two inductors should be connected in ________. 15. [ ]

16. The R-L time constant indicates the time required for the inductor to allow 63.2% of maximum ________ to flow in the circuit. 16. [ ]

17. When the applied AC voltage across an inductor is maximum, the current flow will be ________. 17. [ ]

18. In a purely inductive circuit, the (A) ________ leads the (B) ________ by 90°. 18A. [ ] 18B. [ ]

19. The opposition to current flow developed by an inductor in an AC circuit is called ________ ________. 19. [ ]

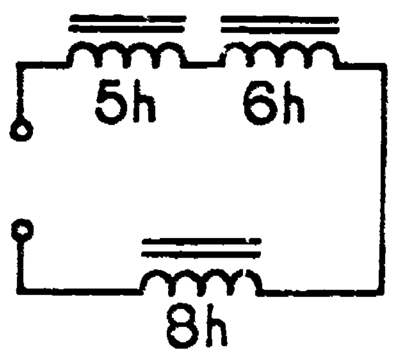
20. Inductors offer the greatest opposition to current flow in an ________ (AC or DC) circuit. 20. [ ]

21. The letter symbol for inductive reactance is ________ 21. [ ]

22. Inductive reactance is measured in the basic unit ________. 22. [ ]

23. What is the formula for finding the AC resistance of an inductor? 23. [ ]

24. What is the total inductance of the following circuit? 24. [ ]



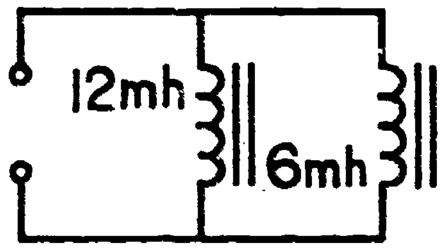
Show work

Name: ______________

Date: ______________

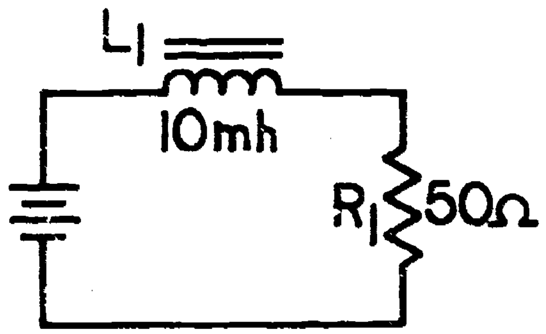
Period: ______________

25. What is the total inductance in the following parallel circuit? 25. [ ]



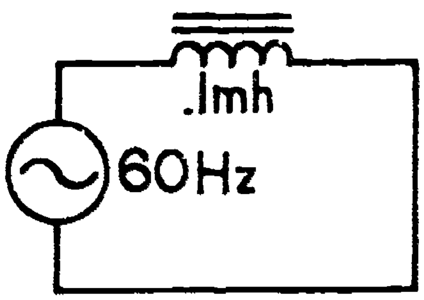
Show work

26. Compute the inductive time constant utilizing the following circuit values. 26. [ ]



Show work

27. Find X_L if the AC frequency is 60Hz and the circuit inductance is .1mh. 27. [ ]



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Date: ______________

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WORKSHEET

TRANSFORMERS

1. A transformer consists of at least __________ coils of wire wrapped around an air or iron core. 1. [ ]

2. The letter symbol for a transformer is __________. 2. [ ]

3. Iron core transformers use a __________ core to reduce eddy current losses. 3. [ ]

4. Draw the symbol for an iron core transformer. 4. [ ]

5. The wire used in winding transformers and inductors uses __________ as an insulating material to prevent shorting of the coils. 5. [ ]

6. The input winding of a transformer, which is usually connected to the source, is called the __________ winding. 6. [ ]

7. The output winding of the transformer which is usually connected to a load, is called the __________ winding. 7. [ ]

8. If the coils of a transformer are wound on a hollow cardboard or plastic form, the device is known as an __________ __________ transformer. 8. [ ]

9. A transformer utilizes a process known as __________ induction to transfer energy from one winding to another. 9. [ ]

10. As in the inductor, an expanding and __________ magnetic field allows for the operation of the transformer. 10. [ ]

11. If a steady DC voltage were applied to the primary winding, would you expect a sustained output at the secondary? 11. [ ]

12. A transformer has the ability to increase or decrease circuit (A) __________ or (B) __________. 12A. [ ] 12B. [ ]

13. If a transformer reduces the input voltage, it is called a __________ transformer. 13. [ ]

3๖๐

Name: ____________

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14. A step-up transformer will increase the input voltage, but at the same time will __________ the available current. 14. [ ]

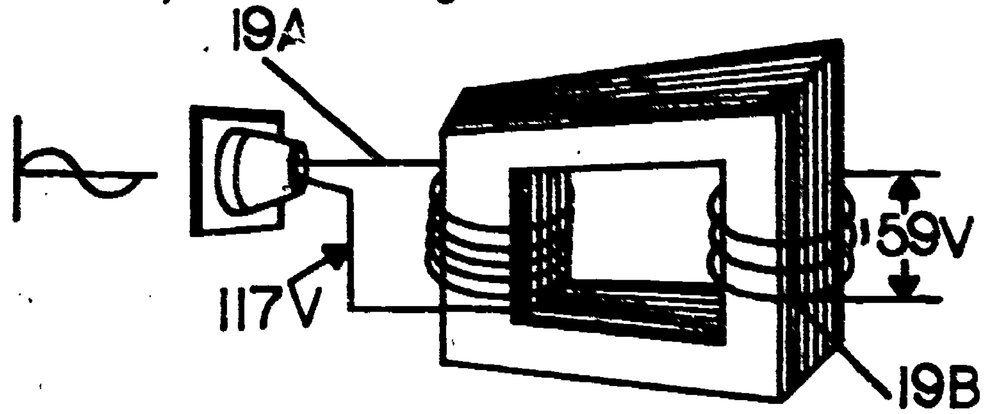
15. How does the input power and output power of a transformer compare? 15. [ ]

16. If the primary winding contains more turns of wire than the secondary winding, the the transformers will __________ voltage. 16. [ ]

17. The number of turns in the secondary of the transformer compared to the number of turns in the primary is described as the __________ __________. 17. [ ]

18. What is the phase relationship between the input and output voltage? 18. [ ]

19. Identify the windings in the transformer below: 19A. [ ] 19B. [ ]



20. Would the above transformer be classified as a step-up or step-down transformer? 20. [ ]

21. Observe the input wave applied to the transformer above. Draw a sketch of the output wave. 21. [ ]

22. Give the turns ratio formula which equates turns to voltage. 22. [ ]

23. If a transformer has a 4 to 1 turns ratio, it is classified as a __________ (step-up or step-down) transformer. 23. [ ]

24. A transformer has a 200 turn primary, and a 40 turn secondary, what is the turns ratio? 24. [ ]

25. If a transformer operates with a 10 volt input, has a 500 turn primary and 1000 turn secondary, then the secondary voltage is __________. 25. [ ]

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GRADE:	

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 12"

1. Explain how an inductor reacts in a DC circuit?

2. How does an inductor react in an AC circuit?

3. Inductors oppose a change in __________ through the actions of an expanding or collapsing magnetic field.

4. List the common units for measuring inductance.

5. In a purely inductive AC circuit, what is the phase relationship between voltage and current?

6. List the basic formula for finding total inductance in a series circuit, and in a parallel circuit.

7. What is inductive reactance?

8. What is the formula for inductive reactance?

9. Define an inductive time constant.

10. Find the total inductance in the following problems:
(Draw the circuit out; then solve the problem)

    A. Four inductors in series· 1mh, 8mh, 15mh, and 9mh.

Name: ______________

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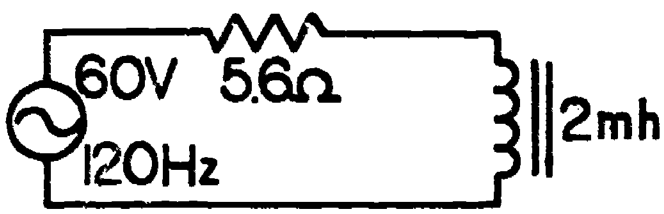
B. Two inductors in parallel: 18h, and 36h.

C. Two inductors in series: 6mh and 1h.

D. Three inductors in parallel: 8mh, 32mh, and 4mh.

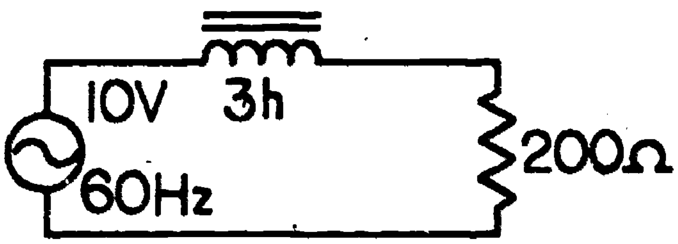
11. Find X_L in the following problems:

A.



X_L = ______________

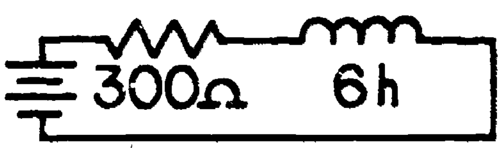
B.



X_L = ______________

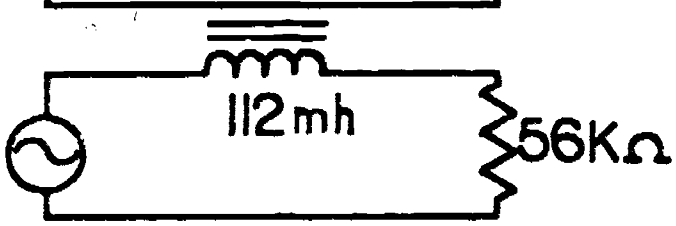
12. Find the time constant in the following problems:

A.



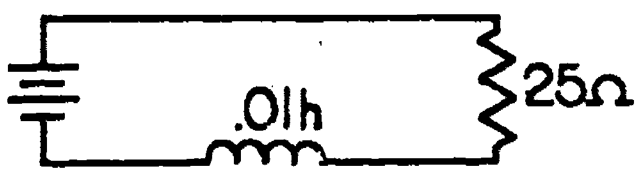
t = ______________

B.



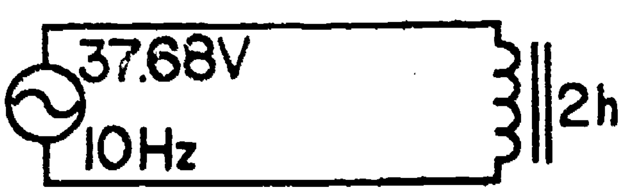
t = ______________

C.



t = ______________

13. Find the current flow in the following problem.



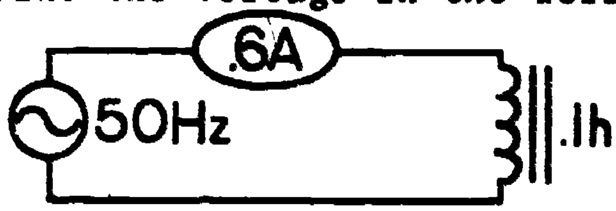
I = ______________

Name: ______________________

Date: ______________________

Period: ______________________

14. Find the voltage in the following circuit.



E = ______________________

15. Can a transformer produce an output in a DC circuit? If so, when?

16. Does a transformer react to an AC input? Explain;

17. List the common ways of rating transformers.

18. What is the phase relationship between the input voltage and the output voltage of a transformer?

19. Explain the difference in purpose between the primary and secondary winding of a transformer.

20. Define the concept of mutual induction.

21. How does the power applied to the primary of the transformer compare to the power available at the secondary of the transformer?

22. List the power formula for transformers.

23. What is the difference between a step-up and a step-down transformer in reference to voltage?

Name: ____________

Date: ____________

Period: ____________

24. List the turns ratio formula for number of turns vs voltage.

25. If the primary winding of a transformer has 120 volts at .5 amps applied, and the secondary has a current flow of 1.5 amps what is the secondary voltage?

26. Solve the following transformer problems utilizing the proper formulas.

A. E_p equals 50V; E_S equals 150V; I_S equals .250A; find I_p.

B. N_p equals 1k; N_S equals 1.4k; E_p equals 117V; find E_S.

C. N_S equals 500; N_p equals 150; I_p equals 3A; find I_S.

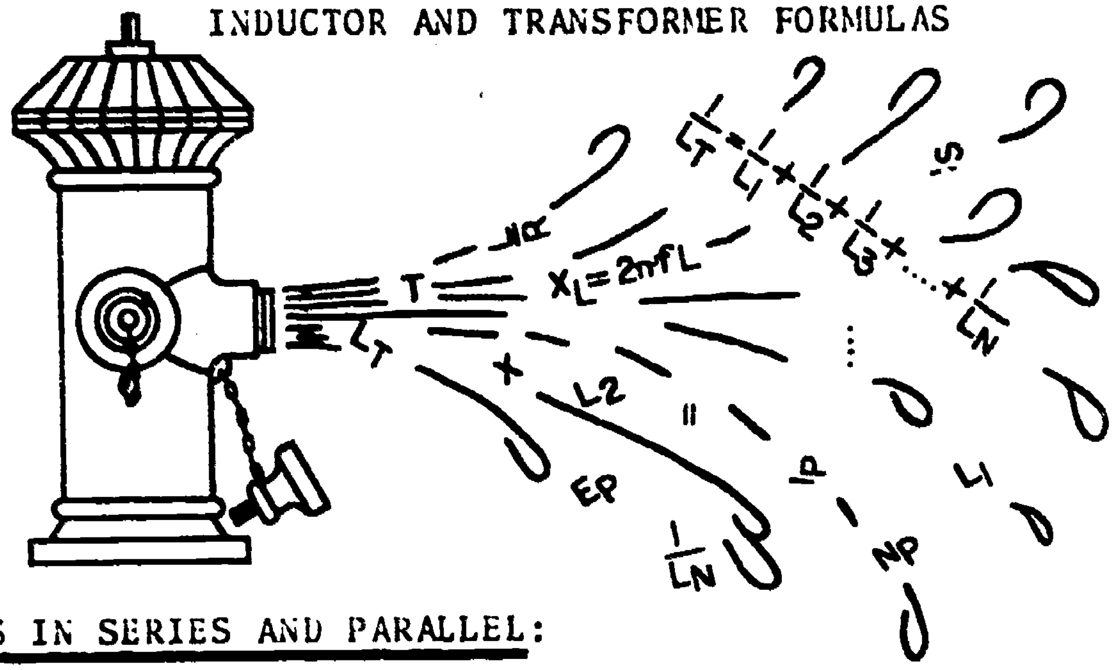
Name: ________________

Date: ________________

Period: ________________

INFORMATIONAL HANDOUT

INDUCTOR AND TRANSFORMER FORMULAS



INDUCTORS IN SERIES AND PARALLEL:

SERIES FORMULAS:

When inductors are connected in series the total effective inductance increases, thus L_T will always be larger than the largest "henry value" inductor in the series string.

Total Inductance $L_T = L_1 + L_2 + L_3 + \ldots + L_N$

Note the similarity of this formula to the series resistance formula.

PARALLEL FORMULAS:

Connecting inductors in parallel will decrease the total effective inductance, thus L_T will always be less than the value of the smallest "henry value" inductor.

Total Inductance - (Equal inductor values) $L_T = \frac{L}{N}$ $\frac{\text{inductance of one inductor}}{\text{number of inductors}}$

- (Two inductors unequal value) $L_T = \frac{L_1 x L_2}{L_1 + L_2}$

- (General formulas) $\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots + \frac{1}{L_N}$

$$L_T = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots + \frac{1}{L_N}}$$

Note the similarity of these formulas to the parallel resistance formulas.

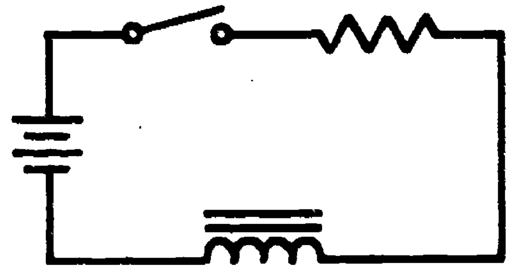
Name: ______________

Date: ______________

Period: ______________

R-L TIME CONSTANT:

An R-L network contains a resistor and an inductor connected in series with a DC source. This circuit will cause the current to change gradually between zero and maximum when the circuit is energized, and to fall gradually from maximum to zero when the circuit is switched off.



The rate at which the inductor allows current to flow through the circuit depends upon the inductance and resistance present in the circuit. The higher the inductance, or the lower the resistance, the slower the change in current flow.

TIME CONSTANT FORMULA:

$$T = \frac{L}{R}$$

Where T = time in seconds

L = inductance in henrys

R = resistance in ohms

One time constant (1T) is the time required to allow 63.2% of maximum current to flow through the circuit.

INDUCTIVE REACTANCE:

Inductors act as a simple resistance in a DC circuit, once current flow has stabilized, but in an AC circuit, the inductor poses a peculiar opposition to the flow of AC current. This opposition to AC current is called inductive reactance and is dependent upon frequency and inductance.

FORMULA:

$$X_L = 2\pi f \times L$$

Where X_L = inductive reactance in ohms

2π = 6.28, a mathematical constant

f = frequency in hertz

L = inductance in henrys

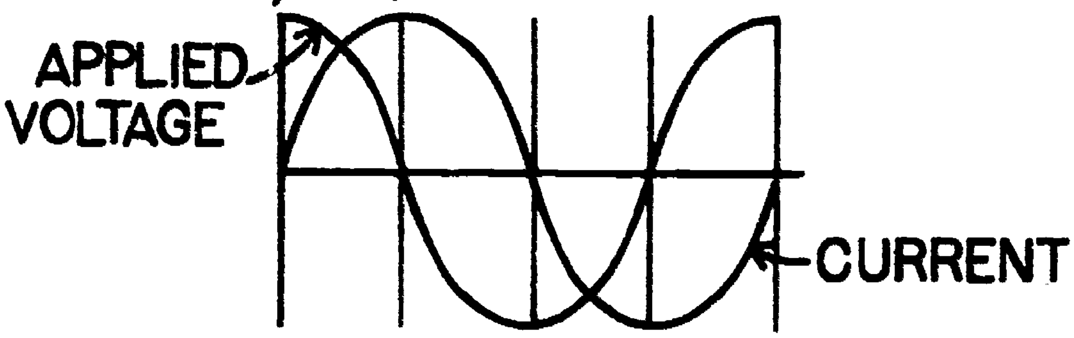
Name: ______________

Date: ______________

Period: ______________

INDUCTIVE PHASE RELATIONSHIPS:

In a purely inductive AC circuit the applied voltage leads the current by 90°.



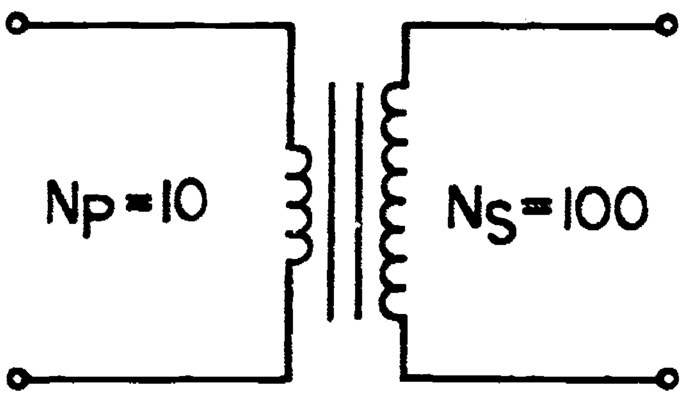
TRANSFORMER TURNS RATIO FORMULAS:

A transformer utilizes the principle of mutual induction to transfer energy from the primary to the secondary winding of the transformer. This transfer of energy is dependent upon the number of turns of wire in the primary and secondary coils. This relationship between primary and secondary turns is called the "turns ratio", and can be used to describe turns vs voltage vs current relationships.

TURNS RATIO FORMULA:

Turns ratio is a comparison of the number of turns in the secondary to the number of turns in the primary.

$$\text{Turns ratio} = \frac{N_s}{N_p} \text{ or } N_s : N_p$$



Where N_s = number of turns in secondary

N_p = number of turns in primary

The turns ratio for the above transformer then, is $\frac{N_s}{N_p} = \frac{100}{10} = \frac{10}{1}$ or 10:1. This information says that for an input of say 20V in the primary, then we would expect a secondary output of 200 volts.

Name: ____________

Date: ____________

Period: ____________

VOLTAGE RATIO:

Assuming a transformer has unity coupling, such as a power transformer, the following formula holds true.

$$\frac{E_s}{E_p} = \frac{N_s}{N_p}$$

Where E_s = secondary voltage

E_p = primary voltage

N_s = number of turns in secondary

N_p = number of turns in primary

Knowing any three terms, you can solve for the unknown fourth term.

CURRENT RATIO:

In a like manner primary and secondary currents and turn ratio can be equated or compared as follows:

$$\frac{I_p}{I_s} = \frac{N_s}{N_p}$$

Again, knowing any three terms will allow you to solve for the remaining term.

TRANSFORMER POWER RELATIONSHIP:

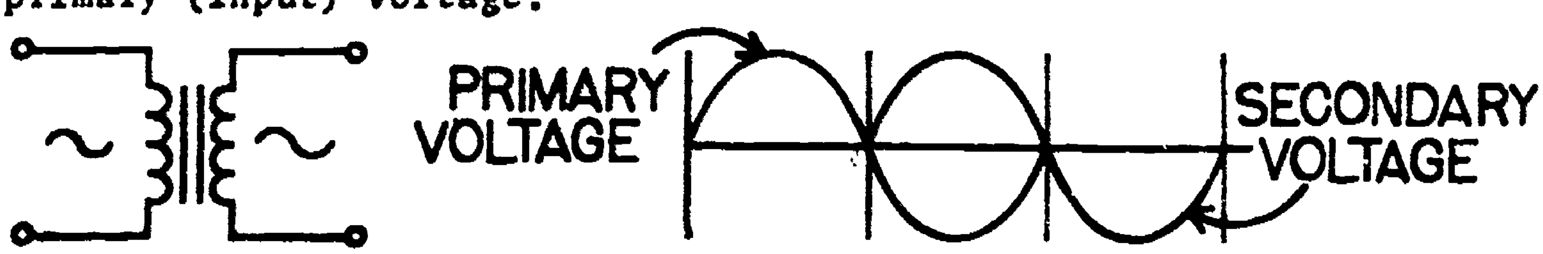
Recall, electrical power can be found by multiplying E times I. In a transformer, energy in the form of a varying voltage and current enters or is applied to, the primary winding, forming a pulsating magnetic field which transfers energy to the secondary by mutual induction. You will find that the power input and the power output in a transformer has a direct relationship. In fact, the input power equals the output power.

Thus. $I_p \times E_p = I_s \times E_s$

TRANSFORMER PHASE RELATIONSHIPS:

Primary versus secondary voltage interaction.

The induced voltage in the secondary is 180° out of phase with the primary (input) voltage.



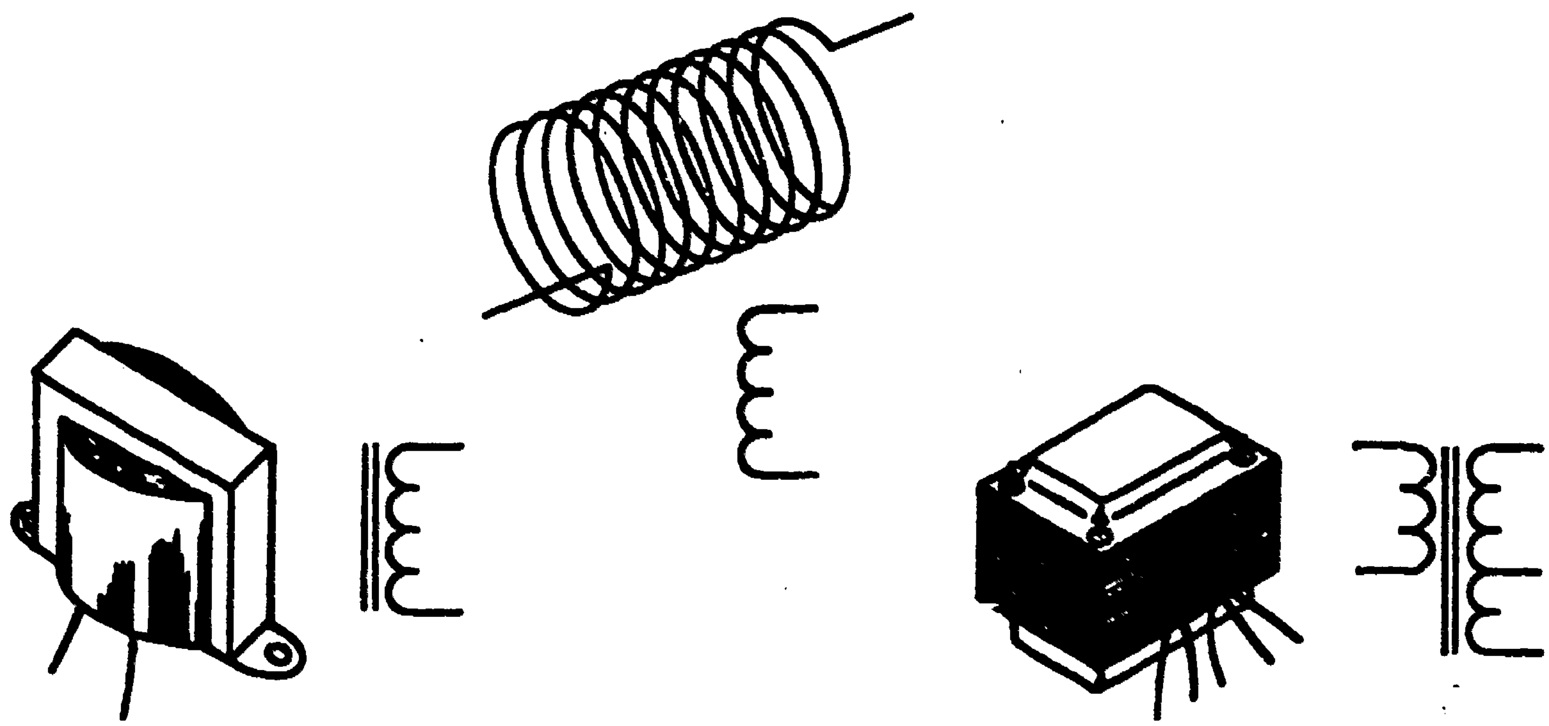
Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

INDUCTORS/TRANSFORMERS - WHAT THEY ARE AND HOW THEY FUNCTION



INDUCTORS

GENERAL INFORMATION:

In its basic form, the inductor is a coil that has an inductance value that is determined by a number of specific factors. The most essential of these are:

- The number of turns in the coil.
- The total length of the coil.
- The cross-sectional area of the coil/core.
- The permeability of the core material.

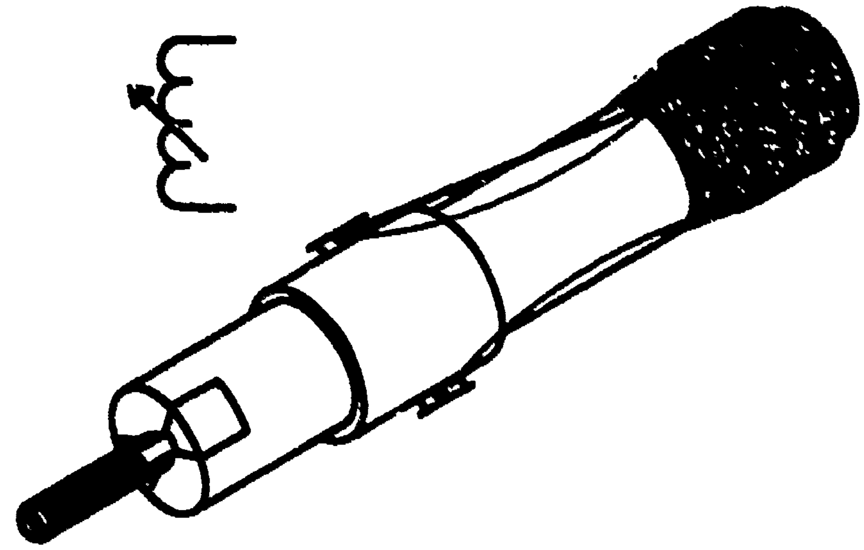
There are formulas for calculating the inductance of various types of coils, and utilizing these formulas, one can design a coil to have any desired value. Inductors are generally either iron-core or air-core and sometimes are referred to as "chokes" or "reactors".

Inductors are available in both fixed and variable form, with the latter used principally in high-frequency circuits only. The position of the core within a variable inductor can be adjusted by threading the core, using an adjustment tool, and positioning it such that the required inductance is set.

Name: ______________

Date: ______________

Period: ______________



Rating: Iron-core inductors are rated in terms of INDUCTANCE, RESISTANCE, AND CURRENT CAPACITY.

Radio-frequency chokes are rated in terms of INDUCTANCE, QUALITY FACTOR, AND OPERATING FREQUENCY.

Quality factor "Q" is a measure of a coil's quality and this refers to the ratio of its inductive reactance to its DC resistance at a specific frequency.

$$Q = \frac{X_L}{R}$$

Capacity: The basic electrical value of an inductor is the henry, however, you may encounter millihenries (mh) or microhenries (μh) as the designated rating on a given component. You can convert millihenries into henries and vice-versa simply by moving the decimal point 3 digits to the left or right as appropriate. For example, .007h is the same as 7mh. Note, many times the value is not printed directly on the inductor or coil and the system of identification is sometimes difficult at best! Good Luck.

USES FOR INDUCTORS:

After all this discussion on inductors, it might be a good idea to find out what they are used for. The inductor is a versatile device and can be used to perform a number of different circuit functions. Inductors are generally utilized in a wide array of tuning and filter circuits, lets look at some circuit usage.

- Iron-core inductors are used in circuits where the frequencies are in the audio range (20-20khz).
- Air-core and ferrite-core inductors used in circuits above 20 kilohertz.
- Generally, high frequency inductors are used with capacitors to form tuned (resonant) circuits which allow you to select or reject signals.

Name: ____________

Date: ____________

Period: ____________

TRANSFORMERS

GENERAL INFORMATION:

In its basic form, the transformer consists of two coils electrically insulated from each other, yet generally wound upon the same core and interacting magnetically. Magnetic coupling is used to transfer electrical energy from one coil to another. The coil that is connected to an AC source of energy is called the PRIMARY WINDING, and the coil to which energy is transferred is called the SECONDARY WINDING. Remember that in some transformers there may be more than one secondary winding. Sometimes the secondary winding also contains a special connection at a given point to provide a different output, this is referred to as a tap. Now, when you have on a schematic, the reference "CT," immediately think .... center-tapped connection, which means divide the output voltage in half.

Type: Transformers can be usually classified as either power or audio variety. Note, sometimes the abbreviation "XMFR" is used to indicate the term transformer.

POWER XMFR = a device which can obtain different (step-up or step-down) voltages from a typical AC power line.

AUDIO XMFR = a device which allows coupling of signals from one stage to another.

At this point you should be aware of two other types of special transformers that you may encounter in typical electronic work. Look at these!!!!!

AUTOTRANSFORMER = a device like a power transformer, however it consist of a single winding that is tapped to provide the necessary step-up or step-down function.

ISOLATION XMFR = a device not generally concerned with the step-up or step-down function, but instead serves as a safety device by isolating the ground conductor of the power line from a chassis.

Note! Power transformer cases (frame) are made of metal and can add considerably to the overall weight of the device and should be considered when designing parts layout.

Rating: Power XMFR - specification given are generally the primary's operating voltage and/or frequency, and the secondary's output voltage and maximum current. Transformer leads are sometimes color coded or the specifications are located on the XMFR case, but this is not consistently done so if necessary refer to an appropriate reference. A typical rating might read as follows: PRI., 120V, 60Hz; Sec., 300V CT at 50MA; 6.3V CT at 3A.

Name: ____________

Date: ____________

Period: ____________

Audio XMFR - specifications given are generally the primary and secondary impedance. Don't forget that most electronic stores sell this kind of transformer with the schematic diagram code attached either on a piece of paper or on the box itself so do not discard it before checking placement. A typical rating might read as follows: Primary impedance (Z) 100K , Secondary impedance (Z) 2.5K .

TRANSFORMER SAFETY:

Power transformers can be very D A N G E R O U S!!! Especially since they often have one high voltage winding. This device can present a severe shock hazard so extreme care must be observed when testing for voltages or working in the power supply stage of a piece of equipment. Remember ..... "a misplaced finger can result in a real tingler"!!!

TRANSFORMER TESTING:

Transformers can suffer from the same problems or defects that occur in many electronic components so you can apply all previous "troubleshooting" experience when working with transformers or, for that matter, inductors.

When checking transformers, be on the look out for:

- Shorts between windings
- Excessive current flow
- Grounded windings (shorts between the windings and the core or frame)
- Internal shorts between turns

Kinds of tests: Generally a continuity check is able to determine an open winding which may exist within the transformer, however, continuity between windings indicate a shorted condition. CAUTION!! When taking continuity measurement power is turned off.

Many technicians like to run a performance test on transformers; which means apply a known voltage to the primary winding and observe the secondary voltage for the proper reading.

USES FOR TRANSFORMERS:

The principal application of this component can be simply stated, a device that utilizes mutual inductance to transfer electrical energy (AC) from one circuit to another. Its application then must be based on this specific ability and the needs of a circuit. Hence you will find that this component is widely used in power supplies, amplifiers, power distribution systems, consumer products, etc.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

ANSWER SHEET

EXAM LIII U12

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.	■				26.	■				51.					76.				
2.	■				27.				■	52.					77.				
3.		■			28.	■				53.					78.				
4.		■			29.				■	54.					79.				
5.	■				30.				■	55.					80.				
6.	■				31.		■			56.					81.				
7.	■				32.			■		57.					82.				
8.	■				33.			■		58.					83.				
9.	■				34.				■	59.					84.				
10.		■			35.			■		60.					85.				
11.	■				36.		■			61.					86.				
12.	■				37.			■		62.					87.				
13.		■			38.				■	63.					88.				
14.	■				39.			■		64.					89.				
15.		■			40.		■			65.					90.				
16.	■				41.					66.					91.				
17.	■				42.					67.					92.				
18.		■			43.					68.					93.				
19.		■			44.					69.					94.				
20.	■				45.					70.					95.				
21.	■				46.					71.					96.				
22.				■	47.					72.					97.				
23.		■			48.					73.					98.				
24.		■			49.					74.					99.				
25.	■				50.					75.					100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 12

A. VOCABULARY WORD DECODING

1. core
2. choke
3. henry
4. winding
5. inductance
6. laminations
7. saturation
8. permeability
9. flux lines
10. mutual induction

B. INDUCTANCE AND INDUCTORS

1. current
2. magnetic field
3. henry
4. millihenry,microhenry
5. core
6. increase
7. L
8. 
9. current
10. self induction
11. CEMF
12. true
13. vary
14. parallel
15. series
16. current
17. minimum
18A. voltage
18B. current
19. inductive reactance
20. AC
21. X_L
22. ohm
23. $X_L = 2\pi f L$
24. 19 h
25. 4 mh
26. .2 m sec.
27. .03768 ohm

C. TRANSFORMERS

1. two
2. T
3. laminated
4. (Symbol)
5. enamel or varnish
6. primary
7. secondary
8. air core
9. mutual
10. collapsing
11. No
12A. voltage
12B. current
13. step down
14. decrease
15. equal
16. step down
17. turns ratio
18. 180°
19A. primary
19B. secondary
20. step down
21.
22. $\frac{E_S}{E_P} = \frac{N_S}{N_P}$
23. step up
24. 1:5
25. 20 V

D. QUEST ACTIVITY

1. Acts as straight wire simpl resistance.
2. Offers varying resistance t the circuit depending upon the frequency and amount of inductance.
3. current
4. h, mh, μh
5. voltage leads current by 90
6. series $L_T = L_1 + L_2 + L_3 + \cdots L_N$
   parallel $\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots \frac{1}{L_N}$
7. The AC resistance offered by an inductor
8. $X_L = 2\pi FL$
9. The time required for an inductor to allow 63.2% of it total circuit current to flo
10A. 33 mh
10B. 12 h
10C. 1.006 h
10D. 2.46 mh
11A. 1.51 ohm
11B. 1130.4 ohms
12A. .02 sec.
12B. .000002 sec.
12C. .4 m sec.
13. .3 A
14. 18.84 V
15. Yes, when current starts or stops.
16. Yes, it steps up or steps down the input voltage.
17. E rating, Impedance, Turns Ratio.

18. 180° out of phase
19. input on the primary windings
output from the secondary.
20. energy transfer from the primary to the secondary windings by magnetic field
21. equal or less from the secondary
22. $I_p \times E_p = I_s \times E_s$
23. step up — secondary voltage is greater than the primary
step down — secondary voltage is less than the primary
24. $\frac{E_s}{E_p} = \frac{N_s}{N_p}$
25. 40 V
26A. $I_p \times E_p = I_s \times E_s$

$$I_p = \frac{I_s \times E_s}{E_p} \qquad \frac{.250 \times 150}{50} = .75\ A$$

26B. $\frac{E_s}{E_p} = \frac{N_s}{N_p}$

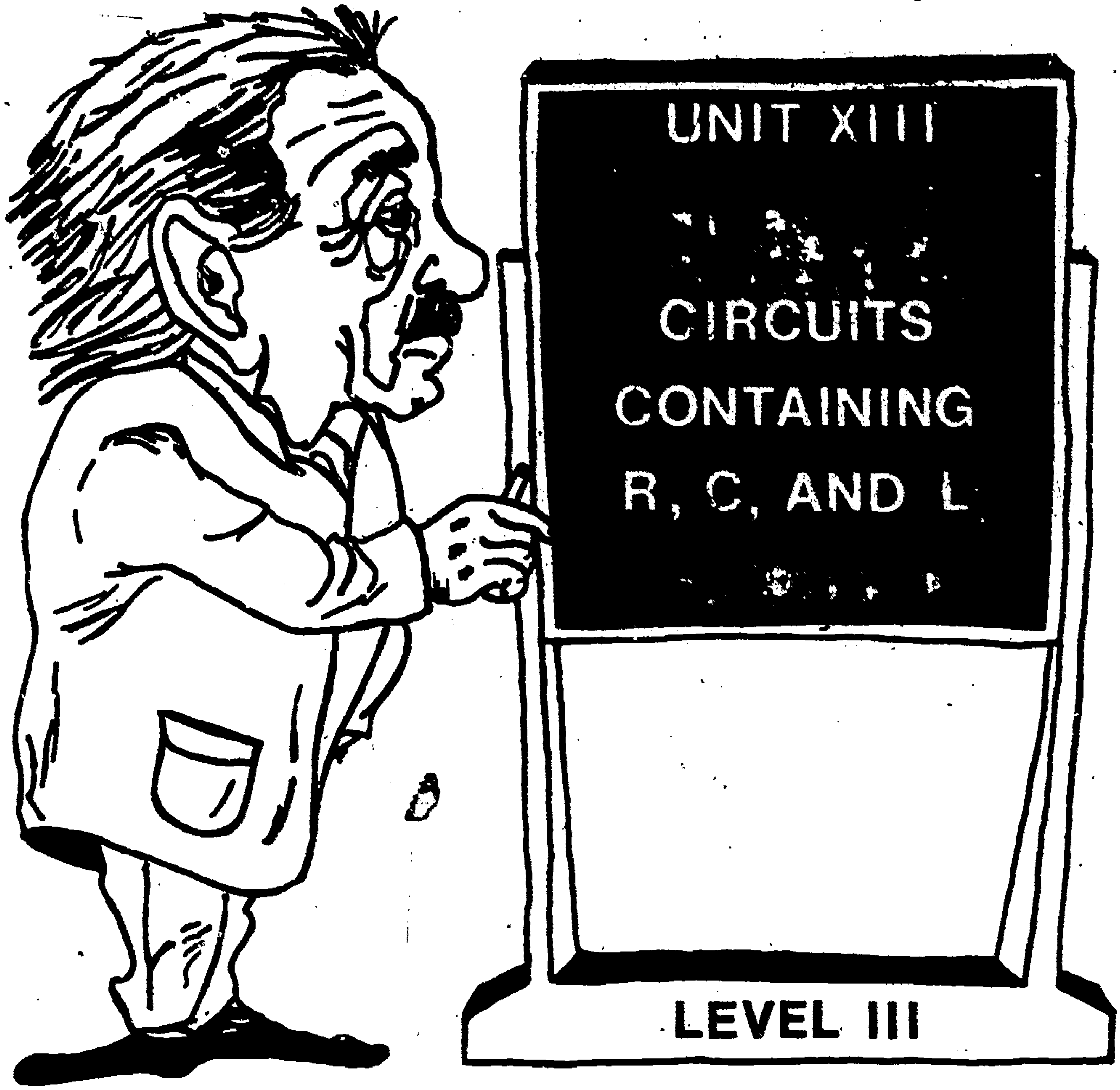
$$E_s = \frac{E_s \times N_s}{N_p} \qquad \frac{117 \times 1.4 \times 10^3}{1 \times 10^3} = 163.8\ V$$

26C. $\frac{I_p}{I_s} = \frac{N_s}{N_p}$

$$I_s = \frac{N_p \times I_p}{N_s} \qquad \frac{150 \times 3}{500} = .9\ A$$

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME____________________

DATE STARTED____________

DATE COMPLETED__________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Circuits Containing R, C, and L

Time Allocation: 2 weeks

Unit Goal:

To broaden and impart enlarged student competence in terms of AC circuits which contain resistors, capacitors, and inductors, thus, enabling impedance and resonance circuit evaluation, and promoting the ability to design circuits for specific situations.

Unit Objectives:

The student will be able to:

1. define the term impedance, indicate its letter symbol, and state the basic unit of measurement.
2. calculate the total impedance of series and/or parallel resistor, capacitor, and inductor circuits utilizing the proper formulas and solving for the unknown.
3. explain electrical resonance and list the essential characteristics of series and parallel resonant circuits.
4. identify several practical applications of tuned circuits, and draw the schematic diagram of at least four basic types of filters.
5. state the formula for the resonant frequency of any RCL circuit.
6. select either a series or parallel resonant circuit from a group of circuit diagrams as specifically requested.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Basic Electronics. Samuel E. Gender and Abraham Marcus, Prentice Hall Inc., 1971. Chapter 7.

Electronic and Electrical Fundamentals Volume II. Published by C.T.I. Education Products, Inc., 1974. Chapters 6 and 7.

Individual Learning Program In AC Electronics. Heathkit Continuing Education, Heath Company, 1976. Unit 6.

Overview:

This unit, because of its complex technical nature and the depth of subject matter, can be presented, modified, or omitted as desired by the instructor in order to facilitate individual program needs.

The unit should be introduced with a review on the characteristics of both capacitive and inductive circuits. This kind of review is more conducive for a smooth transition into the special phenomenon topics of impedance and resonance.

Be aware that the instructor, at this level, is only presenting a shallow overview of concepts in reference to RCL or combination circuits. For example, the student should feel that one characteristic of an RCL circuit is that it can be made to respond to a single given frequency (resonance), yet this type of general concept can be lost if the instructor and students drown in the guagmire of formulas, technical conditions and mathematics which can be associated with these topics in a penetrating analysis.

Series and/or parallel RCL circuit topics, again, should be informative in terms of fundamental properties like impedance and resonant characteristics, yet extensive examination is not recommended.

This unit should conclude with a reemphasis on the applications of tuned circuits, expecially their role in regards to circuitry which provides oscillation, amplification, signal separation, and the elimination of interference and noise. The final thought generated should be that resonant circuits, filters, and tuned circuits are interacting devices or concepts that provide a vital phase of electronic theory without which many commonly used everyday items could not exist.

A variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. Be sure when reviewing, to stress that in a RCL circuit the various reactances and resistance values cannot be just added in order to determine total circuit impedance. If this is emphasized properly the student will never be confused during problem solving sessions.
2. Some instructors either omit or gloss over a very effective teaching technique called vector analysis. This system can minimize the need for cumbersome mathematical computations and is a natural for classroom use especially in Units 11, 12, and 13.
3. In addition to formal lecture topics, spend a moment describing the concept of stray capacitance and inductance. Although stray quantities are usually low in value, they can cause faulty operation of some circuits. Describe some basic wiring techniques to help reduce this problem, and remember this kind of instruction can promote better craftmanship during laboratory experiments or project construction.
4. Do not forget to summarize Ohm's Law for alternating current in respect to capacitive reactance, inductive reactance, and impedance. Review, discussion, and possible evaluation of this

Methodology continued:

suggestion idea during instruction can avoid student technical disorientation.

$(E = I \times X_C,\ E = I \times X_L,\ \text{and}\ E = I \times Z)$

5. Most electronic laboratories contain an instrument which will allow measurement of resonant frequencies. A simple grid-dip meter can be utilized since it basically is a small AC generator that can be adjusted over a wide frequency range. Several demonstrations can assist the instructor in describing methods of troubleshooting of RCL circuits so take advantage of this meter if available.

Supplemental Activities and Demonstrations:

1. Many of the characteristics of both series or parallel resonant circuits can be verified through demonstration. Instructor can show current flow, voltages around the LCR circuit, and alter various component values in order to observe circuit function.
2. The last topic in this unit is very essential, yet fun to investigate during classroom instruction. Basic filters (band-pass, low-pass, high-pass, band-reject) can be drawn on the chalkboard, constructed in front of the class, and then students can simultaneously plot a response curve on an overhea transparency while others perform the various readings. For each circuit type demonstrated the class has a vivid impression of its frequency response characteristics.
3. Typical household radios can be examined in terms of identifying resonant circuits and their application. Indicate the use of resonant circuits in the antenna circuit, point to resonant circuits used in the tuning circuit, and show those resonant circuits that assist in obtaining selectivity and high impedance. If a radio is not handy utilize a radio schematic and project the image on a wall and discuss.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Multiple Choice
5. Worksheet - Impedance
6. Worksheet - Resonance and Filter Circuits
7. Quest Activity
8. Informational Handout (Impedance, Resonance and Filter Circuits
9. Unit Module Answer Key

XIII. Circuits Containing R, C, and L

A. What is impedance?

B. Impedance in RC circuits

C. Impedance in RL circuits

D. Impedance in RCL circuits

E. Resonance

F. Introduction to filters

Test Number _____

LIII-U13

UNIT EXAM

CIRCUITS CONTAINING R, C, AND L

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. Impedance represents the total "AC resistance" of a circuit containing resistance, capacitance, and inductance. (T-F)

2. The letter symbol for impedance is I. (T-F)

3. If the impedance of a circuit is minimum, the circuit current will be maximum. (T-F)

4. Impedance is measured in the base unit ohms. (T-F)

5. The formula for computing impedance in a series RL circuit is $Z = \sqrt{R^2 + X^2}$ (T-F)

6. In an RCL circuit a condition can exist where $X_C = X_L$. This condition is called reactance. (T-F)

7. The letter symbol for resonant frequency is "f_r". (T-F)

8. A filter circuit that can pass one frequency and reject neighboring frequencies has poor selectivity. (T-F)

9. A circuit designed to pass some frequencies and block others is called an integrated circuit. (T-F)

10. Filter circuits can be divided into two broad catagories; "frequency selective", or "power supply" filters. (T-F)

11. Filter circuits utilize only capacitors and resistors to provide frequency selective networks. (T-F)

12. Series resonant circuits provide maximum impedance at resonance. (T-F)

13. One characteristic of a parallel resonant circuit is that it allows minimum current flow when operating at its resonant frequency. (T-F)

14. A high-pass filter is designed to attenuate high frequencies. (T-F)

15. The "f_r" of a tank circuit can be found by utilizing the formula $f_r = \frac{1}{2\pi\sqrt{LC}}$. (T-F)

16. The total opposition to current flow in a circuit that contains resistance, capacitive reactance, and inductive reactance is described as:
(A) impedance, (B) reactance, (C) resistance, (D) resonance.

17. The letter symbol for impedance is:
(A) X, (B) I, (C) Z, (D) f_r.

18. The basic unit of measurement for impedance is the:
(A) farad, (B) ohm, (C) henry, (D) hertz.

19. To solve for the impedance of a series RC circuit you should apply which of the following formulas:
(A) $Z = \sqrt{R^2 + X^2_C}$, (B) $Z = \sqrt{R^2 \cdot X^2}$, (C) $Z = \sqrt{R^2 + (X_C - X_L)^2}$,
(D) either A or C.

20. Impedance represents a force __________ the flow of current and is analogous to __________ in a D-C circuit.
(A) opposing, resistance, (B) opposing, conductance, (C) aiding, resistance, (D) aiding, conductance.

21. In a series LC circuit at resonance:
(A) maximum current flows in the LC circuit, (B) minimum current flows in the LC circuit, (C) the current leads the voltage at the source, (D) the current lags the voltage at the source.

22. In a parallel LC circuit the impedance at resonance is:
(A) very low, (B) very high, (C) the same as when off-resonance, (D) equal to the impedance of a series circuit.

23. At resonance in a series RCL circuit Z has its __________ value, and is equal to __________.
(A) minimum, R, (B) maximum, X, (C) maximum, R, (D) minimum, X.

24. As frequency increases in an LC circuit, inductive reactance ________ and capacitive reactance __________.
(A) increases, increases, (B) increases, decreases, (C) decreases, increases, (D) decreases, decreases.

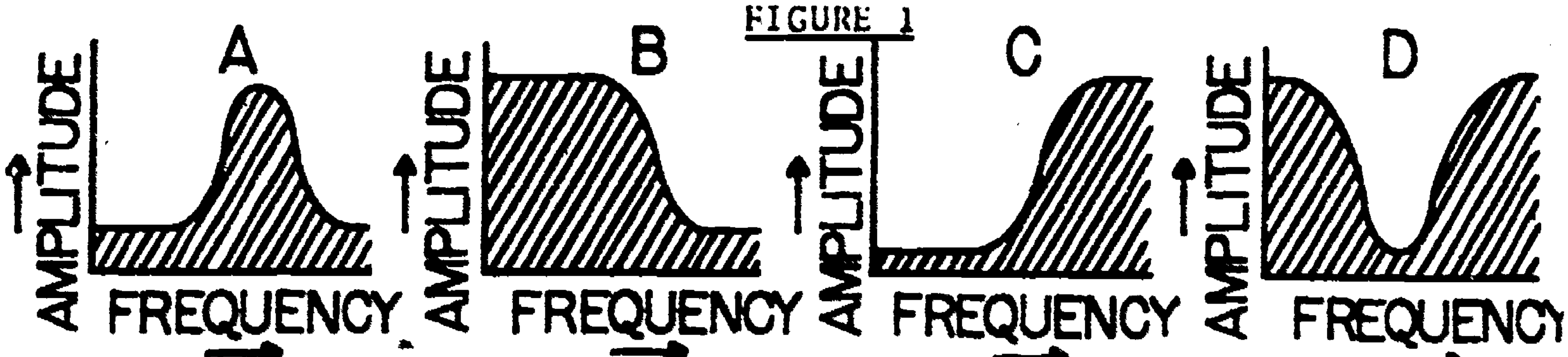
25. There will always be a frequency in a RCL circuit, called the ______ frequency, at which __________.
(A) natural, $X_L = X_C$, (B) oscillating, $R = 0$, (C) resonant, $X_L = X_C$ (D) reactance, $X = 0$

26. At resonance, the impedance is very __________ and the current is very __________ in a parallel RCL circuit.
(A) large, large, (B) large, small, (C) small, large, (D) small, small.

27. The behavior of a parallel resonant RCL circuit is essentially ______ to that of a series resonant RCL circuit.
(A) similar, (B) opposite, (C) unrelated, (D) identical.

28. A parallel RCL circuit behaves inductively __________ and capacitively __________.
(A) at D-C, at resonance, (B) at resonance, at D-C, (C) above resonance, below resonance, (D) below resonance, above resonance.

FIGURE 1



29. Identify the response curve (in figure 1) for a low-pass filter.
(A) curve A, (B) curve B, (C) curve C, (D) curve D.

30. Locate the response curve from figure 1 which represents a band-reject filter.
(A) curve A, (B) curve B, (C) curve C, (D) curve D.

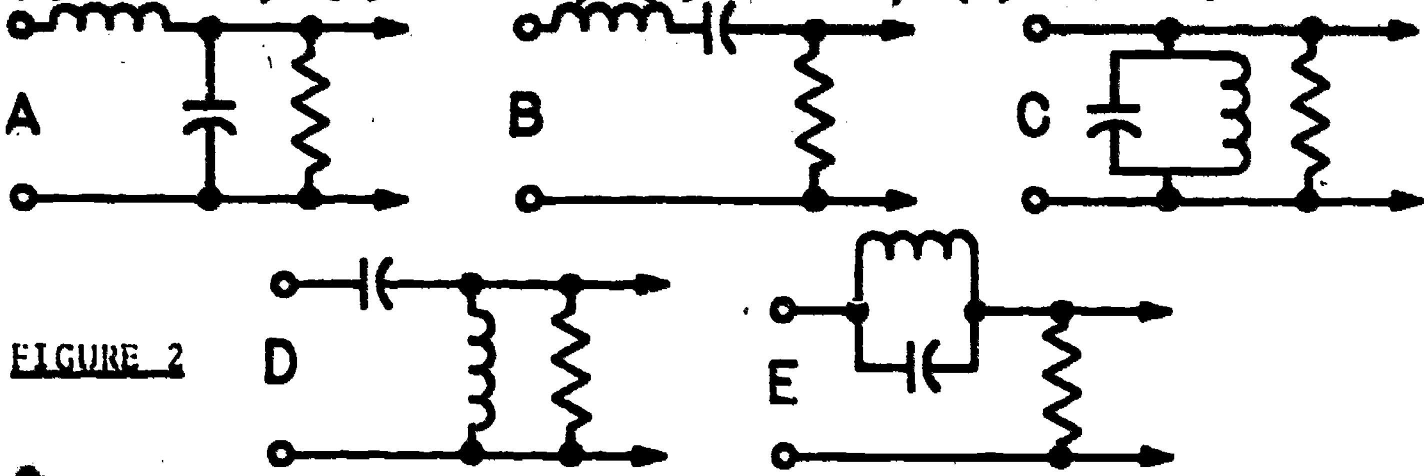
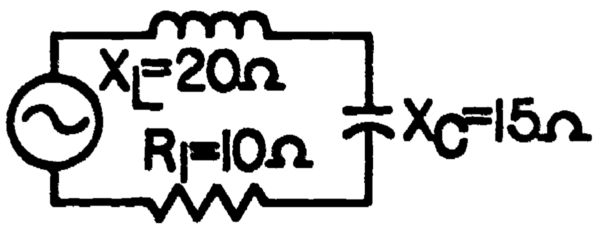


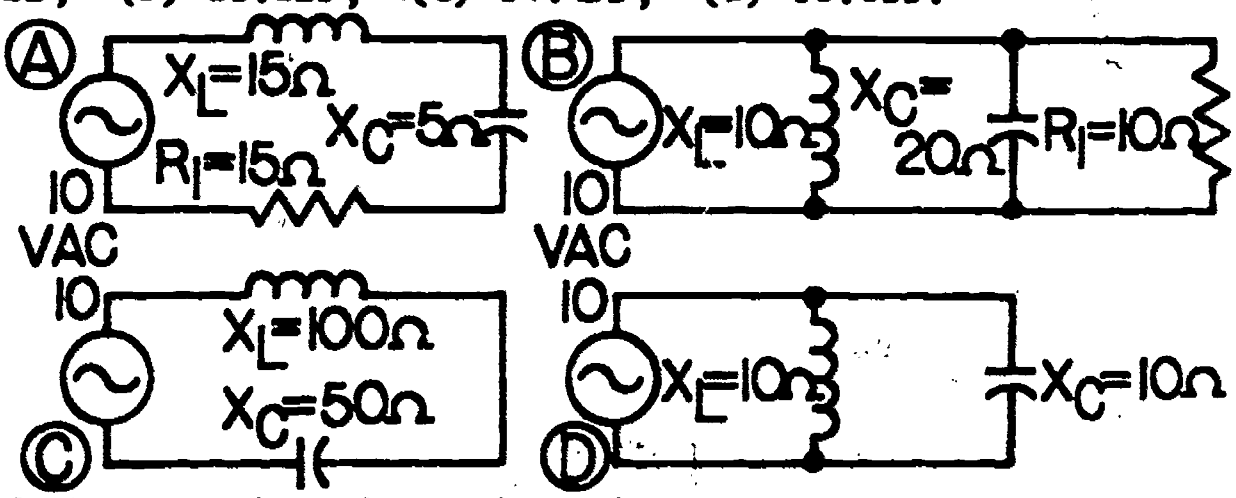
FIGURE 2

31. Utilizing figure 2, locate the schematic for a high-pass filter.
(A) circuit A, (B) circuit B, (C) circuit D, (D) circuit E.

32. Which of the circuits in figure 2 represents a band-pass filter?
(A) circuit B, (B) circuit C, (C) circuit E, (D) both B and C.



33. What is the impedance of the circuit shown above?
(A) 8.2Ω, (B) 11.2Ω, (C) 14.4Ω, (D) 18.8Ω.



34. Which of the circuits shown above is at resonance.
(A) figure A, (B) figure B, (C) figure C, (D) figure D.

35. An 8-henry choke is connected in series with a 2 μfd capacitor. What is the resonant frequency?
(A) 126.5 Hz, (B) 12.65 Hz, (C) 40 Hz, (D) 400 Hz.

Name: ______________

Date: ______________

Period: ______________

TECHNICAL GLOSSARY

ACCEPTOR CIRCUIT:	A series, capacitor-inductor circuit which offers minimum impedance (total AC resistance) at resonance. Thus, accepts or passes signals at resonant frequency.
ATTENUATION:	The process of decreasing the amplitude of a signal, usually to minimum or zero value.
BAND PASS FILTER:	A filter circuit designed to pass signals within a predetermined continuous band of frequencies, and attenuate frequencies above and below that band.
FILTER:	An electrical circuit utilizing an inductor, capacitor and/or resistor to eliminate or attenuate specific frequencies or bands of frequencies.
IMPEDANCE:	The total resistance to AC current flow offered by a circuit containing resistance, capacitance, and inductance. Letter symbol: Z
LC CIRCUIT:	A circuit containing both inductance and capacitance.
PARALLEL RESONANCE:	A parallel LC circuit which offers maximum resistance to current flow at resonance, that is, when the capacitive reactance and inductive reactance are equal.
RC CIRCUIT:	A circuit containing both resistance and capacitance.
RCL CIRCUIT:	A circuit containing resistance, capacitance, and inductance.
REJECT CIRCUIT:	A parallel LC circuit which offers maximum resistance (impedance) to current flow at resonance. The circuit will reject or block signals at the resonant frequency.
RESONANCE:	The single frequency in an LC or RCL circuit at which $X_L = X_C$.
RL CIRCUIT:	A circuit containing resistance and inductance.
SERIES RESONANCE:	A series RCL circuit which offers minimum opposition to AC current flow at its resonant frequency, (when $X_L = X_C$).
TANK CIRCUIT:	A parallel resonant circuit commonly used in radio and TV circuits to align the I.F. circuitry.
TUNED CIRCUIT:	A circuit containing capacitance, inductance and resistance in series or parallel, set to its resonant frequency, and utilized as a filter.

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

VOCABULARY - MULTIPLE CHOICE

Select the term that best fits the given definition, and fill in the adjacent answer box.

1. A circuit containing both an inductor and a capacitor connected either in series or parallel.

   ○ IC circuit
   ○ RC circuit
   □ LC circuit
   △ RL circuit

2. The proces of decreasing the amplitude of a signal to minimum or zero.

   ○ Resistance
   ○ Filter
   □ Resonate
   △ Attenuate

3. The opposition to AC current flow offered by an inductor.

   ○ Reactance
   ○ Impedance
   □ Resonance
   △ Resistance

4. A filter circuit designed to attenuate a single band of frequencies.

   ○ Band pass filter
   ○ Band reject filter
   □ Acceptor circuit
   △ Reject circuit

5. The total AC resistance offered by an RCL circuit.

   ○ Reactance
   ○ Impedance
   □ Resonance
   △ Resistance

6. The specific frequency in an LC circuit where $X_L = X_C$.

   ○ Reactance
   ○ Impedance
   □ Resonance
   △ Resistance

Name: ______________

Date: ______________

Period: ______________

7. An RCL circuit which offers maximum opposition to AC current flow at resonance.

   ○ Tuned circuit
   ○ Series resonance circuit
   □ Parallel resonance circuit
   △ Attenuation

8. An RCL circuit which offers minimum opposition to AC current flow at resonance.

   ○ Tank circuit
   ○ Series resonant circuit
   □ Parallel resonant circuit
   △ Attenuation

9. The opposition to AC current flow offered by a capacitor.

   ○ Reactance
   ○ Impedance
   □ Resonance
   △ Resistance

10. A filter circuit designed to pass a single frequency.

   ○ Band pass filter
   ○ Band reject filter
   □ Acceptor circuit
   △ Tuned circuit

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

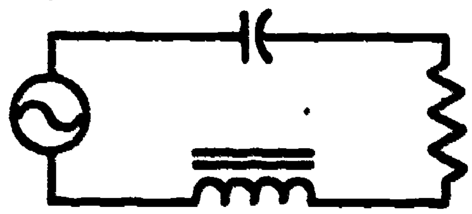
IMPEDANCE

MATCHING:

1. Impedance
2. RC circuit
3. RL circuit
4. RCL circuit
5. Reactance
6. Letter symbol for reactance.
7. Letter symbol for impedance.

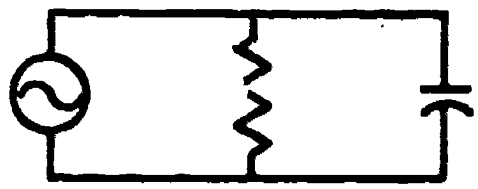
A. X

B.



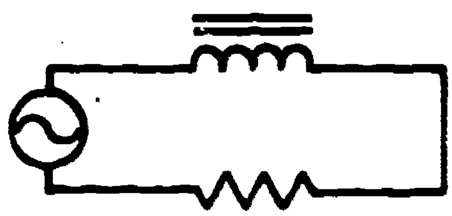
C. The AC resistance offered by a capacitor or inductor.

D.



E. The total opposition to AC current flow of a circuit containing resistance and inductance.

F.



G. Z

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____

8. List the formulas for finding impedance in a series; (A) RC circuit, (B) RL circuit, (C) RCL circuit.

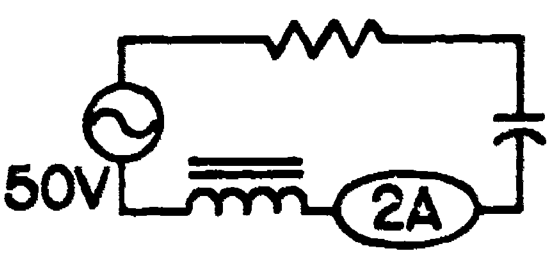
8A. ____

8B. ____

8C. ____

9. Find the impedance in the following problem:

9. ____



Show work

Name: ____________

Date: ____________

Period: ____________

10. Solve for the "Z" of a series RC circuit which has a resistance of 4 ohms, and a capacitive reactance of 3 ohms. 10. [ ]

Show work

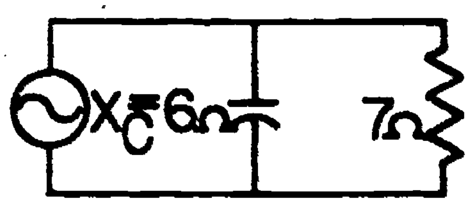
11. Find the "Z" of a series RL circuit which has a resistance of 5 ohms, and an inductive reactance of 8 ohms. 11. [ ]

Show work

12. Utilizing the following formula for calculating impedance in a parallel RC circuit 12. [ ]

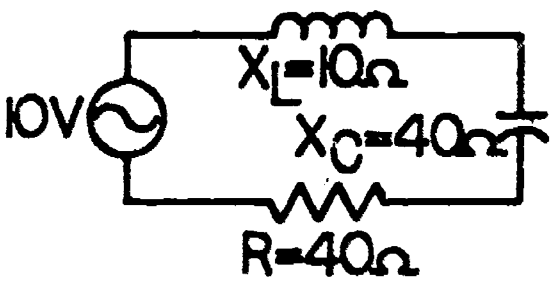
$$Z = \frac{RX_C}{\sqrt{R^2 + X_C^2}}$$

solve for "Z" in the following circuit.



Show work

13. Solve for impedance in the following RCL circuit: 13. [ ]



Show work

SCORE:

GRADE:

Name: ____________

Date: ____________

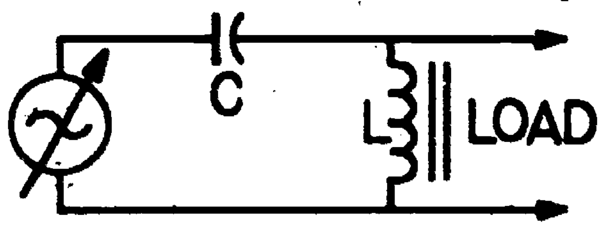
Period: ____________

WORKSHEET

RESONANCE AND FILTER CIRCUITS

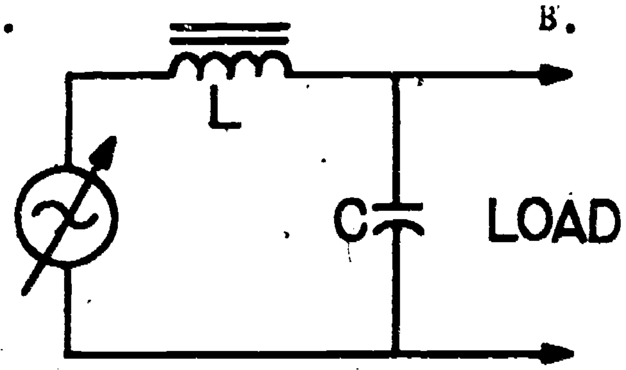
Identify the following filter circuits by matching the circuit drawing with its functional description. (Hint: unscramble the letters beneath each circuit for a clue).

1.



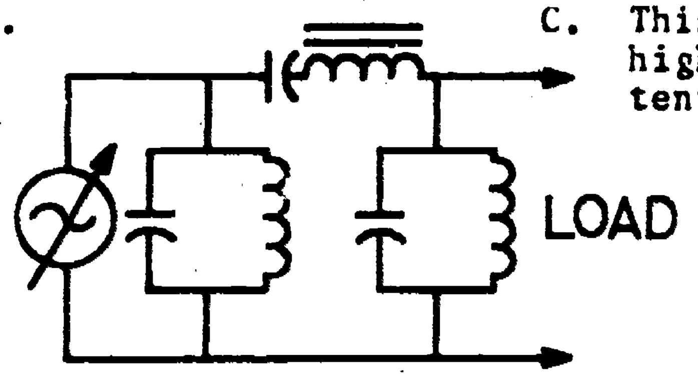
(SSHPGIHA)

2.



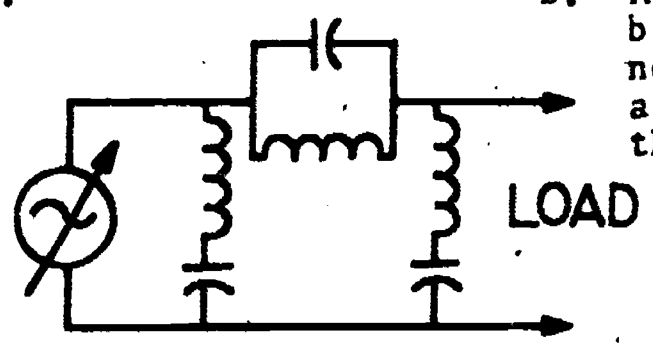
(WPOSSLA)

3.



(BASSDAPN)

4.



(RENTDAJBEC)

A. This circuit will pass only a desired band of frequencies, on or near resonance, and block all other frequencies from reaching the load.

B. A filter designed to pass only frequencies below a desired value, and attenuate high frequencies.

C. This circuit will pass high frequencies and attenuate low frequencies.

D. A filter designed to block frequencies on or near resonance, and pass all other frequencies to the load.

1. ____________

2. ____________

3. ____________

4. ____________

5. The resonant frequency of a circuit is that frequency which causes X_L to equal ________.

5. ____________

Name: ____________

Date: ____________

Period: ____________

6. List the formula for finding resonant frequency (f_r). ____________ 6. [ ]

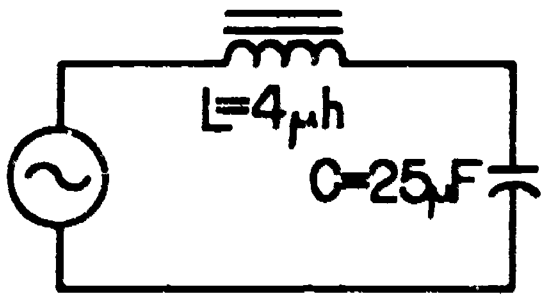
7. The unit of measurement for f_r is the ________. 7. [ ]

8. A circuit can have more than one resonant frequency. (T-F). 8. [ ]

9. If a series RCL circuit is operating at resonance, current flow will be ________. (Minimum or maximum) 9. [ ]

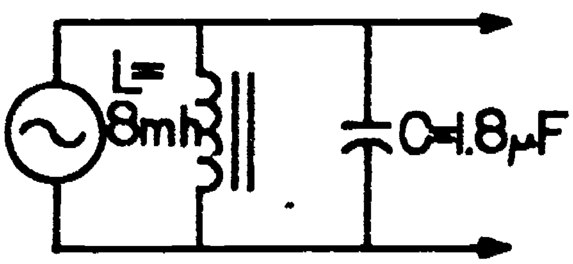
10. When a parallel LC circuit is functioning at resonance, the circuit current will be ________. (Minimum or maximum) 10. [ ]

11. Solve for the resonant frequency of the series LC circuit below. 11. [ ]



Show work

12. Calculate "f_r" for the parallel LC circuit below. 12. [ ]



Show work

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 13"

1. Identify the conditions that occur in a series RCL circuit at resonance. (Place a check mark in the answer box corresponding to all correct answers).

   A. $X_L = X_C$ — 1A.

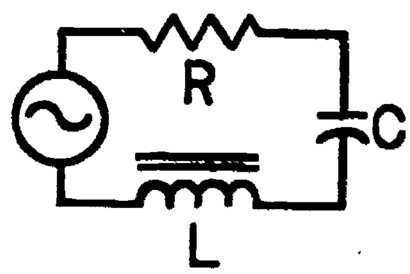
   B. $Z = R$ — 1B.

   C. Current is maximum — 1C.

   D. Impedance is maximum — 1D.

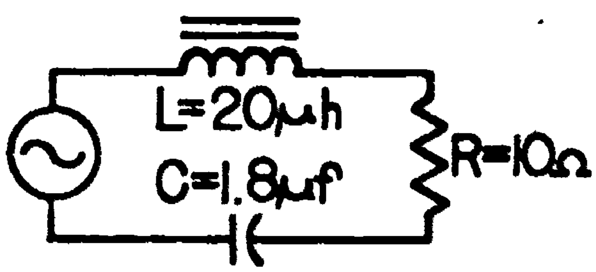
   E. Current is minimum — 1E.

   F. Impedance is minimum — 1F.



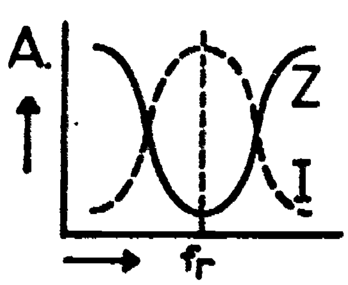
2. State the formulas for finding the resonant frequency of any RCL circuit. — 2.

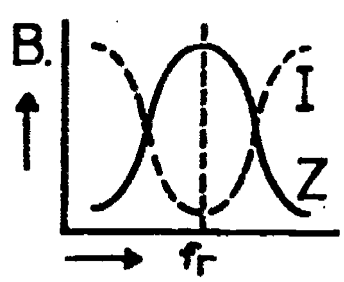
3. Solve for the "f_r" of the circuit below. — 3.



Show work

4. Identify the figure representing the response curve of a series RCL circuit. — 4.





5. Using the terms; resistive, capacitive and inductive, explain how a series RCL circuit appears:

   A. When the applied frequency is below the resonant frequency. — 5A.

   B. When the applied frequency equals the resonant frequency. — 5B.

Name: ______________

Date: ______________

Period: ______________

C. When the applied frequency is above the resonant frequency. 5C. ☐

6. Identify the conditions that occur in a parallel LC circuit at resonance (check the appropriate box).

A. $X_L = X_C$ 6A. ☐

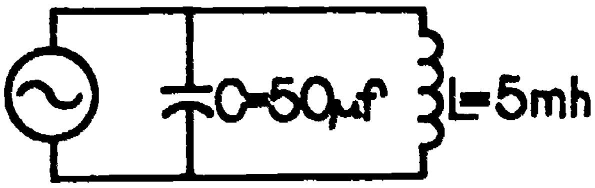
B. Current is maximum 6B. ☐

C. Impedance is maximum 6C. ☐

D. Current is minimum 6D. ☐

E. Impedance is minimum 6E. ☐

7. Solve for "f_r" in the problem below. 7. ☐



Show work

8. Select the response curve which represents the action of a parallel LC circuit at resonance. 8. ______

9. Using the terms; resistive, capacitive, and inductive, explain how a parallel LC circuit appears:

A. Below resonance 9A. ______

B. At resonance 9B. ______

C. Above resonance 9C. ______

10. Filter circuits utilize the frequency sensitivity or reactance of (A) __________ and (B) __________ (components) to form frequency selective circuits. 10A. ______ 10B. ______

Name: ____________

Date: ____________

Period: ____________

11. An inductor tends to pass (A)__________ (high or low) frequencies, while a capacitor tends to pass (B)__________ (high or low) frequency signals. 11A. [ ] 11B. [ ]

12. Draw a schematic diagram for a low-pass filter.

13. Draw the schematic diagram for a high-pass filter.

14. Draw a schematic for a band-pass filter.

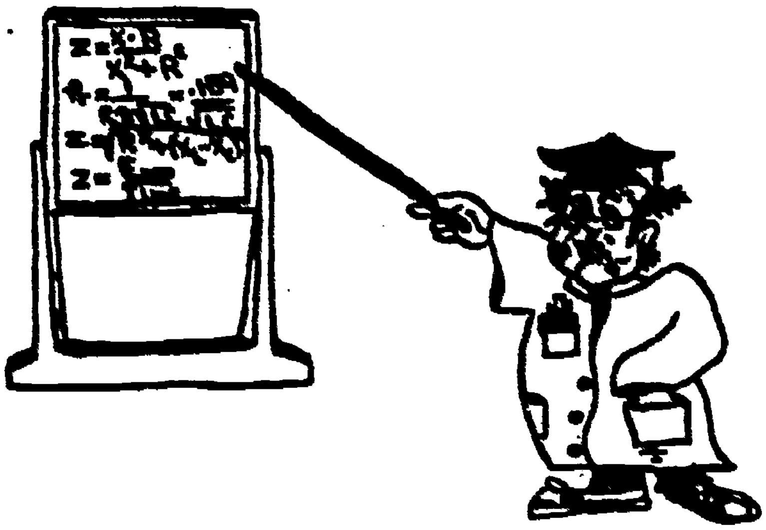
Name: ______________

Date: ______________

Period: ______________

INFORMATIONAL HANDOUT

IMPEDANCE, RESONANCE, AND FILTER CIRCUITS

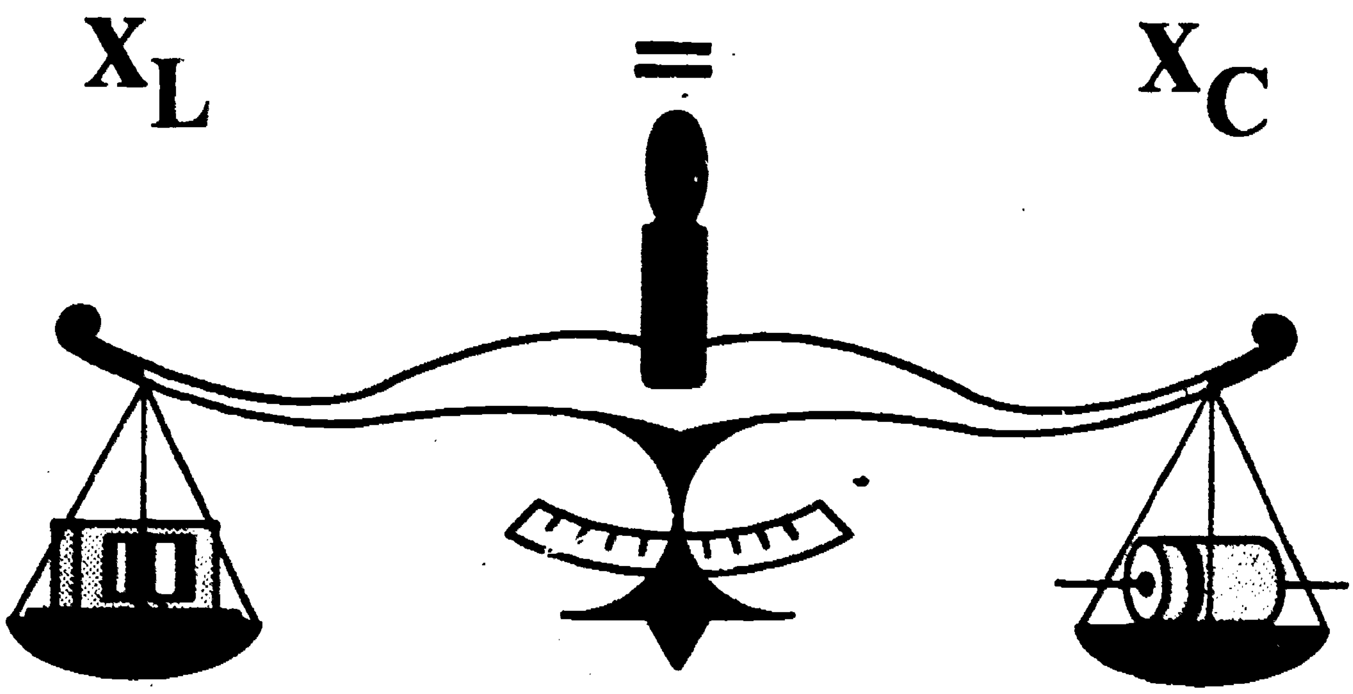


IMPEDANCE

The impedance of a circuit represents the total "AC resistance" of a circuit containing resistance and reactance; that is, resistance, X_L and/or X_C. The letter symbol for impedance is Z, and impedance can be solved for by using one of the following formulas.

General Formula	Series Impedance	Parallel Impedance
$Z = \frac{E_{app}}{I_{line}}$	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	$Z = \frac{X \cdot R}{X^2 + R^2}$ WHERE $X = \frac{X_L \cdot X_C}{X_L + X_C}$

RESONANCE



Name: ______________

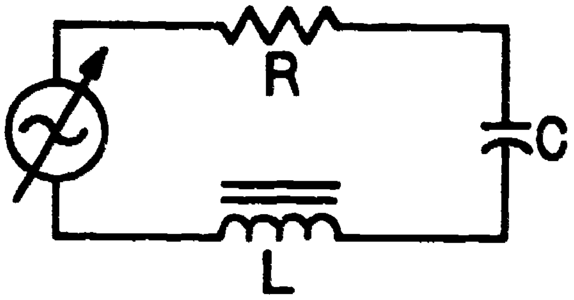
Date: ______________

Period: ______________

A resonant condition occurs in an RCL circuit when $X_L = X_C$. As you know, capacitive reactance and inductive reactance vary with frequency (as frequency increases X_L increases, but X_C decreases). Thus, X_L and X_C have opposite response to frequency and the single frequency where $X_C = X_L$ is called the resonant frequency (f_r) of the circuit. The "f_r" of a circuit can be found using the following formulas:

$$f_r = \frac{1}{2\pi\sqrt{LC}} \text{ or } f_r = \frac{.159}{\sqrt{LC}}$$

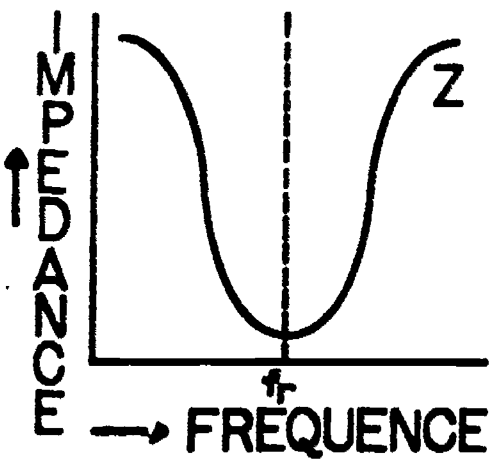
CHARACTERISTICS OF A SERIES RESONANT CIRCUIT



Basic series RCL circuit.

A series RCL circuit at resonance offers minimum impedance (Z) to current flow. When the applied frequency is varied, however, the value of impedance increases. The impedance of a series RCL circuit can be plotted on a graph to show the effects of a varying frequency.

The figure below is an impedance response curve for any series RCL circuit. The graph shows the effects of varying the applied frequency above and below the resonant frequency (f_r), and the summary, to the right, explains the operational characteristics.

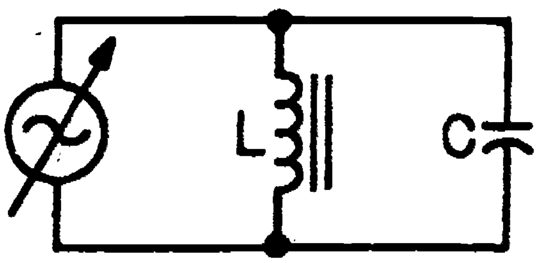


At resonance; the series RCL circuit offers minimum impedance, thus allows maximum current flow at resonance. The circuit appears resistive.

Below resonance; circuit appears capacitive, that is X_C is greater than X_L.

Above resonance; circuit appears inductive, that is X_L is greater than X_C.

CHARACTERISTICS OF A PARALLEL RESONANT CIRCUIT



Basic parallel LC circuit

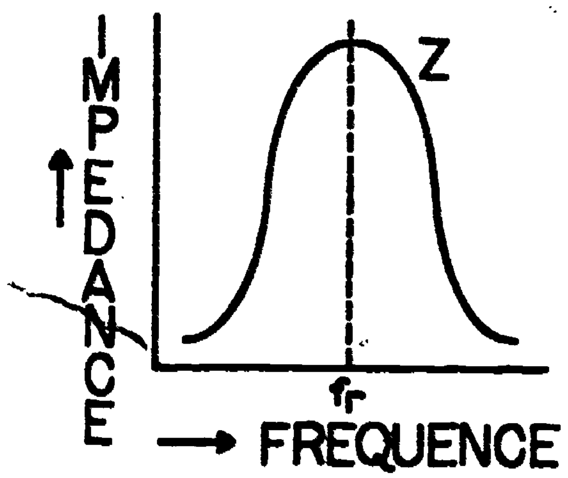
Name: ____________

Date: ____________

Period: ____________

A parallel LC circuit has a high impedance at its resonant point. When the applied frequency is varied above or below resonance, the impedance decreases or drops off.

The figure below shows the impedance response curve for a typical parallel LC circuit as the frequency is varied above and below the resonant frequency. The summary explains the circuits operational characteristics.



At resonance; the parallel LC circuit offers maximum impedance, and thus minimum current flow. The circuit appears resistive.

Below resonance; the circuit appears inductive. X_L is less than X_C, allowing more current flow in the inductor branch.

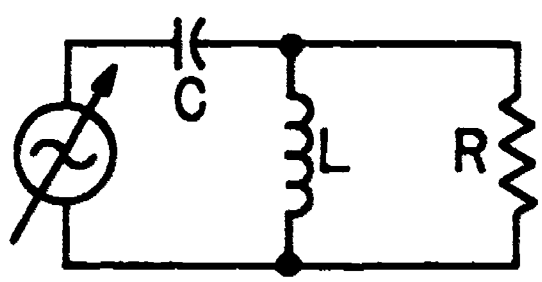
Above resonance; the circuit appears capacitive. X_C is less than X_L, allowing more current flow in the capacitor branch.

FILTER CIRCUITS

Filters are frequency selective circuits which utilize the operating characteristics of capacitors, inductors, and/or resistors to attenuate selected frequencies. Filter circuits can be divided into broad catagories; "frequency selective", or "power supply" filters. We will now discuss four basic frequency selective filters.

HIGH-PASS FILTER

A high-pass filter takes advantage of the characteristics of a capacitor and inductor to provide a circuit which will pass only frequencies that occur higher than a desired value and attenuate lower frequencies. The frequency value is determined by the selection of C and L.



CIRCUIT CHARACTERISTICS:

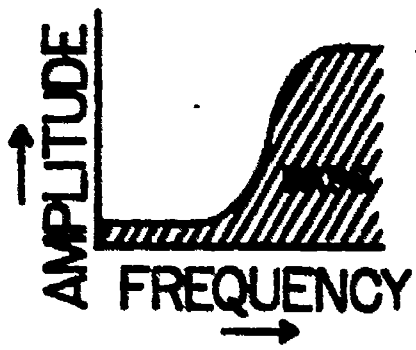
1. The majority of the "low frequency" signals applied to the filter will be blocked by the capacitor due to a high X_C.

2. "Low frequency" signals that move through the capacitor will be shunted past the load, through the inductor, due to a low X_L.

Name: ______________

Date: ______________

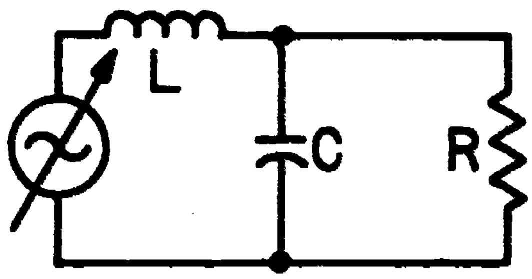
Period: ______________

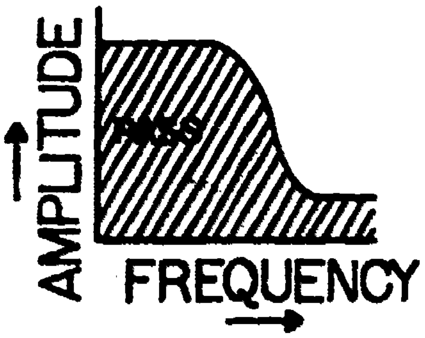


3. High frequency signals will be passed by the capacitor, due to low X_C, and blocked from flowing through the inductor, by a high X_L, thus only high frequency signals will be forced to move throug the load.

LOW-PASS FILTER

A low-pass filter again utilizes an inductor-capacitor network to develop a circuit which will pass only frequencies occuring lower than a desired value and attenuate higher frequencies. Again, the frequency value is determined by the value selected for L and C.





CIRCUIT CHARACTERISTICS:

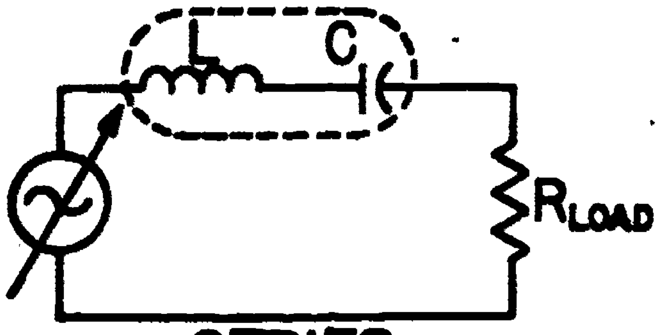
1. The majority of the "high frequenc signals applied to the filter are blocked by the inductor due to a high X_L.

2. "High frequency" signals which mov through the inductor will be shunted past the load by the capacitor, which offers low reactance to high frequency signals.

3. Low frequency signals will be passed by the inductor, due to low X_L, and blocked by the capacitor, which will exhibit a high X_C, thus only the low freauency signals wil be felt at the load.

BAND-PASS FILTER

Band-pass filters are designed to pass a narrow band of frequencies and block or attenuate all other frequencies. These characteristics can be obtained by utilizing either a series resonant or parallel resonant circuit.



SERIES

CIRCUIT CHARACTERISTICS:

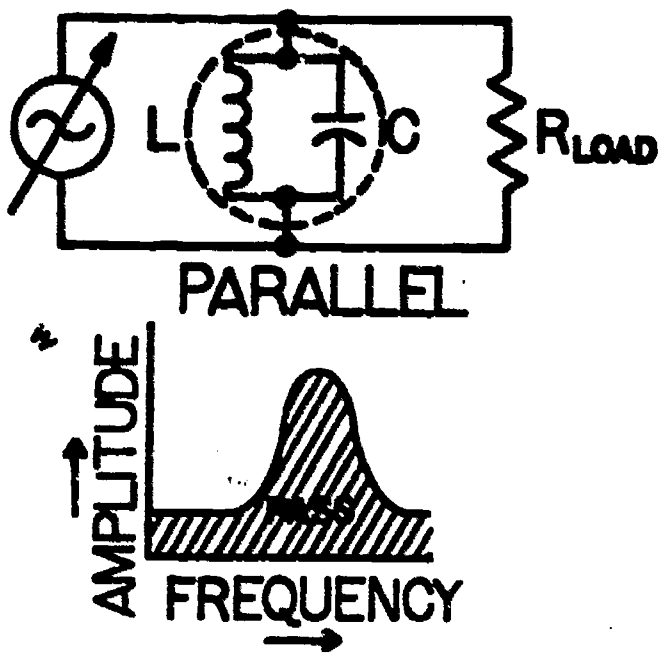
Series resonant circuit:

At frequencies near resonance, the impedance of the LC circuit is low, thus allowing current flow through the load. At frequencies above or below resonance the "Z" of the circuit increases, and blocks current flow.

Name: ____________

Date: ____________

Period: ____________

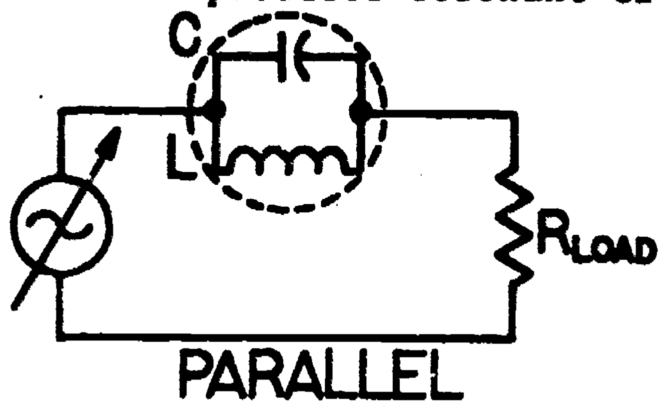


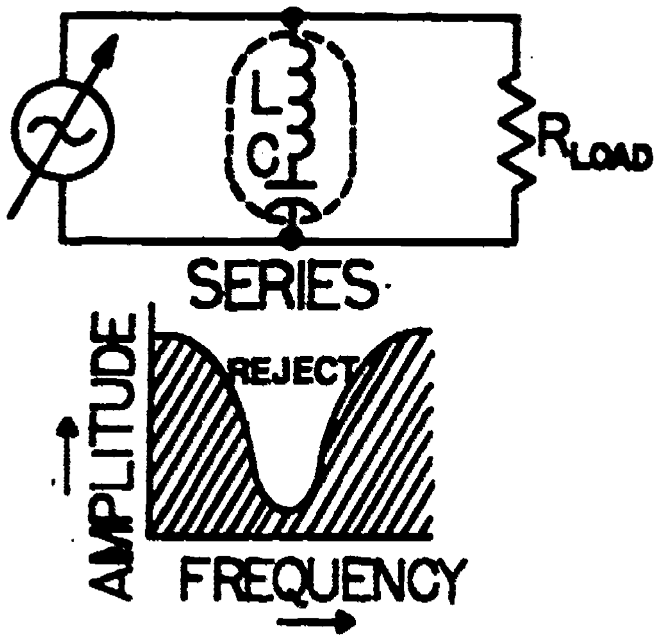
Parallel resonant circuit:

When frequencies near resonance are applied to the filter the parallel LC circuit offers high impedance to current flow, thus forcing the input signal through the load. As the applied frequency moves above or below resonance, the LC circuit offers a lower "Z" which allows the signal to be shunted through the parallel LC circuit and hence by pass the load.

BAND-REJECT FILTER

The function of a band-reject filter is to reject or attenuate a small band of frequencies on or near the circuits resonant frequency, and to pass all other frequencies. A band-reject filter can be designed utilizing either a parallel resonant circuit, or a series resonant circuit.





CIRCUIT CHARACTERISTICS:

Parallel resonant circuit:

On or near resonance, the parallel LC circuit offers high impedance, and blocks circuit current flow. As frequencies move above or below resonanc the "Z" decreases, and the signal will be present at the load.

Series resonant circuit:

At or near resonance, the series LC circuit offers low "Z", thus current will flow through the resonant circuit, while being shunted away from the load. As the input frequency move above or below resonance "Z" increases and the signal will then flow through the load.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

ANSWER SHEET

EXAM LIII U13

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.	■				26.		■			51.					76.				
2.		■			27.		■			52.					77.				
3.	■				28.				■	53.					78.				
4.	■				29.		■			54.					79.				
5.	■				30.				■	55.					80.				
6.		■			31.			■		56.					81.				
7.	■				32.				■	57.					82.				
8.		■			33.		■			58.					83.				
9.		■			34.				■	59.					84.				
10.	■				35.			■		60.					85.				
11.		■			36.					61.					86.				
12.		■			37.					62.					87.				
13.	■				38.					63.					88.				
14.		■			39.					64.					89.				
15.	■				40.					65.					90.				
16.	■				41.					66.					91.				
17.			■		42.					67.					92.				
18.		■			43.					68.					93.				
19.			■		44.					69.					94.				
20.	■				45.					70.					95.				
21.	■				46.					71.					96.				
22.		■			47.					72.					97.				
23.	■				48.					73.					98.				
24.		■			49.					74.					99.				
25.			■		50.					75.					100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 13

A. VOCABULARY - MULTIPLE CHOICE

1. LC circuit
2. attenuate
3. reactance
4. band reject filter
5. impedance
6. resonance
7. parallel resonance circuit
8. series resonance circuit
9. reactance
10. acceptor circuit

B. IMPEDANCE

1. E
2. D
3. F
4. B
5. C
6. A
7. G

8A. $Z = \sqrt{R^2 + X_C^2}$

8B. $Z = \sqrt{R^2 + X_L^2}$

8C. $Z = \sqrt{R^2 + (X_L - X_C)^2}$

9. $Z = \frac{E}{I}\ \frac{50}{2} = 25$ ohms

10. $Z = \sqrt{R^2 + X_C^2} = 5$ ohms

11. $Z = \sqrt{R^2 + X_L^2} = 9.43$ ohms

12. 9.21 ohms
13. 50 ohms

C. RESONANCE AND FILTER CIRCUITS

1. high pass C
2. low pass B
3. band pass A
4. band reject D
5. X_C
6. $fr = \frac{1}{2\pi\sqrt{LC}}$
7. hertz
8. false
9. maximum
10. minimum
11. 15.9 K hertz
12. 1327 hertz

D. QUEST ACTIVITY

1A. ✓
1B. ✓
1C. ✓
1D.
1E.
1F. ✓

2. $fr = \frac{1}{2\pi\sqrt{LC}}$ or $\frac{.159}{\sqrt{LC}}$
3. 26539 Hz
4. A

5A. capacitive
5B. resistive
5C. inductive
6A. ✓
6B. ✓
6C. ✓
6D. ✓
6E.

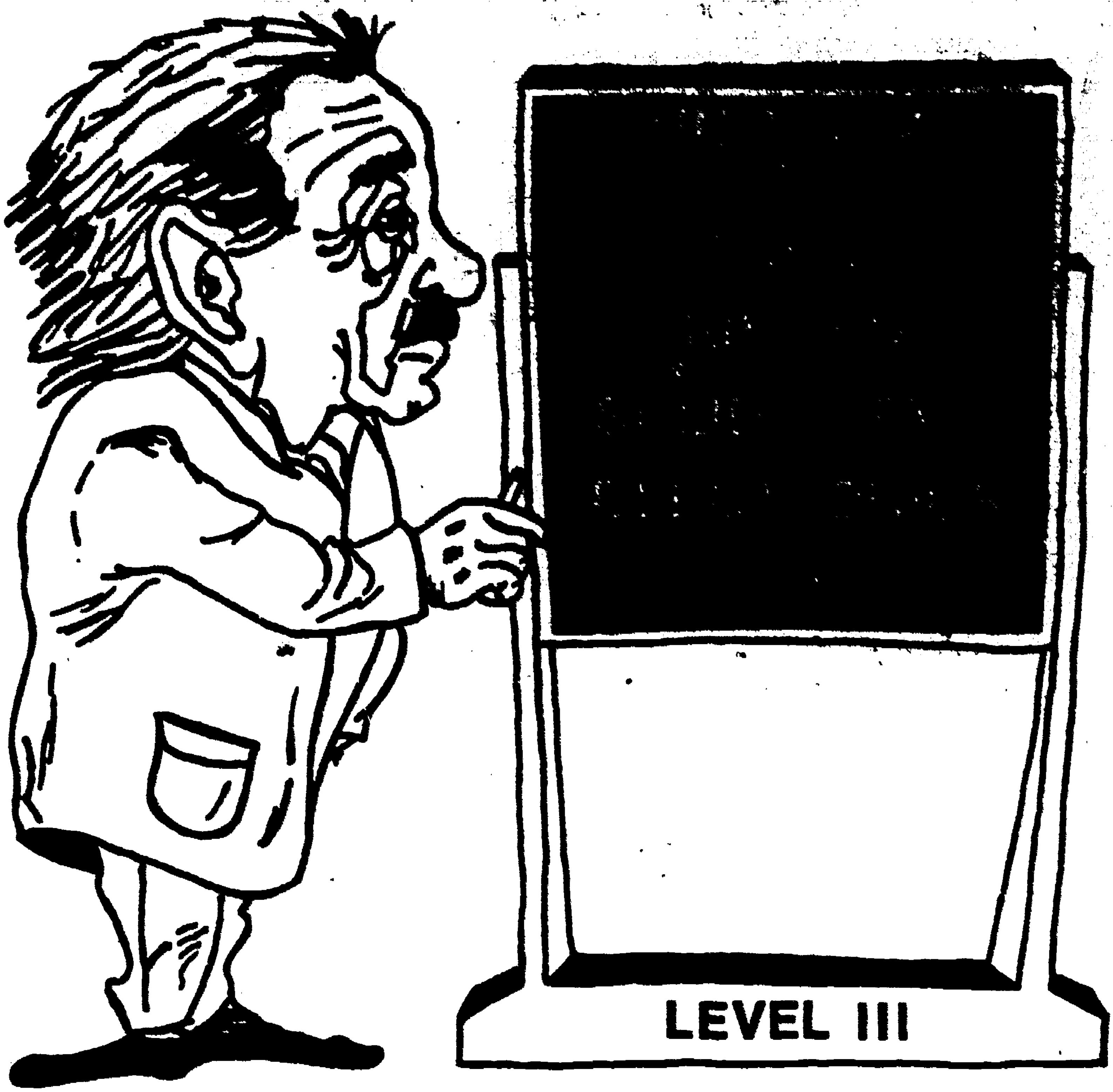
7. 318 hertz
8. B

9A. inductive
9B. resistive
9C. capacitive
10A. inductors (either way)
10B. capacitors
11A. low
11B. high

12. (subjective answer)
13. (subjective answer)
14. (subjective answer)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME________________
DATE STARTED__________
DATE COMPLETED________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Vacuum Tube and Solid-State Electronics

Time Allocation: 3 weeks

Unit Goal:

To achieve student competence in apprehending a basic overview of the importance and purpose of active devices such as diodes, vacu tubes, and transistors.

Unit Objectives:

The student will be able to:

1. explain the necessity, function, and basic electrical composition of a typical power supply stage.
2. indicate the method in which vacuum tubes are classified, and list three common circuit applications of vacuum tubes.
3. compare and contrast the relationship between the amplitude output voltages of both the half-wave rectifier circuit and the full-wave rectifier circuit.
4. match a schematic symbol of a rectifier (solid state), diode, triode, pentode, and transistor to a list of definitions provided.
5. identify the means of quality checking a solid state diode, vacuum tube, or transistor and then demonstrate the skill nec essary to perform such a test.
6. recognize common types of transistor cases and analyze a base ing diagram in order to identify lead placement.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Electricity and Basic Electronics. Stephen R. Matt, Goodheart-Willcox 1977. Chapters: 15, 16, 17, and 19.

Electronics in Action Book 2. George H. Delpit, Chas. A. Bennett Co., 1972. Circuits: 1, 2, 9, 10, and 27.

Fundamentals of Electricity. Robert Seippel, American Technical Socie 1974. Chapters: 12, 13, 14, and 15.

Overview:

Unit 14 is presented as the last technical unit of this level, and its purpose is to assist in the transition from electricity into the study of electronic theory. In depth technical topic coverage which may not be presented in this unit are dedicated for presentation at a more appropriate time conceptionally.

The unit should be introduced by explaining the necessity of power supplies, then the instructor can examine the kinds of components utilized in this stage. Active devices, diodes and rectifiers are a good and logical starting point to the more sophisticated field of electronics.

The next topics are covered in a manner that promotes general understanding of rectification, yet this theory excites the imagination of students because it deals, for the first time, with stages that inevitable will form part of an electronic system. Both half-wave and full-wave rectification along with bleeders and filters are presented in an informative format rather than composed from a technical dissection of the circuitry.

The unit concludes with an overview of basic factors related to tube and solid state circuit application. Vacuum tubes are allowed a significant amount of instructional time for several reasons. Tube theory enables a solid foundation of subject matter to build upon, and even modern solid state devices can be digested easier when vacuum tubes have been discussed in a previous situation. In addition, industry has specifically asked that it not be omitted from electronic curriculum taught in technical classes, they feel that it is a competency that is essential to the training process.

A variety of appropriate exercises and laboratory experiments and/or projects should be coordinated with all unit topics when feasible.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. This unit was included to provide student motivation to continue their studies, so do not bear down excessively in terms of technical specifics, but instead stress concepts with emphasis on application of active devices within a stage or system.
2. Have students physically examine a variety of active devices and indicate verbally the system of identification being utilized. If sockets or heat sinks are handy, it is beneficial to allow students to handle those support items as well as the devices, in order to facilitate hardware familiarity. Also, show students how they can apply heat sink compound when necessary to create a proper seal and thermal conductivity.
3. It is recommended that the instructor try to stock and display an array of parts catalogs, component cross reference data books, and substitution manuals whenever possible. An imaginative and persistent instructor can obtain most of these items free by personally contacting local companies, or asking distributors for end of the year clearance data books, and/or by checking with student's parents who work in the electronics field,——it is well worth the effort!

Methodology continued:

4. A circuit comparison is an appropriate activity which can illustrate both stage function and device operation while assisting students in overall technical comprehension. Use breadboarded circuits, in front of the class, which contain a power supply and basic amplifier circuit. Four boards can be utilized so that two contain solid state stages and the other two represent their vacuum tube counterpart. Discuss and compare them for function, performance, size, cost, durability, etc.

Supplemental Activities and Demonstrations:

1. Demonstrate the testing techniques and equipment utilized in quality checking such devices as vacuum tubes, diodes and transistors. When practical, indicate servicing hints or tips which may enable students to identify or locate specific malfunctioning parts such as shorted, opened, and/or intermittent components.
2. Have students investigate electron tube construction through specific identification of elements. Old tubes are available and simple to break apart for viewing. Cover the glass tube envelope with a cloth, then strike glass with a hammer and slowly dismantle each internal part. Use a tube manual to aid in identification and then have students mount exposed elements for instructor approval.
3. With the aid of an opaque projector, transistor manual, and a variety of transistors the instructor can easily show all students how to locate important data about a device. Read the designation off the transistor and then locate corresponding technical data, silhouette outline, and lead arrangements information from within the transistor manual or data book.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Glossary Cryptics
5. Worksheet - Vacuum Tubes, Junction Diodes, Transistors
6. Worksheet - Power Supply and Amplifier Systems
7. Quest Activity
8. Informational Handout (Vacuum Tube and Semiconductor Packages and Numbering Systems)
9. Informational Handout (Tube, Diode, and Transistor Testing)
10. Unit Module Answer Keys

XIV. Vacuum Tube and Solid-State Electronics

A. Power supplies

1. AC conversion to DC

2. Basic requirements of electronic devices

3. Types of diodes

4. Diode construction and basic operation

5. Half-wave rectification

6. Full-wave rectification

7. Bleeders and filters

B. Basic factors relating to tube and transistor circuit application

1. Triode tube

2. Other tubes

3. Type identification and substitution

4. Electron tube defects

5. Testing electron tubes

6. Transistor and electron tube comparison

7. Solid-state triodes (transistors)

8. Basic tube and transistor circuitry

Test Number ____

LIII-U14

UNIT EXAM

VACUUM TUBE AND SOLID-STATE ELECTRONICS

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. The plate of a vacuum tube is designed to emit electrons. (T-F)

2. The diode is the simplest type of vacuum tube. (T-F)

3. An electron tube which contains a cathode, plate, and control grid is called a diode. (T-F)

4. A device or circuit which increases the value (voltage, current, or power) of an electrical signal is called an amplifier. (T-F)

5. The first number on a tube type designation indicates the required plate voltage. (T-F)

6. Under normal operating conditions, the plate of a vacuum tube is biased positively. (T-F)

7. A device or circuit which has the ability to change AC to pulsating DC is called a regulator. (T-F)

8. Silicon and asphalt are two common semiconductor materials. (T-F)

9. The terminals of a semiconductor diode are designated as the anode and cathode. (T-F)

10. The process of "smoothing out" the output wave of a rectifier circuit is called filtering. (T-F)

11. The half wave rectifier is a more efficient circuit, with a smoother output than a full wave rectifier. (T-F)

12. A common component utilized as a filtering device in a power supply circuit is a transistor. (T-F)

13. For each complete AC cycle applied to a full wave rectifier, two DC output pulses will be produced. (T-F)

14. Transistor circuits have the advantage of requiring, two DC for operation than an equivalent vacuum tube circuit. (T-F)

15. The three elements of a bipolar transistor (NPN or PNP) are identified as the plate, cathode, and base. (T-F)

16. The triode vacuum tube was invented by:
(A) Samuel F.B. Morse, (B) Thomas A. Edison, (C) Dr. Lee De Forest, (D) John Fleming.

17. The rectifier in a power supply:
(A) converts the AC input to pulsating DC, (B) converts the DC input to AC, (C) smooths out the pulsating DC developed by the circuit, (D) is always a semiconductor device.

18. Vacuum tube and transistor manuals provide data related to:
(A) physical specification (device size), (B) basing diagrams, (C) technical specifications, (D) all of the above.

19. In a complete power supply the output pulses from the rectifier shoul next be processed by a:
(A) diode, (B) power transformer, (C) filter, (D) bleeder.

20. A type 12AX7 tube would probably:
(A) require a filament voltage of 7 volts, (B) be a diode tube, (C) have 7 active elements, (D) both A and B.

21. The designation system for transistors and semiconductors: (A) is the same as the vacuum tube system, (B) indicates the number of junctions within the semiconductor, (C) may utilize a 1N or 2N designation, (D) is standard throughout the industry.

22. The plate of a vacuum tube is generally: (A) negative with respect to the grid, (B) negative with respect to the cathode, (C) positive with respect to the cathode, (D) the same potential as the grid.

23. When a vacuum tube diode conducts, the electrons inside the tube flow from: (A) the cathode to the heater, (B) the heater to the cathode, (C) the plate to the cathode, (D) the cathode to the plate.

24. In order for a semiconductor diode to conduct or allow current flow: (A) the cathode must be biased negative, (B) the anode must be biased positive, (C) the anode must be biased negative, (D) both A and B.

25. The purpose of an electronic power supply is to furnish the proper operating __________ for circuit operation. (A) voltage, (B) resistance, (C) current, (D) both A and C.

26. The component part of a power supply which steps up or steps down the AC source voltage is the: (A) transistor, (B) transformer, (C) diode, (D) capacitor.

27. The transistor element whose function is similar to the grid of a triode tube is the: (A) plate, (B) cathode, (C) emitter, (D) base.

28. Transistors may be tested by utilizing a: (A) tube tester, (B) ohmmeter, (C) transistor tester, (D) both B and C.

29. Transistors are __________ sensitive devices, while vacuum tubes are __________ sensitive devices. (A) voltage, current, (B) resistance, electron, (C) current, voltage, (D) majority carrier, minority carrier.

30. Audio amplifiers amplify signals in the frequency range:
(A) above 30,000 MHz, (B) between 30,000 Hz and 30,000 MHz, (C) between 10,000 Hz and 40,000 KHz, (D) between 10 Hz and 20,000 Hz.

31. The term amplification refers to a circuit's ability to increase the ________ of an input signal.
(A) voltage, (B) current, (C) power, (D) all of the above.

32. An amplifier which causes a severe change in the signal characteristics, or shape, from input to output is said to be:
(A) providing a large gain, (B) causing distortion, (C) operating properly, (D) both B and C.

33. A popular style transistor amplifier circuit is designated as:
(A) common grid, (B) common emitter, (C) common plate, (D) common element.

34. The term used to describe "how much" amplification an amplifier can provide is called:
(A) gain, (B) bandwidth, (C) distortion, (D) frequency.

35. Which of the following component numbering schemes would identify a transistor?
(A) 1N4002, (B) 12AV6, (C) 2N3906, (D) C106B1.

Name: ____________

Date: ____________

Period: ____________

TECHNICAL GLOSSARY

AMPLIFICATION: The process of increasing the amplitude, voltage, current and/or power level of a signal.

AMPLIFIER: A device or circuit utilizing an electron tube, transistor, integrated circuit, or other amplifying component that increases the strength of the input signal.

ANODE: The plate or positive element in a vacuum tube, or the positive junction of a semiconductor diode.

BLEEDER RESISTOR: A resistor connected across the output of a power supply, which is utilized to slowly discharge the filter capacitor, and/or to improve voltage regulation.

CATHODE: A vacuum tube element, usually kept negative, which when heated provides a source of free electrons for tube operation.

DIODE: A two element electron tube, consisting of a plate and a cathode, normally utilized as a rectifier. Symbol: *

ELECTRON EMISSION: The escape of electrons from certain materials. In the case of a vacuum tube, electron emissions are produced by heating the cathode material, and referred to as thermionic emission.

ELECTRON TUBE: Two or more conductive elements (at least a cathode, and plate) enclosed in an evacuated envelope, and utilized to control electron flow in a circuit.

FILAMENT: A wire within an electron tube, which when heated boils off or produces electrons. The filament can also be referred to as a heater.

FULL WAVE RECTIFICATION: A rectifier circuit which produces two DC output pulses for each complete AC cycle input. A full wave rectified AC wave appears as follows: AC input , DC output

HALF WAVE RECTIFICATION: A rectifier circuit which produces one DC output pulse for each complete AC cycle input. A half wave rectified AC wave appears an follows: AC input , DC output

HEATER: Another name for the filament of a vacuum tube. In an indirectly heated cathode tube, the heater is a piece of resistance wire which heats up when current is passed through it. The heat given off causes the surrounding cathode sleeve to become hot, and emit electrons.

INPUT WAVE: The signal applied to a circuit.

*Symbol on last page.

Name: ______________

JUNCTION DIODE: A device consisting on one piece of N-type and one piece of P-type semiconductor material joined at a junction. Solid state diodes are able to rectify and detect. Symbol: 

N-TYPE MATERIAL: A doped semiconductor material which contains excess electrons, giving the material an overall negative charge.

OUTPUT WAVE: The signal produced or extracted from a circuit.

PENTODE: An amplifying tube with five elements including a cathode plate, control grid, screen grid, and a suppressor grid. Symbol: *

PLATE: An electron tube element designed to attract electrons. The plate, or anode, is biased positively and is part of the output circuit of an electron tube.

POWER SUPPLY: An electronic stage designed to provide various AC or DC voltages for equipment operation. The power supply circuit may include a transformer, rectifier, filter and/or regulator.

POWER SUPPLY FILTER: A type of filter circuit designed to smooth out or flatten the DC output pulses of a rectifier such that the rectified AC signal approaches a pure DC wave.

P-TYPE MATERIAL: A doped semiconductor material which has vacancies in its crystal lattice (holes), thus an overall positive potential is exhibited.

PULSATING DIRECT CURRENT: A current flow that is constantly changing in value, (amplitude) but not in direction. The following graph explains a positive direction, pulsating DC, current flow: 

RECTIFICATION: The process of converting an AC signal into a pulsating DC signal.

RECTIFIER: A device that changes alternating current into a pulsating direct current. It may be a vacuum tube diode, a junction diode, or a selenium unit, all of which operate on the principle of permitting current flow in only one direction.

SEMICONDUCTOR: A substance which can act as either a conductor or insulator depending upon temperature and impurities present in the material. Two common semiconductor materials are silicon and germanium.

TETRODE: A four element vacuum tube, which contains a plate, cathode, control grid, and screen grid. Symbol: *

TRANSISTOR: A three element semiconductor device containing a base, emitter, and collector, which can be utilized as an amplifier or high speed switch. The transistor is often referred to as a solid state triode. Symbol: *

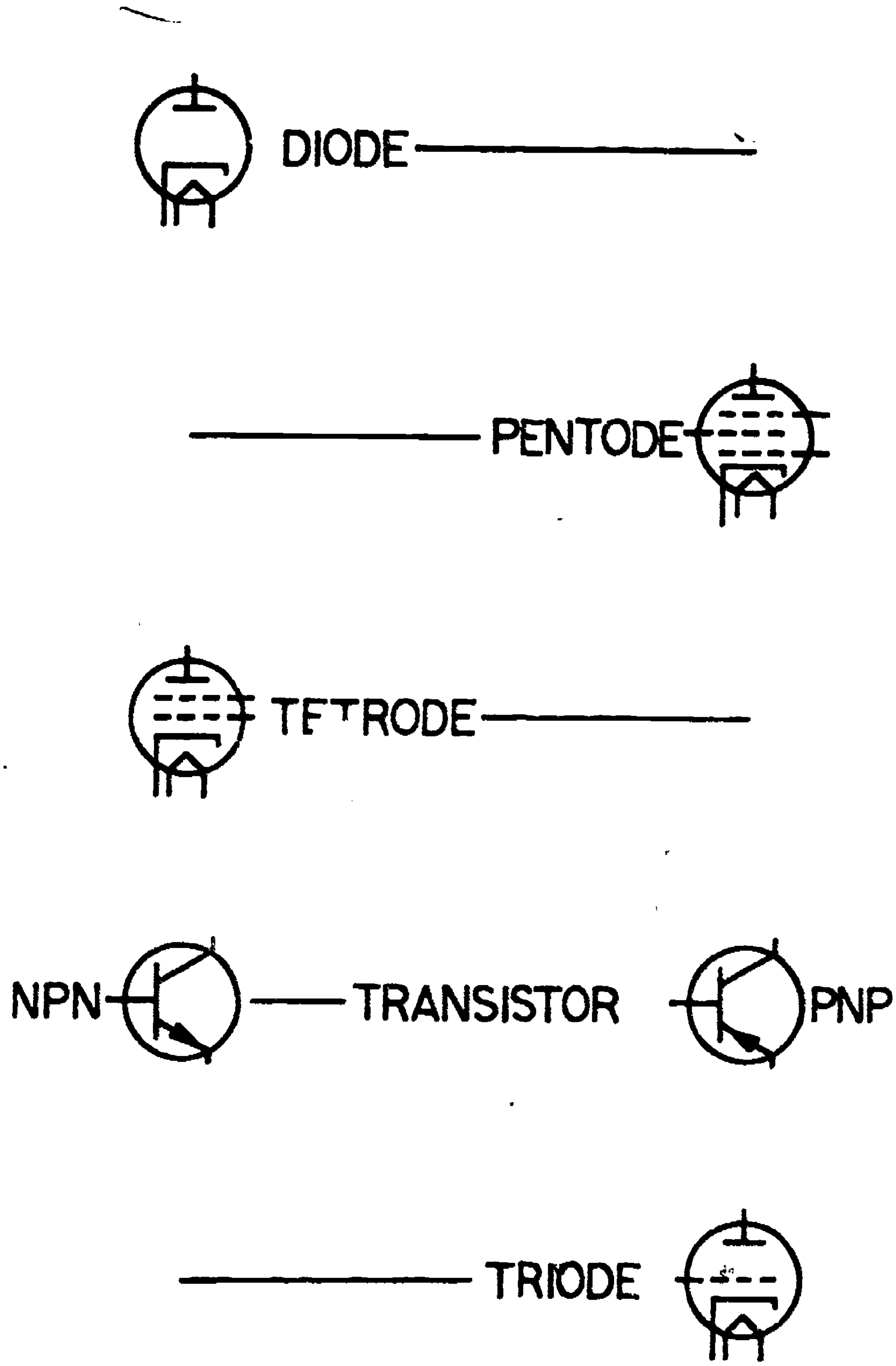
*Symbols on last page.

Name: ______________

TRIODE: A three element vacuum tube amplifying device which contains a plate, cathode, and control grid.
Symbol: *

VACUUM TUBE: A vacuum or gas-filled enclosure containing a number of elements (cathode, plate, grids). Electron flow from the cathode to the plate can be controlled so that an input signal can be amplified, rectified, or changed in shape.

SYMBOLS



SCORE:

GRADE:

Name: ______________

Date: ______________

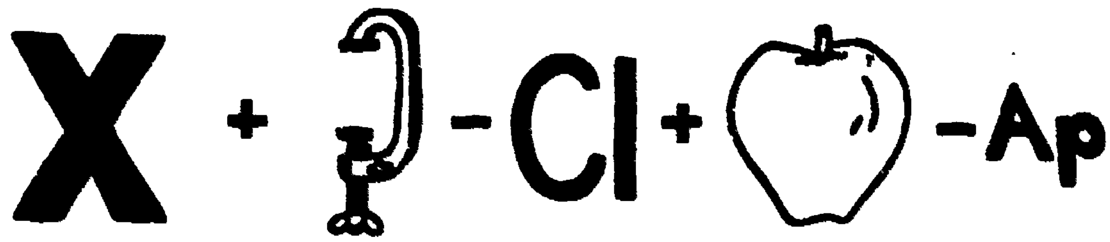
Period: ______________

WORKSHEET

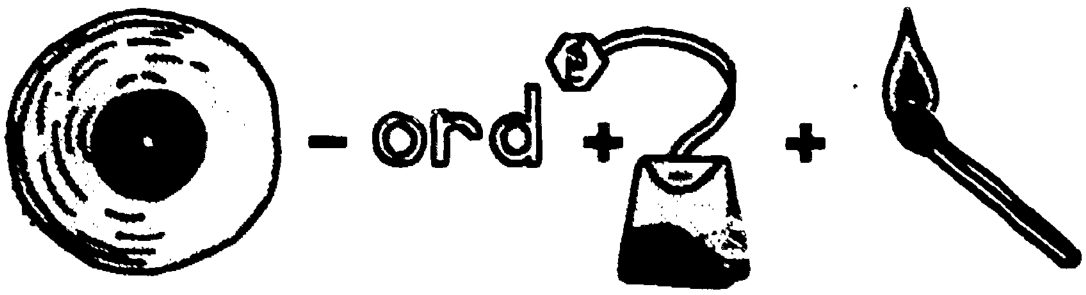
GLOSSARY CRYPTICS

Decode the cryptic messages below to identify the electronic term.

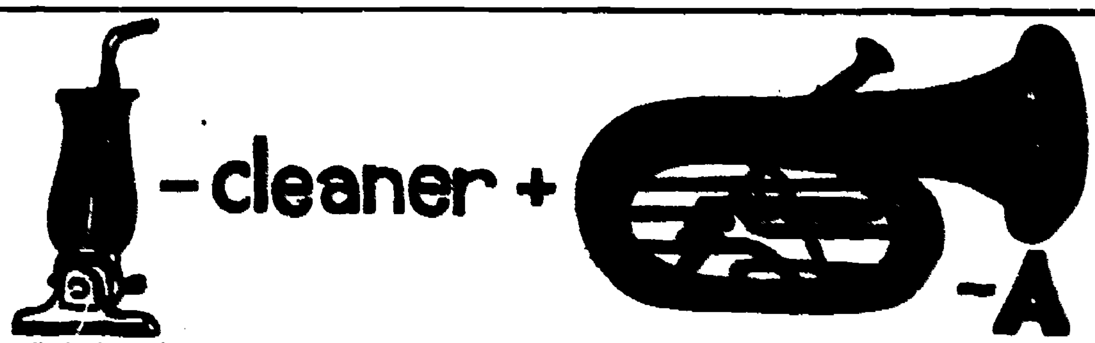
EXAMPLE:

A. 

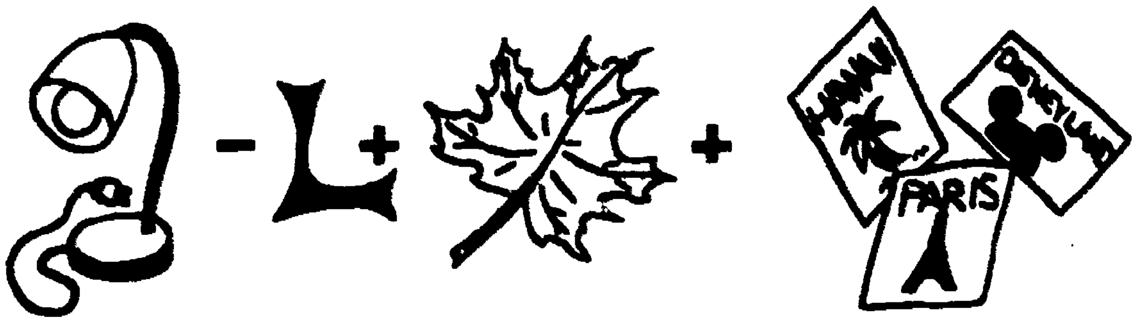
A. EXAMPLE

1. 

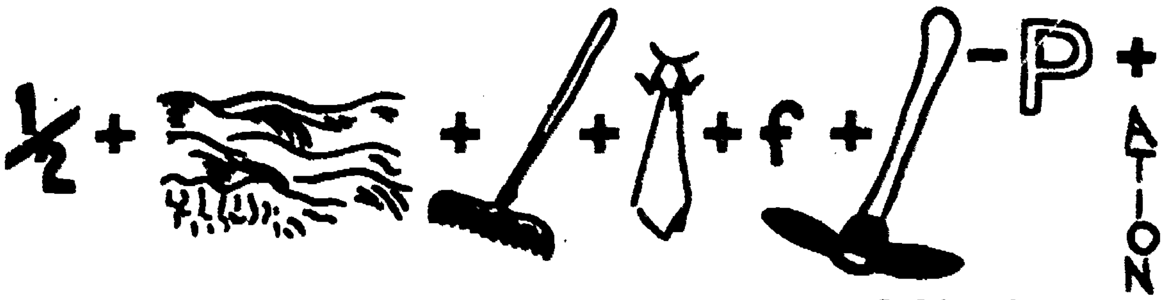
1. ______________

2. 

2. ______________

3. 

3. ______________

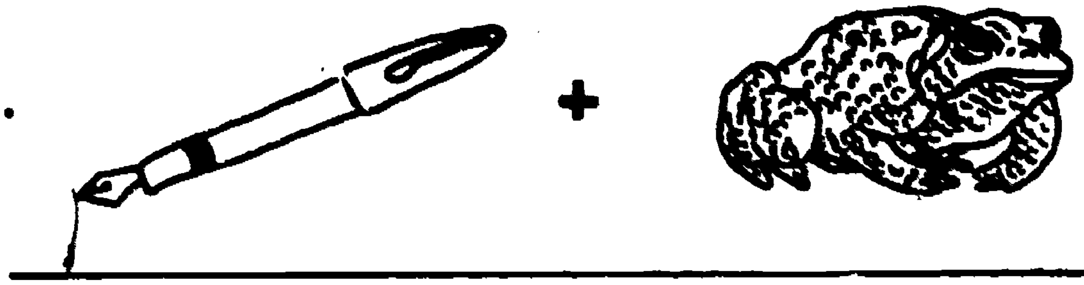
4. 

4. ______________

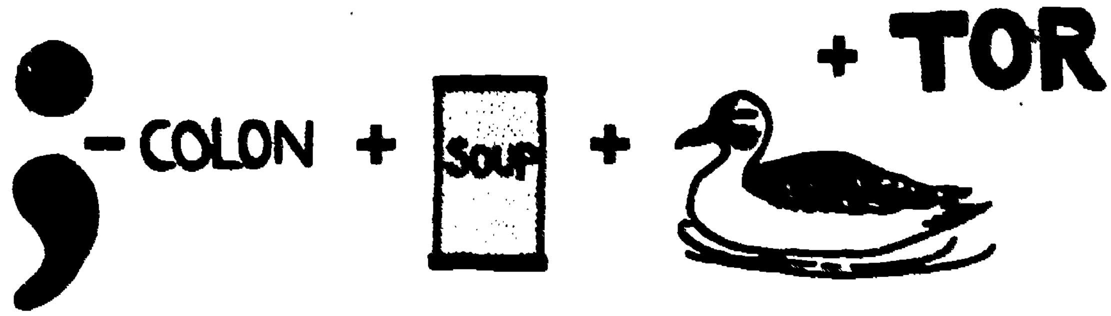
Name: ____________________

Date: ____________________

Period: ____________________

5. 

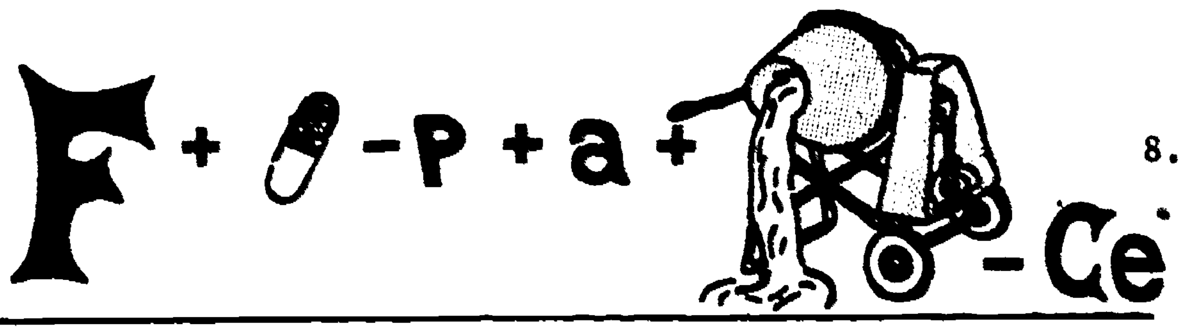
5. [ ]

6. 

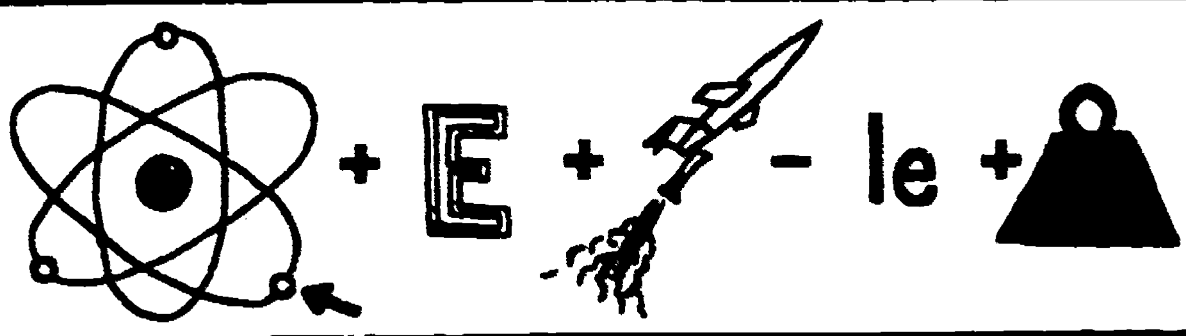
6. [ ]

7. 

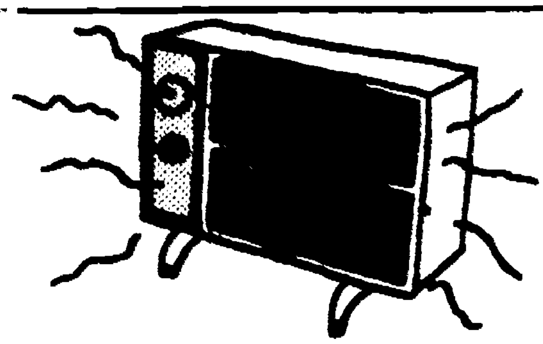
7. [ ]

8. 

8. [ ]

9. 

9. [ ]

10. 

10. [ ]

SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

VACUUM TUBES, JUNCTION DIODES, TRANSISTORS

1. Utilizing your knowledge of numbering systems, match the devices below with the appropriate number designation.

A. 

1. 1N4002
2. 12AU7
3. 2N3904
4. 330Ω
5. 5µF 50V
6. 1.2kΩ/8Ω

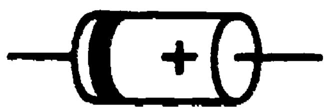
1A. ______

B. 

1B. ______

C. 

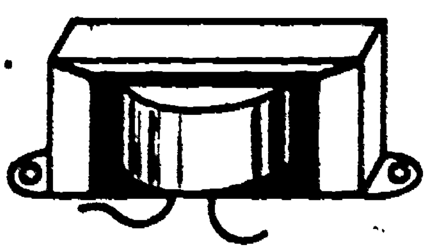
1C. ______

D. 

1D. ______

E. 

1E. ______

F. 

1F. ______

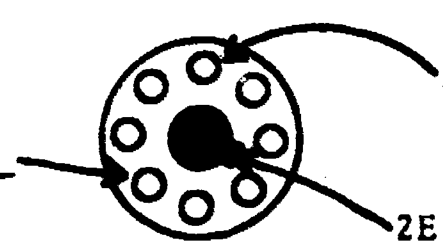
2. Study the basing diagrams of the following active devices, and label the leads or terminals.

2A.__________ 2B.__________

Junction Diode

2A. ______

2B. ______



2D.Pin# __________

2C.Pin# __________

2E.__________

Bottom View Octal Base Tube

2C. ______

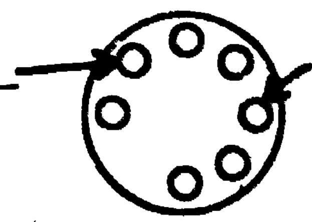
2D. ______

2E. ______

Name: ______________

Date: ______________

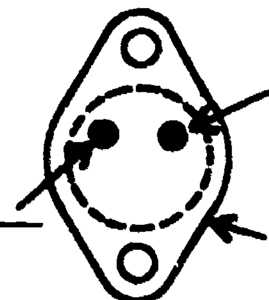
Period: ______________

2F.Pin# __________  2G.Pin# __________

Bottom View 7 Pin Minature Tube

2F. [ ]

2G. [ ]



2I. __________

2H. __________

2J. __________

Bottom View TO-3 Power Transistor Case

2H. [ ]

2I. [ ]

2J. [ ]

2K. __________

2M. __________

2L. __________

Bottom View TO-5 Transistor Case

2K. [ ]

2L. [ ]

2M. [ ]

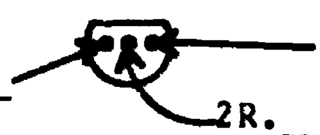
2P. __________

2N. __________ Base

Bottom View TO-92 Transistor Case

2N. [ ]

2P. [ ]



Base

2Q. __________

2R. __________

Bottom View TO-92 Transistor Case

2Q. [ ]

2R. [ ]

3. Using a semiconductor replacement or substitution guide locate two appropriate replacements for a 2N2222 transistor.

	Brand Name		Part #
3A.		-	
3B.		-	

4. List one possible substitution for a 12AX7 vacuum tube.

4. [ ]

5. Draw the pin out diagram for a 6V6 tube.

5. [ ]

Name: ____________

Date: ____________

Period: ____________

6. A tube tester generally has the ability to perform at least three functional tests on a vacuum tube. Identify these tests.

6A. [ ]

6B. [ ]

6C. [ ]

7. Describe how an ohmmeter can be used to test a junction diode.

8. Explain the procedure, in detail, for testing a transistor using an ohmmeter.

PNP

NPN

Name: ______________

Date: ______________

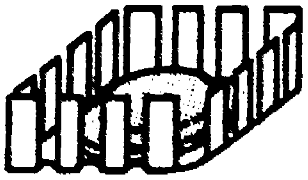
Period: ______________

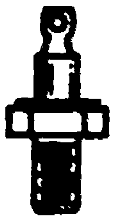
ADDITIONAL CHALLENGE

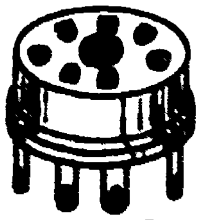
See if you can handle these!!!

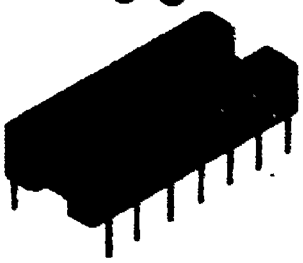
A. Identify the following items.

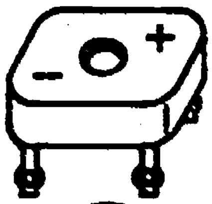
1. 

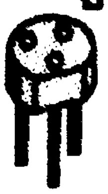
2. 

3. 

4. 

5. 

6. 

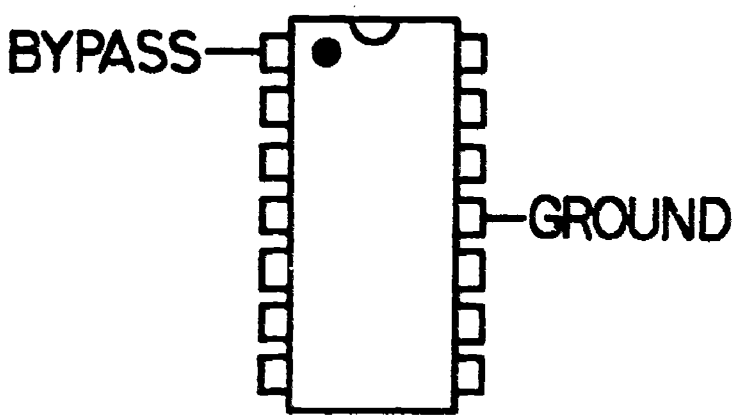
7. 

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________
6. ______________
7. ______________

Name:	______________________
Date:	______________________
Period:	______________________

Here's another!!

B. Complete the pin out diagram for the LM 380N integrated circuit amplifier shown below. Hint: use the National Linear Data Book to locate the integrated circuit.



Pin #1	Bypass
Pin #11	Ground
B1. Pin #2	
B2. Pin #3	
B3. Pin #4	
B4. Pin #5	
B5. Pin #6	
B6. Pin #7	
B7. Pin #8	
B8. Pin #9	
B9. Pin #10	
B10. Pin #12	
B11. Pin #13	
B12. Pin #14	

SCORE:

GRADE:

Name: ____________

Date: ____________

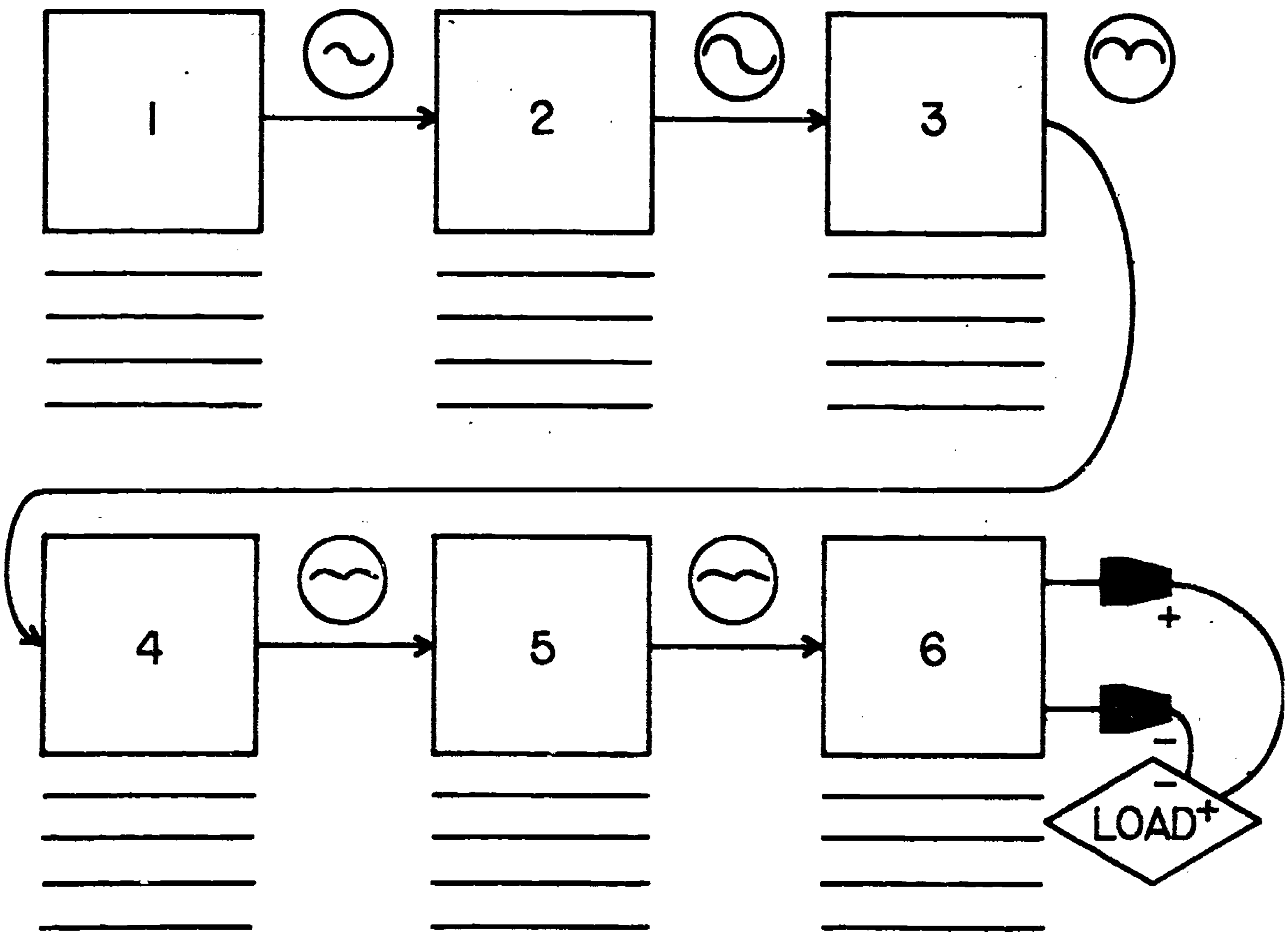
WORKSHEET

Period: ____________

POWER SUPPLY AND AMPLIFIER SYSTEMS

1. Utilizing the appropriate "puppets" on the attached page; cut out and place each puppet element in proper order to form a functional power supply stage. Below each power supply element give a short explanation of its function.

POWER SUPPLY



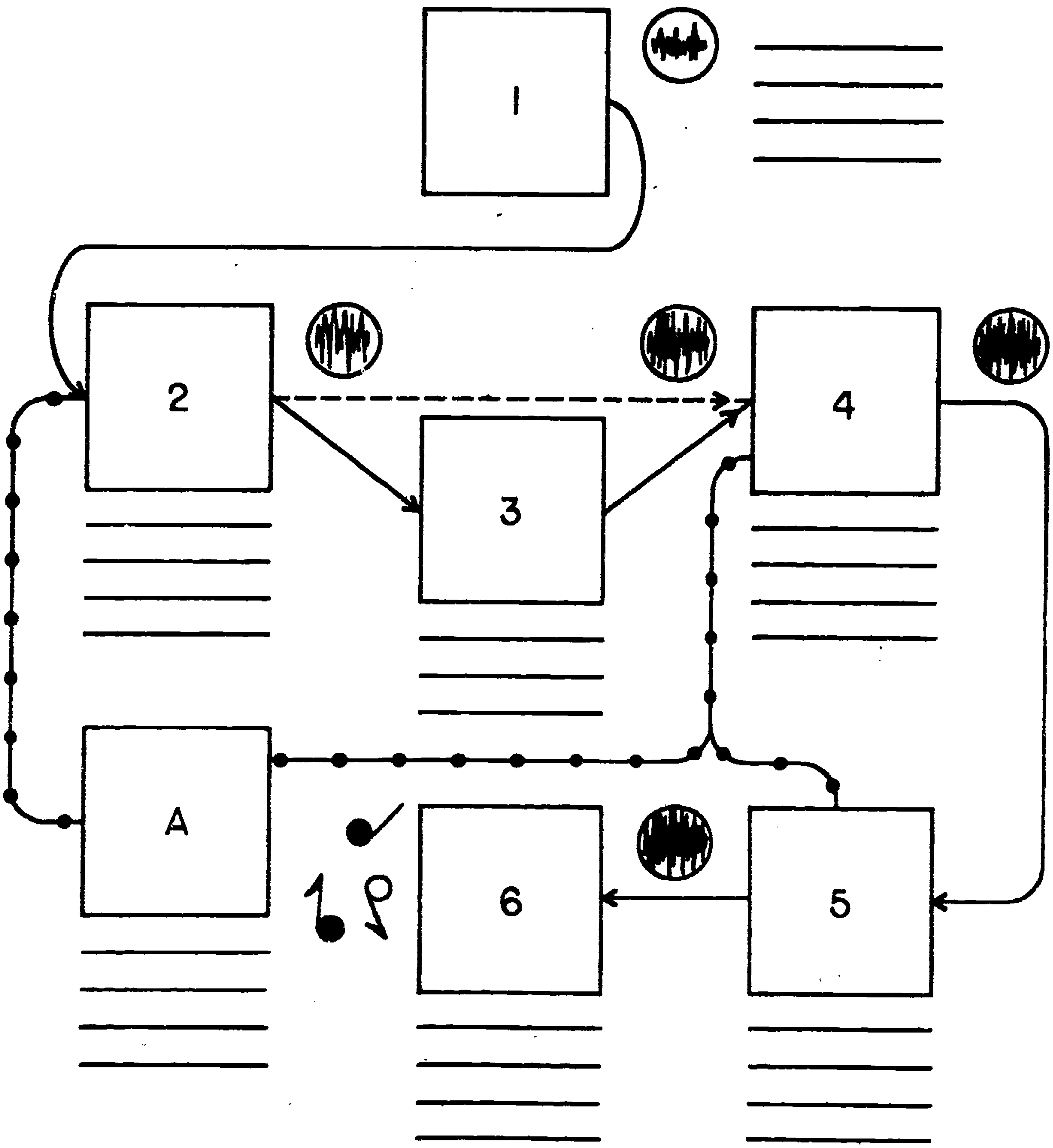
Name: ____________

Date: ____________

Period: ____________

2. Using the audio amplifier system puppets, assemble them in proper sequence, and explain the function of each element.

AMPLIFIER (AF)



SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

QUEST ACTIVITY

"UNIT 14"

1. An electron tube is mounted in a circuit by plugging it into what is called a tube: (A) holder, (B) receptacle, (C) base, (D) socket. 1. [ ]

2. The element of an electron tube which emits electrons is the: (A) cathode, (B) plate, (C) screen grid, (D) control grid. 2. [ ]

3. The diode is the simplest form of electron tube. (T-F) 3. [ ]

4. Electron tubes are often called __________ tubes. 4. [ ]

5. In normal operation, the plate of an electron tube is __________ charged with respect to the cathode. 5. [ ]

6. Electron emission from a heated cathode is known as: (A) space charge, (B) Franklin Effect, (C) thermonic emission. 6. [ ]

7. During the manufacture of most semiconductor devices, substances called impurities are added to semiconductor materials in a process called: (A) addition, (B) injection, (C) fusing, (C) doping. 7. [ ]

8. An n-type semiconductor material contains many free __________. 8. [ ]

9. A p-type semiconductor material is one that contains many __________. 9. [ ]

10. The most commonly used semiconductor materials are germanium and __________. 10. [ ]

11. A diode can act as a rectifier device because it will allow current to flow in only one __________. 11. [ ]

12. A device or a circuit which changes alternating current into direct current is called a __________. 12. [ ]

13. The process of smoothing out the output voltage of a rectifier circuit is called: (A) filtering, (B) smoothing, (C) leveling, (D) grading. 13. [ ]

Name: ____________

Date: ____________

Period: ____________

14. It is easier to filter the output voltage of a full-wave power rectifier than a half-wave rectifier. (T-F) 14. [ ]

15. The basic filtering device used in a rectifier circuit is an ________ capacitor. 15. [ ]

16. The ability of a power supply to maintain a constant output voltage regardless of the load applied to its output is called: (A) filtering, (B) regulation, (C) ripple voltage, (D) no-load voltage. 16. [ ]

17. The main purpose of a bleeder resistor is to: (A) discharge the filter capacitors, (B) reduce the current drain on the power supply, (C) improve power supply regulation, (D) both A and C. 17. [ ]

18. Name four basic "parts" or sections of a power supply circuit. 18A. [ ] 18B. [ ] 18C. [ ] 18D. [ ]

19. Draw the output wave form of a half wave rectifier circuit. 19. [ ]

20. Draw the output wave form of a full wave rectifier circuit. 20. [ ]

21. When a semiconductor diode becomes defective, it is usually ________ or shorted. 21. [ ]

22. When resistance testing a good diode it will show equal amounts of resistance in both the forward and reverse-bias condition. (T-F) 22. [ ]

23. An electron tube that contains a cathode, a plate, and a control grid is called a: (A) controller, (B) triode, (C) diode, (D) pentode. 23. [ ]

24. The purpose of the control grid in an electron tube is to control the number of ________ that pass from the cathode to the plate. 24. [ ]

Name: ______________

Date: ______________

Period: ______________

25. A pentode tube contains ________ grid elements. (A) 1, (B) 2, (C) 3, (D) 4. 25. [ ]

26. A transistor usually requires much less energy for its operation as compared to an electron tube that performs the same function. (T-F) 26. [ ]

27. The three elements of a p-n-p transistor are the emitter, the base, and the: (A) grid, (B) plate, (C) cathode, (D) collector. 27. [ ]

28. Technical information relating to transistor operation and application is given in a publication known as a transistor: (A) program, (B) type, (C) manual, (D) list. 28. [ ]

29. A transistor can be permanently damaged by excessive heat. (T-F) 29. [ ]

30. A finned metallic device on which a transistor is sometimes mounted to prevent it from becoming overheated is called a heat: (A) dissipator, (B) sink, (C) shield, (D) protector. 30. [ ]

31. If the emitter "arrow" in the schematic symbol of a transistor points away from the base, the symbol represents ________ transistor. 31. [ ]

32. Transistors are inserted into a circuit either by soldering their leads into the circuit, or by plugging them into a transistor ________. 32. [ ]

33. A defective transistor is usually either open or ________. 33. [ ]

34. A device or circuit which increases the amplitude (voltage or current) of an input signal is called an amplifier. (T-F) 34. [ ]

35. Draw a schematic diagram for a simple transistor amplifier. 35. [ ]

Name: ____________

Date: ____________

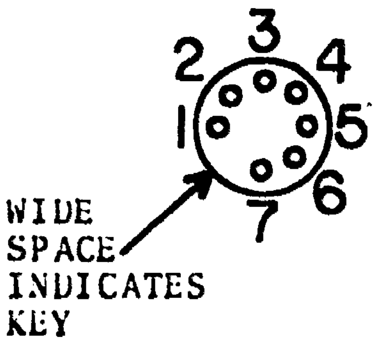
Period: ____________

INFORMATIONAL HANDOUT

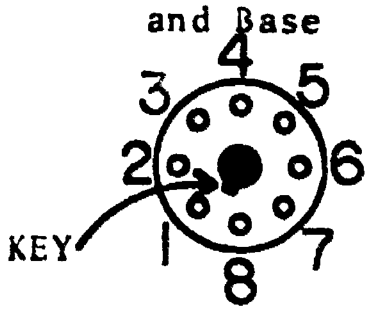
VACUUM TUBE AND SEMICONDUCTOR PACKAGES AND NUMBERING SYSTEMS

VACUUM TUBE - Cases and basing.

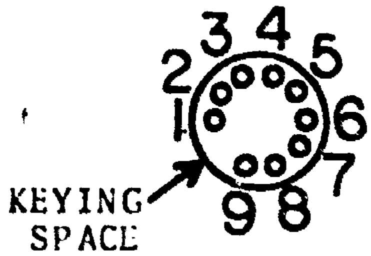
7-Pin Miniature
Tube and Base



Octal Tube
and Base



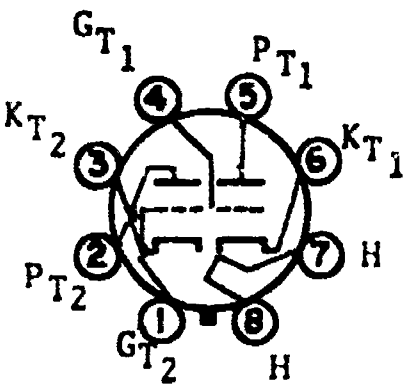
9-Pin Miniature
Tube and Base



Sample Pin-out Diagram

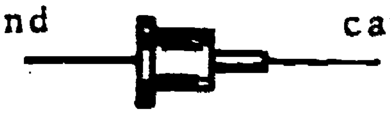
6SN7GTB

Glass octal type
Twin-triode



SEMICONDUCTOR DIODE - Cases and lead I.D.

anode end



cathode end

"Top hat" type
DO-1

Name: ____________

Date: ____________

Period: ____________

anode end  cathode end

"Bullet" type

anode end  cathode end

"Banded" type
DO-15

anode end  cathode end

"Symbol" style

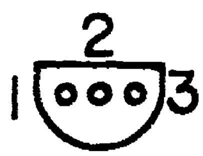
anode  cathode

DO-5

TRANSISTOR - Cases, base views, and lead I.D.

TO-5 Case

1. emitter
2. base
3. collector



TO-92 Case

1. emitter
2. base
3. collector

or

1. base
2. emitter
3. collectc

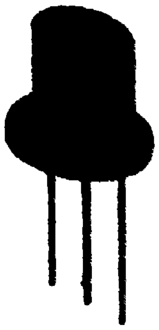
or

1. emitter
2. collector
3. base

Name: ____________________

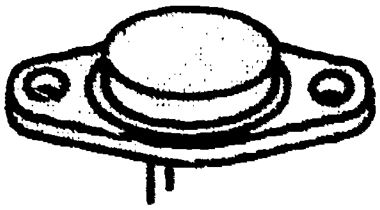
Date: ____________________

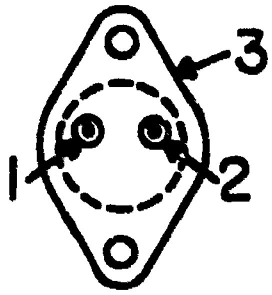
Period: ____________________



TO-98 Case

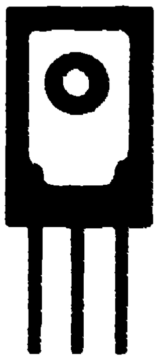
1. emitter
2. collector
3. base

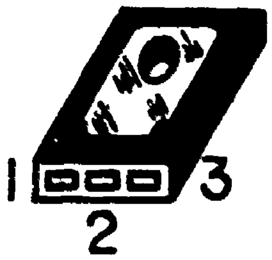




TO-3 Case

1. base
2. emitter
3. collector



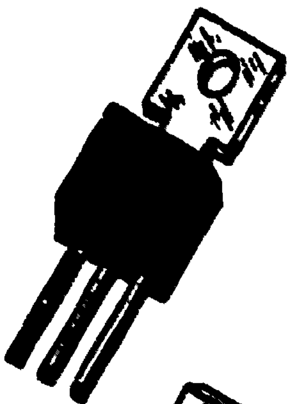


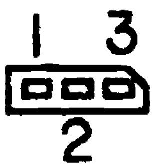
TO-126 Case

1. emitter
2. collector
3. base

or

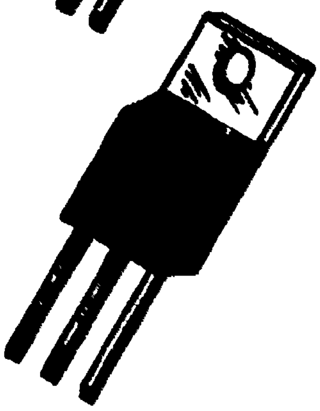
1. base
2. collector
3. emitter

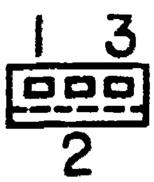




TO-202 Case

1. emitter
2. base
3. collector





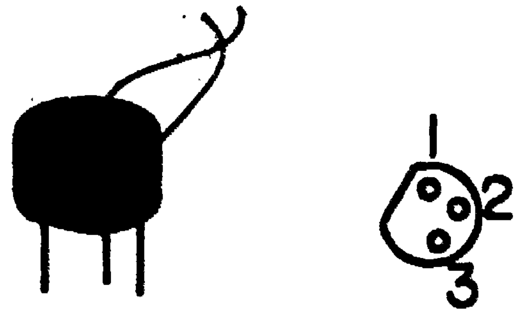
TO-220 Case

1. base
2. emitter
3. collector

Name: ______________

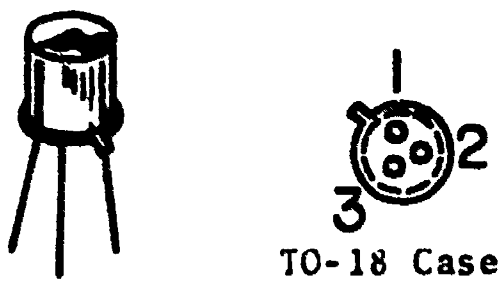
Date: ______________

Period: ______________



TO-5P (plastic pack) Case

1. emitter
2. base
3. collector



TO-18 Case

1. emitter
2. base
3. collector

ACTIVE DEVICE NUMBERING SYSTEMS

VACUUM TUBES:

Electron tubes are identified by a numbering system which contains information related to heater voltage, intended application, number of electrodes, type of envelope, and revisions - if any.

EXAMPLE:

6 SN 7 GT B (6SN7GTB)

- 6 — indicates approx. heater voltage
- SN — relates to intended application
- 7 — indicates the number of elements in the tube
- GT — indicates glass tube or envelope
- B — identifies the tube as a second revision to the original tube

SEMICONDUCTOR DIODES:

Most diodes or rectifiers are identified with a "1N" followed by other numbers

EXAMPLE:

1N 4004 (IN4004)

- 1N — indicates diode

NOTE: The "1N" prefix is not an exclusive designation. Many special purpose diodes or rectifiers will use other numbering designations.

Name: ______________

Date: ______________

Period: ______________

TRANSISTORS:

The prefix "2N" followed by other numbers is used to identify bipolar transistors (NPN and PNP transistors).

EXAMPLE:

2N 3904 (2N3904)

identifies transistor

AGAIN: This prefix is not universally applied, so many transisitors will be identified by other numbering systems.

Name: ____________

Date: ____________

Period: ____________

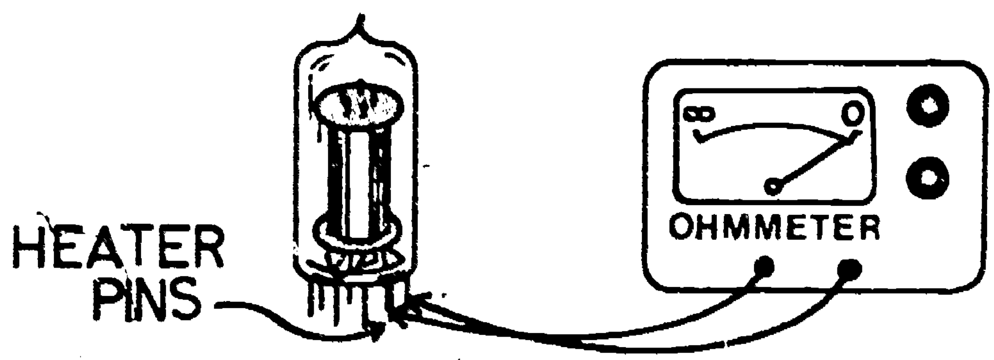
INFORMATIONAL HANDOUT

TUBE, DIODE, AND TRANSISTOR TESTING

TESTING VACUUM TUBES:

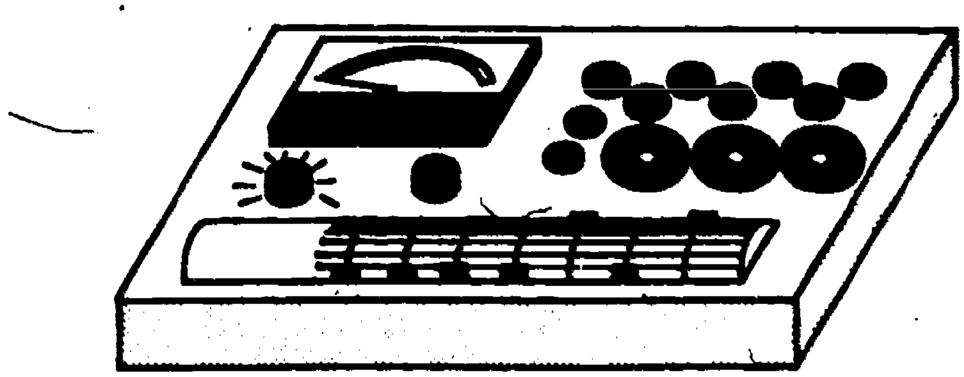
The standard instrument for testing electron tubes is the "tube tester," but, there are three other methods for identifying defective tubes which can be just as effective. These methods are; 1) visual inspection, 2) continuity tests and 3) tube substitution. As you know, the heater or filament of the vacuum tube glows "cherry" red when the tube is operating. If the filament is burnt out or open, the tube will not function. A quick visual inspection, with power on, can sometimes be used to locate a tube with a non-functional filament.

A visual inspection is not always conclusive, so you should consider performing a continuity test on the filament. To do this, locate the pins on the tube base that are connected to the heater, (you may have to refer to the pin-out diagram in the tube manual for your particular tube), then attach the ohmmeter leads to the two heater pins. A good heater will indicate continuity, or low resistance.



Another common tube fault is a short condition between the heater and cathode. To test for the existance of this type of short, connect one lead of your ohmmeter to a heater pin, and the other lead to the cathode pin. There should be no continuity.

Other tube checks, such as cathode emissions, gas condition, and conductance (quality test) can be accomplished by using a tube tester. Be sure to refer to the operating manual for your particular tube tester for instructions.



Name: __________

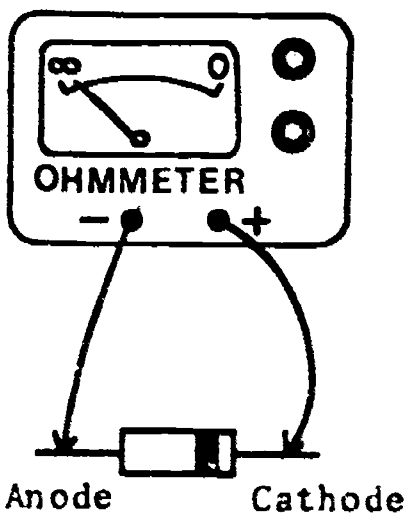
Date: __________

Period: __________

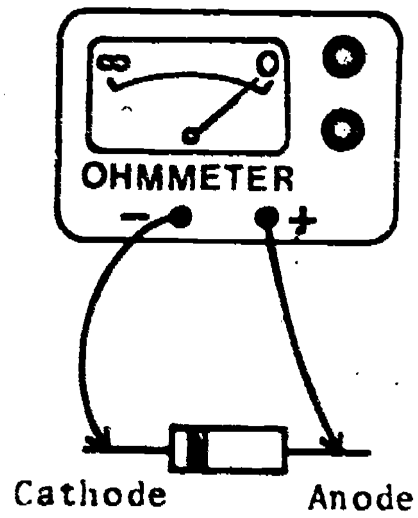
TESTING SEMICONDUCTOR DIODES:

If a diode becomes defective it is usually due to an open or shorted condition. This malfunction is generally caused by an excessive current flow through the semiconductor material of the diode. Often tube and transistor testers have the additional capability to test diodes and rectifiers. If you have these particular instruments available, they should provide an accurate test of diode function.

Another test of diode function can be performed with your ohmmeter. Resistance testing of a diode will identify an open or shorted condition. Recall, a diode is designed to allow current flow in only one direction, and to block current flow in the opposite direction. Thus, if the diode is forward biased, it will conduct and offer low resistance. But, if the diode is reverse biased, it will not conduct, offering high resistance. This technique of diode testing is illustrated below.



Reverse-Bias Condition - provides a high resistance reading.



Forward-Bias Condition - provides a low resistance reading.

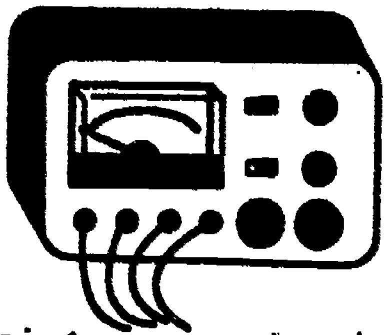
TESTING TRANSISTORS:

Transistors frequently become defective as a result of overheating, caused by excessive current flow. This condition can result in either shorts, opens, or deterioration in electrical characteristics and performance. Transistor testing can be accomplished by: 1) using a transistor tester, 2) substitution, or 3) using an ohmmeter. The transistor tester provides the most realistic indication of a transistors operational characteristics. Most testers will examine a transistor for leakage, opens, shorts, and gain.

Name: ____________

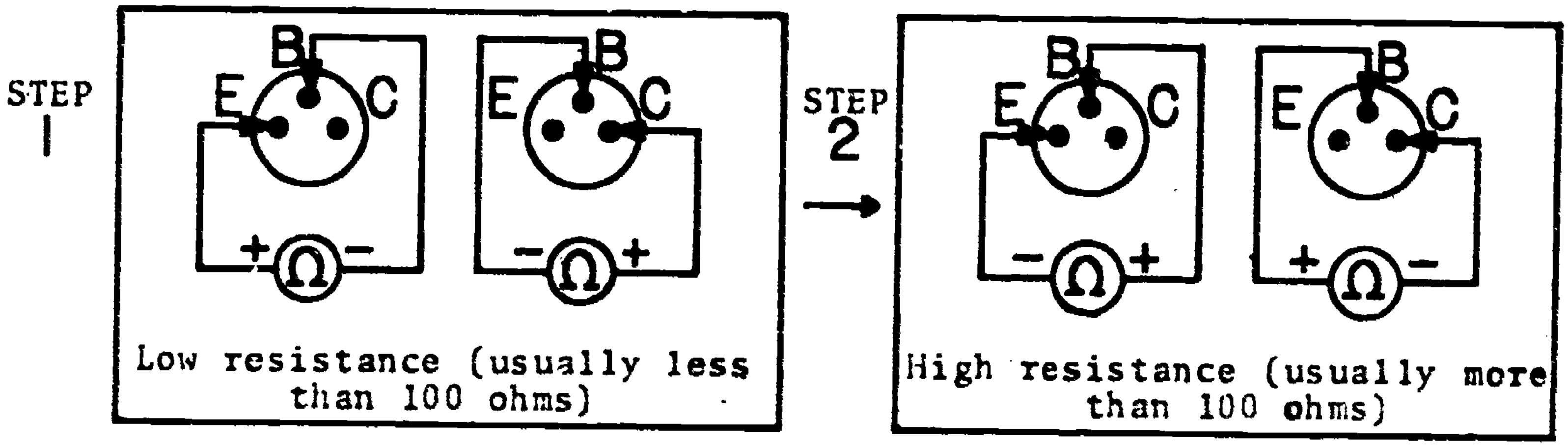
Date: ____________

Period: ____________

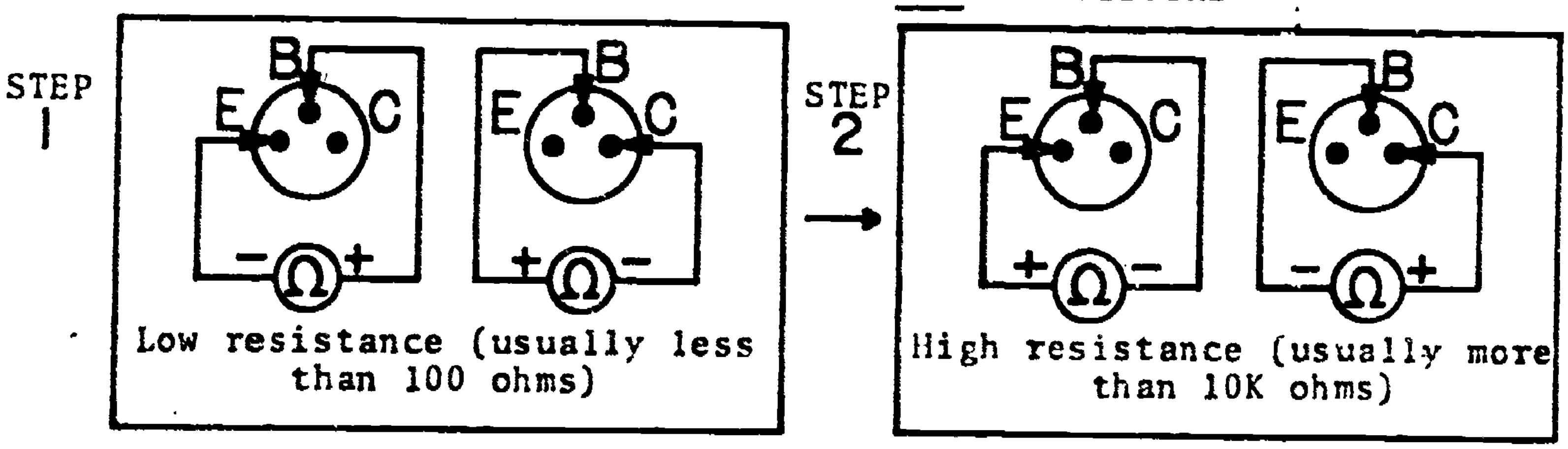


A suspected faulty transistor can also be checked by replacing it with a similar transistor of known quality. If the circuit problem is cleared up by this substitution, the original transistor was obviously bad.

A final method for testing transistors is to perform a resistance test using an ohmmeter. The resistance test will identify a short or open condition only, it will not give an accurate measurement of "electrical performance." When performing a resistance test, the best policy is to remove the transistor from the circuit or socket. Set the range selector of your meter to one of the lower positions, (ex. X10, or X100) and follow the procedure illustrated below.



RESISTANCE TEST FOR PNP TRANSISTORS



RESISTANCE TEST FOR NPN TRANSISTOR

NOTE: Most technicians regard substitution as the best test of any active component. So, if you are not satisfied, or you have some doubts about your instrument checks, do not overlook the possibility of direct part substitution.

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

ANSWER SHEET

EXAM ____

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.		■			26.		■			51.					76.				
2.	■				27.				■	52.					77.				
3.		■			28.				■	53.					78.				
4.	■				29.			■		54.					79.				
5.		■			30.				■	55.					80.				
6.	■				31.				■	56.					81.				
7.		■			32.		■			57.					82.				
8.		■			33.		■			58.					83.				
9.	■				34.	■				59.					84.				
10.	■				35.			■		60.					85.				
11.		■			36.					61.					86.				
12.		■			37.					62.					87.				
13.	■				38.					63.					88.				
14.		■			39.					64.					89.				
15.		■			40.					65.					90.				
16.			■		41.					66.					91.				
17.	■				42.					67.					92.				
18.				■	43.					68.					93.				
19.			■		44.					69.					94.				
20.			■		45.					70.					95.				
21.			■		46.					71.					96.				
22.			■		47.					72.					97.				
23.				■	48.					73.					98.				
24.				■	49.					74.					99.				
25.				■	50.					75.					100.				

*Show work for problems on back of answer sheet.

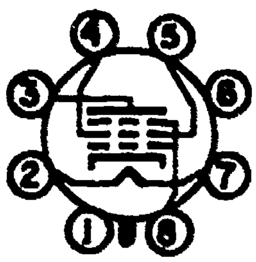
ANSWER KEY
UNIT 14

A. GLOSSARY CRYPTIC

1. rectifier
2. vacuum tube
3. amplification
4. halfwave rectification
5. pentode
6. semiconductor
7. plate
8. filament
9. electron emission
10. heater

B. VACUUM TUBES, JUNCTION DIODES, TRANSISTORS

1A. 2
1B. 1
1C. 3
1D. 5
1E. 4
1F. 6
2A. anode
2B. cathode
2C. 3
2D. 6
2E. key
2F. 2
2G. 5
2H. base
2I. emitter
2J. collector
2K. collector
2L. base
2M. emitter
2N. emitter
2P. collector
2Q. emitter
2R. collector
3A. Motorola HEP50015
3B. G.E. GE-20
4. 12DF7
5.



6A. cathode
6B. gas condition
6C. conductance
7. (subjective answer)
8. (subjective answer)

Extra Challenge

A1. integrated circuit
A2. TO-5 heatsink
A3. diode
A4. 7 Pin tube socket
A5. 14 Pin IC socket
A6. bridge rectifier
A7. transistor socket
B1. non inverting input
B2. ground
B3. ground
B4. ground
B5. inverting input
B6. ground
B7. V out
B8. no connection
B9. ground
B10. ground
B11. no connection
B12. V supply

C. POWER SUPPLY AND AMPLIFIER SYSTEM

<u>Power Supply</u>

1. AC input
2. transformer
3. rectifier
4. filter
5. regulator
6. DC output

Amplifier (AF)

1. phono cartridge
2. preamp.
3. tone and volume control
4. 1st AF amplifier
5. power AF amplifier
6. speaker

A. power supply

D. QUEST ACTIVITY

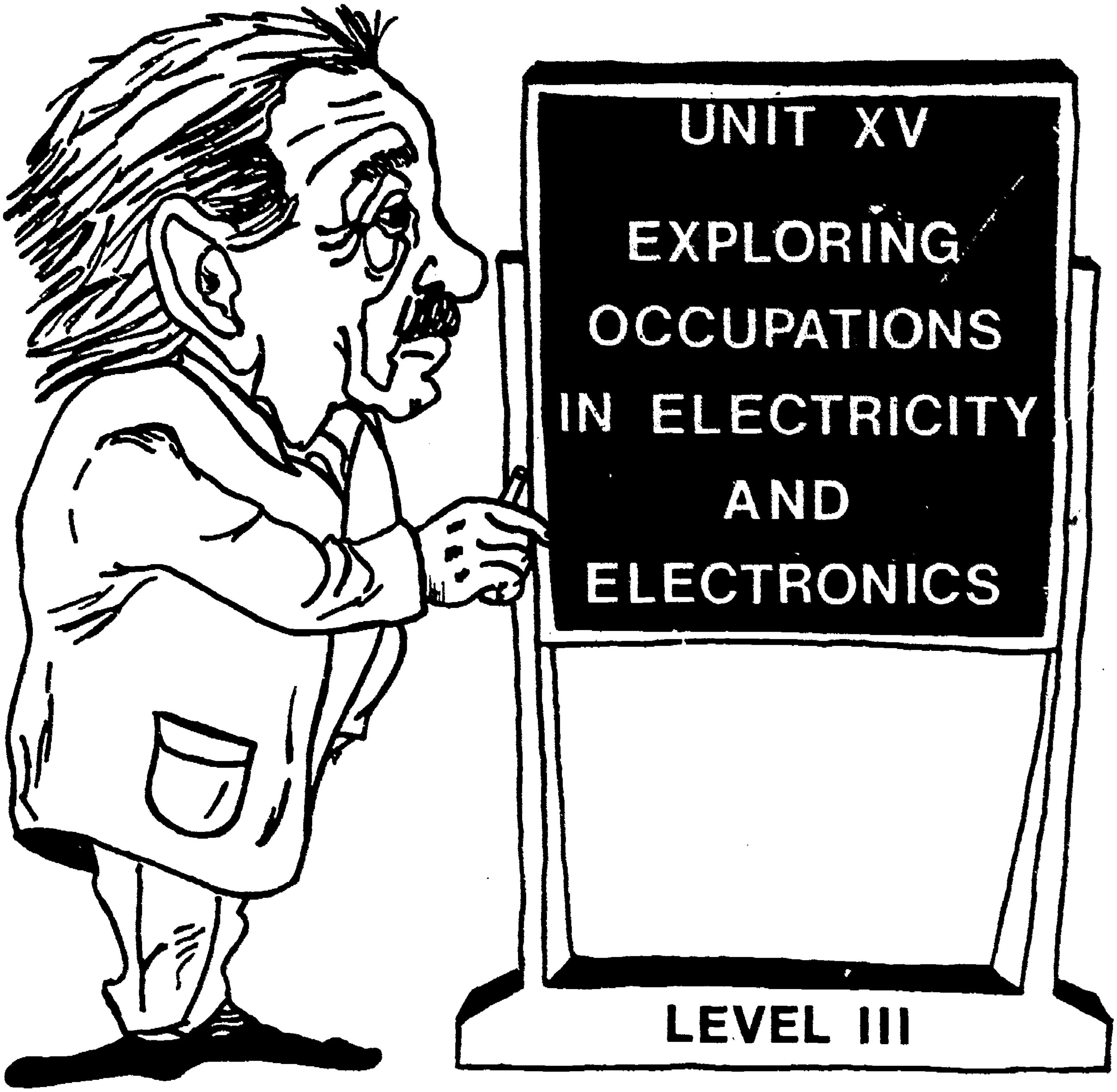
1. D
2. A
3. True
4. vacuum
5. positively
6. C
7. C
8. electrons
9. holes

ANSWER KEY UNIT 14
(continued)

10. silicon
11. direction
12. rectifier
13. A
14. True
15. electrolytic
16. B
17. D
18A. transformer
18B. rectifier
18C. filter
18D. bleader or regulator
19. 
20. 
21. open
22. False
23. B
24. electrons
25. C
26. True
27. D
28. C
29. True
30. B
31. an NPN
32. socket
33. shorted
34. True
35. (subjective answer)

ELECTRICITY / ELECTRONICS

CURRICULUM GUIDE
INSTRUCTIONAL MODULE



STATE OF CALIFORNIA
DEPARTMENT OF EDUCATION

NAME____________________

DATE STARTED______________

DATE COMPLETED____________

BY
R. E. LILLO
N. S. SOFFIOTTO

Title of Unit: Exploring Occupations in Electricity and Electronics

Time Allocation: 2 weeks

Unit Goal:

To acquaint students with the process of occupational exploration through awareness, and to concentrate occupational fields specifically available to the electronics technician.

Unit Objectives:

The student will be able to:

1. identify the four major occupational families in the electricity/electronics area.

2. focus specifically on those technical fields which are currently available to technicians, and demonstrate a knowledge of the occupational duties for each of the four fields.

3. indicate and access verbally those methods of job selection typically utilized when researching a possible occupational choice.

4. select one occupation that personally comes closest to their individual abilities, interest, and attitudes.

5. explain the essential preparation necessary to fulfill the qualifications for entering the specific occupation they have selected.

Evaluation:

The student will demonstrate his/her competence in terms of these measurable objectives based upon individual instructors acceptable performance criteria, which utilizes a combination of written, oral, and laboratory testing procedures.

Instructor References:

Exploring Occupations in Electricity and Electronics. Larry Heath, McGraw-Hill Book Co., 1976. Units 1-8.

Introduction to Electronics. Clyde Herrick and Bill Deem, Goodyear Publishing Company, Inc. 1973. Chapter 2.

Your Career in the World of Work. Milton K. Berlye, Howard W. Sams and Co., 1975. Chapters 1-13.

Overview:

Unit 15 is the last unit of this level, and represents a natural culmination point for all of the previous activity at this level, however, it can also be thought of as the "hook" in assisting students into the field of electronics.

This unit can be introduced by simply discussing what is success and its relationship to a working career. Next, the concept of a career plan based on specific facts, correlated decisions, and precise implementation can be presented and demonstrated.

Utilizing an organizational flow chart one can depict the major electricity/electronics occupational families or clusters. Once identification of clusters has been completed it allows an opportunity to explore one of the most prolific employment work areas, the technician field.

The next topic deals with self assessment and its relationship to the overall job selection process. Emphasis on what kind of person "I" represent today and what type of person "I" desire to be are essential when analyzing the selection process along with such considerations as salary, qualifications, conditions, etc.

The unit concludes with an overview on basic occupational research techniques, methods of obtaining additional occupational information, and an occupational quest activity for students. The quest activity can provide a vehicle for students to examine occupational materials in greater depth, and remember it can also be a means in evaluating unit and teacher effectiveness.

Suggested Presentation Hints/Methodology:

Follow the instructional module unit outline as a basic skeleton for curriculum presentation, however, note the following:

1. This unit was included also as a means to supplement the school guidance program, hence, draw upon their resources for knowledge related to current films, tapes, or any other audio visual materials that may coordinate with electronics and this specific unit on occupations.
2. When discussing a particular work area in a cluster such as the technician area, it is conceivable that a company would allow and arrange for an employee in that specific job title, to be released to give a classroom presentation, so make a contact with a local company prior to starting this unit.
3. Occupational slides can be easily taken by an instructor or sometimes given to the school by a company. Many industrial public relation departments will offer prepared slides to promote fundamental comprehension of products, processes, and people. When viewing these kinds of slides it is easy to inject other job related information.
4. Check the yellow pages of the telephone book for electronic manufacturing firms. Locate a company that will allow a schoo field trip to their business establishment, but take time with

Methodology continued:

the company's representative to describe the kinds of things that the students would be interested in viewing.

5. Do not forget to dramatize the sheer value of work in a person's life. Emphasize that most people work for economic, social, and psychological reasons. Remember to explain to students to be honest and realistic when completing all personal inventories within this unit.

Supplemental Activities and Demonstrations:

1. If the school has a career center, borrow the Occupational Outlook Handbook and have it available as a valuable resource item. Check with the local Bureau of Labor to obtain additional career opportunity bulletins and occupational reprints.
2. Have students informally evaluate their school subjects and activities. Make a table with several columns labeled subject, grade, enjoyment, and reason for rating. Discuss those subjects or activities that they feel can also contribute to future "Marketable skills."
3. Develop with the class a list of career opportunities that were available in the past, but are no longer in existence. Explain the implication of this in their job selection process. Now have students turn in a list of career opportunities that are presently declining and which in the future may no longer be available.
4. Explain the procedures for preparing an itinerary or plan for visiting another country. Now discuss the similarity when preparing a plan for a specific career goal.

Instructional Module Contents:

1. Unit Outline (overhead)
2. Pre-Post Test (keyed)
3. Technical Glossary
4. Worksheet (vocabulary) - Scrambled Word Puzzle
5. Worksheet - Interest Activities, and Hobbies Assessment
6. Worksheet - Personal Profile Analysis
7. Worksheet - Career Research in the Electricity/Electronics Area
8. Worksheet - Interview Evaluation Assignment
9. Quest Activity
10. Informational Handout (Occupations Within the Electronics Technician Work Area)
11. Unit Module Answer Key

XV. Exploring Occupations in Electricity and Electronics

A. Review Cluster breakdown

B. Exploration of occupational fields for the electronic technician

1. Introduction

2. Governmental contract activities

3. Industrial electronic plant activities

4. Consumer market activities

5. Allied occupational fields

C. Methods of researching an occupational choice

1. Assessment of individual abilities, interests, and attitudes

2. Selection of one MAJOR WORK AREA based on abilities, interests, and attitudes

3. Research techniques
   a. Significant occupational data to be considered

   b. Sources of occupational information

4. Student occupational quest activity

Test Number _____

LIII-U15

UNIT EXAM

EXPLORING OCCUPATIONS IN ELECTRICITY AND ELECTRONICS

IMPORTANT-

Indicate your responses on the answer sheet only. Fill in the box corresponding to the correct answer to each question - there is only one correct answer for each question.

1. In the United States, generally, people will work at least forty years in a variety of occupations. (T-F)

2. The way an individual responds or feels about their career has great importance on their overall satisfaction with life. (T-F)

3. The occupation you select really is only important during the working day and has little influence on your personal life. (T-F)

4. Women are generally unsuccessful in an electronics occupation because of the physical dexterity required. (T-F)

5. Most adults in our society are well satisfied with their income and life style, they indicate that career planning is not that essential to obtaining career goals. (T-F)

6. A quick method of checking the demand in a certain major work area is to read the "Help Wanted" section of your local newspaper. (T-F)

7. An important aspect of researching careers and indicating possible choices is to first know and understand yourself. (T-F)

8. A good guide to utilize when deciding on career goals is never make a career decision unless you are absolutely certain of success. (T-F)

9. When seeking employment it is wise to first contact private employment agencies because they provide immediate placement. (T-F)

10. The Dictionary of Occupational Titles is a well illustrated handbook that can act as a career source for approximately 187 different occupations. (T-F).

11. An apprentice is generally a worker, in a trade, that has to be taught both on the job and in special classes. (T-F)

12. Many companies today need between three and ten technicians for every engineer they have employed. (T-F)

13. People who go into the "assembly" occupational area must have a strong mathematics and science background. (T-F)

14. Many of the recent discoveries in the electronics field have come about because of the work of engineers.

15. Technicians generally receive their basic training from either military, vocational technical schools or community colleges.

16. Many career experts feel that the most important factor in an individuals job success is the salary being paid. (T-F)

17. The basic behavior patterns that are developed in high school will not affect our job performance in the future. (T-F)

18. An individuals values are the beliefs that they consider to be important. (T-F)

19. Hobby, interest, or personality assessments are of little or no value when researching a career choice. (T-F)

20. The most important factor in career success is "who you know", and if they will assist you economically.

21. It is important to be aware of the duties employees perform in any career that you are analyzing. (T-F)

22. As long as an individual enjoys what they are doing or are performing a social service, the salary should be of no concern. (T-F)

23. An individual is born with a certain unique personality and really there is not very much that can alter it. (T-F)

24. An Electricity/Electronics Occupational Cluster refers to a major family of related occupations that may have a common function. (T-F)

25. One method of exploring occupations in detail is to conduct a personal job interview in an occupation that interests you. (T-F)

Name: ____________

Date: ____________

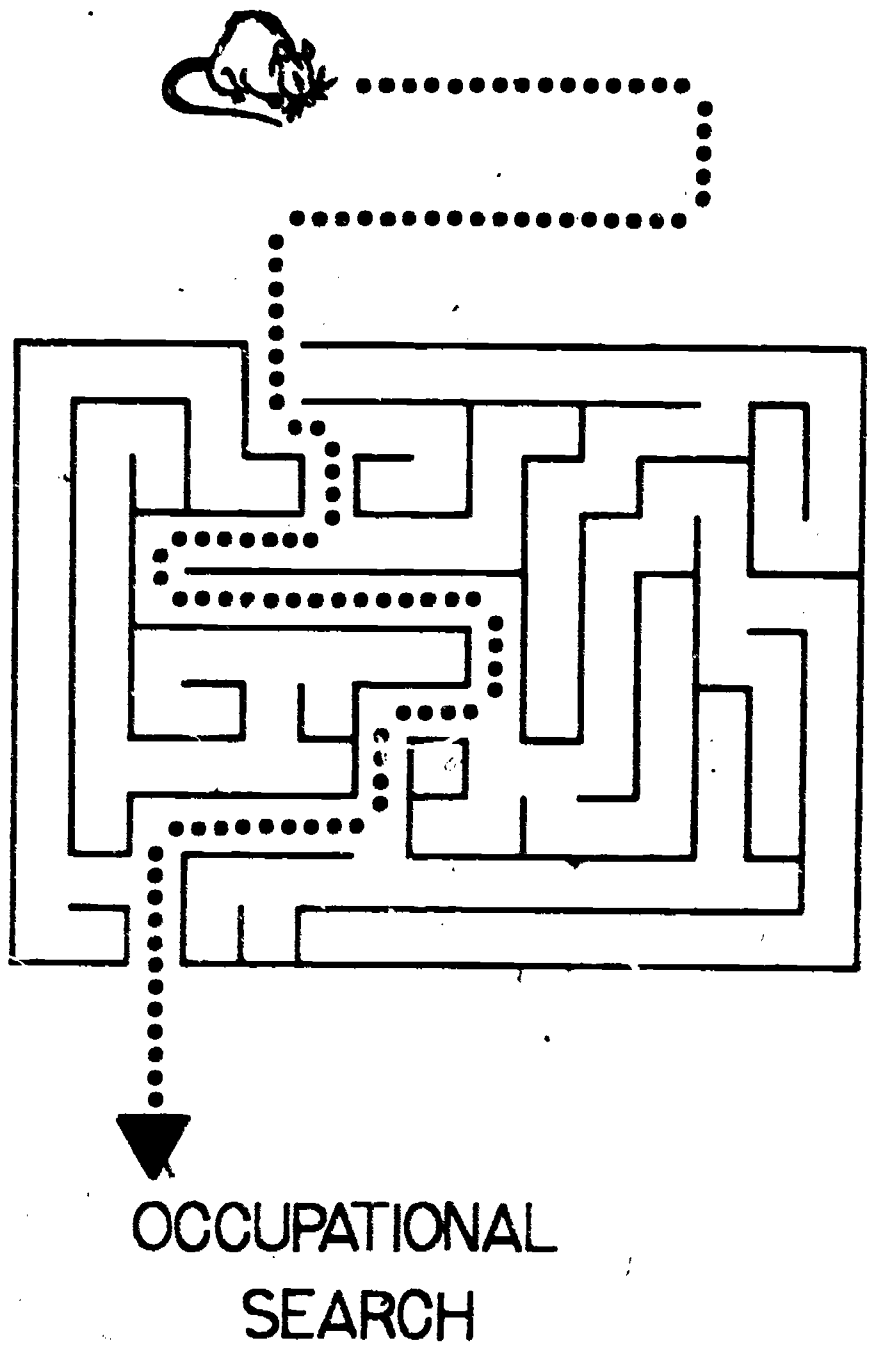
Period: ____________

TECHNICAL GLOSSARY

APPRENTICESHIP:	Apprenticeship is a training system in which a person learns a skilled trade on the job under an experienced craft worker, and generally they attend classroom instruction at night to further enhance their skill development.
APTITUDE:	A natural talent or ability which allows learning of certain skills in an easier fashion. In some careers, such as music, a large share of natural talent is necessary in order to be successful.
CLUSTER:	Refers to an occupational group or a major family of related occupations that may have similar characteristics and common purpose.
COMPETENCY:	The skill or knowledge required of an individual in order to perform a typical job task successfully within a specific occupational area.
DICTIONARY OF OCCUPATIONAL TITLES:	A book which provides a classification structure under which most jobs are arranged according to their interrelationships. Job titles and a definition of what each job entails are several reasons why this book is a vital resource document. Abbrev. D.O.T.
ENTRY-LEVEL JOBS:	Occupations that can be filled by people with a minimum of specialized training, and usually reflect the introductory level of employment opportunities.
INVENTORY:	A system of analyzing or appraising a given subject by utilizing tables or statements, then carefully answering those statements in an honest manner. Evaluation of the results will allow specific insight into the subject being tested.
MAJOR WORK AREA:	Occupational categories contained within an individual cluster. The major work areas can also be subdivided into related job titles for further analysis.
OCCUPATIONAL OUTLOOK HANDBOOK:	This handbook describes approximately 850 specific occupations in terms of task performed, training, qualifications, and other significant data related to occupation
QUALIFICATIONS:	A list of achievements or qualities an employer will look for when considering an individual for employment. Qualifications will vary directly with the kind of employment being offered.
TRADES:	A highly skilled occupation or craft requiring a specialized program of training. This program of learning is referred to as apprenticeship training.

UNION: An organization, made up of workers, which functions generally to improve working conditions and to secure higher wages for its membership. About 17 million workers in the United States belong to labor unions.

WORLD OF WORK: This phrase is utilized when one desires to indicate a realistic assessment of jobs, occupations, or careers which encompass all employable areas where career opportunities are available.



SCORE:	
GRADE:	

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

VOCABULARY - SCRAMBLED WORD PUZZLE

Unscramble the letters below to uncover the terms.

EXAMPLE:

A. EIRSNUACN — A. INSURANCE

1. ATESRD — 1. ______
2. JAMRQ KORW ARAE — 2. ______
3. PRETAPPCINEHSI — 3. ______
4. PETYENCMOC — 4. ______
5. INOUN — 5. ______
6. INOVNRYET — 6. ______
7. DOWRL FO KORW — 7. ______
8. EUATIPDT — 8. ______
9. TENYR VELEL SOBJ — 9. ______
10. RECUSLT — 10. ______
11. CUPOLAIONATC LOUTOKO BADNKOHO — 11. ______
12. SALIFIQUATINCO — 12. ______
13. TIADICRYON FO LANOITOUCPAC SETLIT — 13. ______

Fill in the missing letters to complete the vocabulary word.

14. HINT: A large group of similar jobs. — 14. _ _ U S _ E _

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

INTEREST, ACTIVITIES, AND HOBBIES ASSESSMENT

Each person is unique and has certain "things" he or she likes or dislikes to do. Complete the following inventory; it will give you an idea of what you consider interesting and fun to do!

Write the number 5 in front of the item if it is extremely interesting to you;

Write the number 4 if it is very interesting to you;

XXXX XXXX Write the number 3 if it is fairly interesting to you; XXXX XXXX

Write the number 2 if it is slightly interesting to you; or

Write the number 1 if it is not interesting to you at all.

EXAMPLE:

2 T.V. watching

- Animals/pets
- Appliance/Household repairs
- Arts/crafts
- Automotive customizing and repair
- Ballets and opera
- Bowling
- Building kits/projects
- Camping
- CB/Ham radio
- Chess
- Coin/stamp collecting
- Computer/TV games
- Cooking

Name: ____________

Date: ____________

Period: ____________

- Cycling
- Dancing
- Drafting
- Fishing
- Fixing things/tinkering
- Golf
- Hunting
- Jogging
- Model Building
- Motor/dirt biking
- Music
- Photography
- Ping pong
- Plays/concerts
- Political activities
- Radio control devices
- Reading
- Sailing/boating
- Science experiments
- Sewing/handicrafts
- Skiing-snow/water
- Spectator; athletic events
- Stereo listening
- Swimming
- Tennis
- Travel
- Volleyball/badminton

Name: ____________________

Date: ____________________

Period: ____________________

In the spaces below indicate, from the list just completed, the items you rated "very interesting" or "extremely interesting" and which you like to do best.

TOP 5

- ____________________ 1st choice
- ____________________ 2nd choice
- ____________________ 3rd choice
- ____________________ 4th choice
- ____________________ 5th choice

In the space provided below indicate <u>how</u> each of those top 5 items, which you have indicated are your favorites, might be utilized in some way on a future occupation or job that you select!

(choice) (Utilization)

1. ____________________ .... ______________________________

____

____

2. ____________________ .... ______________________________

____

____

3. ____________________ .... ______________________________

____

____

4. ____________________ .... ______________________________

____

____

5. ____________________ .... ______________________________

____

____

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

PERSONAL PROFILE ANALYSIS

All of us want to be "successful" yet to achieve this end we must plan our occupational choice, and assess our individual abilities, interests, and attitudes honestly.

To begin with, you must be "aware" of the person you are, thus the purpose of this assignment becomes obvious.

Complete the following personal profile in detail and again be completely honest in evaluating your assets and liabilities.

I. Personality

Use a check (✓) when completing this section!

Personality Profile

Trait	Good	Fair	Poor
Attitude			
Courtesy			
Dependability.			
Drive.			
Health			
Honesty.			
Humor.			
Initiative			
Loyality			
Morality			
Neatness			
Personal appearance.			
Pleasantness			
Punctuality.			
Sincerity.			
Tact			
Temperament.			

Personality Profile Analysis:

My personality has several strong points as indicated on the Personality Profile. Listed below are what I feel are the most attractive traits.

1. ____________ 3. ____________

2. ____________ 4. ____________

474

Name: ____________

Date: ____________

Period: ____________

I have also discovered a need to improve these specific traits.

1. ____________ 3. ____________

2. ____________ 4. ____________

II. Interest

The hobbies that interest me the most at present are as follows:

1. ____________ 3. ____________

2. ____________ 4. ____________

The classes in school that are the most exciting to me are:

1. ____________ 3. ____________

2. ____________ 4. ____________

I have always liked to work with: (check 1 or more)

People ☐ Things ☐ Ideas ☐ All ☐

III. Abilities

My main scholastic attributes are: (check 1 or more)

Reading ☐ Verbal ☐ Mechanical ☐ Mathematical ☐

My overall grade point average in high school to date is: ____________.

IV. Values

Indicate your ranking of the specific values listed. Use a number only once and the most important value should be labeled #1 and the least important value #10. Place your personal rating in the circle provided.

Name: ______________________

Date: ______________________

Period: ______________________

(value)	(rating)	(value)	(rating)
Fame	○	Family	○
Health	○	Money	○
Power	○	Religion	○
Humanism	○	Social	○
Creative	○	Artistic	○

V. Decision

Considering the information on this profile and other career assessment data, I feel that I would like to further explore careers related to:

____

SCORE:
GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

CAREER RESEARCH IN THE ELECTRICITY/ELECTRONICS AREA

An important part of exploring occupational information involves the collection of specific career data which can possibly be utilized in forming an appropriate career goal.

Referring to the attached Electricity/Electronics Organizational Cluster Chart, and all other career resource materials available in the classroom, complete the following occupational profiles as directed.

Select three careers which interest you from any Major Work Area found within a particular Cluster and use the format indicated below as a layout guide. Turn in "3" completed profiles neatly stapled together.

Name: ______________ Due Date: ______________

I. Research profile # ________.

II. Name of Major Work Area Selected: ______________

III. Basic duties and responsibilities:

IV. Specific working conditions:

V. Salary range:

VI. Present and future occupational outlook in this career:

VII. Educational and/or special training requirements:

VIII. Availability of local educational or training institutions:

IX. Advantages and disadvantages about this career choice:

X. List your sources of information in completing this profile (bibliography).

SCORE:
GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

CAREER RESEARCH IN THE ELECTRICITY/ELECTRONICS AREA

Major Occupational Families

- Cluster #1.0 — Electronic Manufacturing & Services
- Cluster #2.0 — Electrical Servicing & Repair
- Cluster #3.0 — Electrical Construction
- Cluster #4.0 — Miscellaneous Technical Occupations

Major Work Areas	Major Work Areas	Major Work Areas	Major Work Areas
1.1 Processing	2.1 Electrical Instrument	3.1 Electricians	4.1 Engineering
1.2 Assembly Preparation	2.2 Coil, Motor, and Generator	3.2	4.2 Education
1.3 Assembly	2.3 Appliance and Fixture	3.3	4.3 Radio/Television Broadcasting
1.4 Inspecting and Testing	2.4 Communication Equipment	3.4	4.4
1.5 Set-up Maintenance	2.5 Transportation Equipment	3.5	4.5
1.6 Technician	2.6 Electrical Utilities	3.6	4.6
1.7 Special Occupations	2.7 Misc. Electrical Equipment	3.7	4.7
1.8 Supervising	2.8	3.8	4.8
1.9 Repair and Servicing Electronic Equipment	2.9	3.9	4.9

LIII-U15-19

SCORE:

GRADE:

Name: ____________

Date: ____________

Period: ____________

WORKSHEET

INTERVIEW EVALUATION ASSIGNMENT

One method of exploring occupations in detail is to conduct your own interview. This allows a unique opportunity to find out about specific jobs and how people feel about their career selection.

Introduce yourself to the person you are interviewing and be mature in your questioning. Use the outline below as a question guide during the actual interview process. Interview "1" individual who is working presently within the cluster that your career interests are focused on!

Name of person interviewed: ____________

Company: ____________

Date of interview: ____________

Assignment due: ____________

1. What is the title of your job?
2. How long have you been on this job?
3. How did you get started in this kind of work?
4. What are some of the tasks that you perform on the job?
5. What training and/or education is needed?
6. What do you like best about your job? What do you like least? Why?
7. What future career goals do you have?
8. What do you think are some important things that a person who is considering going into this kind of work should know about it?
9. Does this kind of work have a good future?
10. What kinds of high school courses might provide a solid foundation for this job.
11. Once on the job, is additional schooling or training required or advised?

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SCORE:

GRADE:

Name: ______________

Date: ______________

Period: ______________

WORKSHEET

QUEST ACTIVITY

"UNIT 15"

Listed below are some questions or problems that must be answered before a student decides seriously to consider an occupational area. Use complete sentences and answer in detail the following information.

1. What is the title of the occupation of your choice?

2. What are the reasons why you have selected this particular occupation?

3. What are the names of various occupations in related fields?

4. What are the names of two unrelated alternate occupations that you might choose if your first choice is not possible for some reason?

5. What is the probable beginning salary?

6. What are some of the primary duties in this occupation?

7. What are the advantages and disadvantages of any electronics area occupations?

8. Does the present employment outlook seem favorable?

9. Are local opportunities available in this occupation?

10. What educational training is necessary?

Name: ______________

Date: ______________

Period: ______________

11. Where can you obtain necessary education beyond high school?

12. How do your parents feel about your career choice?

13. What special licenses, examinations, or certificates are necessary?

14. What are the age, sex, height and physical requirements needed?

15. Are there any unusual demands placed upon the worker in your occupational choice?

16. Is there opportunity for advancement within the occupation?

17. What are the fringe benefits of your occupation?

18. What are the various methods for entering this occupations?

19. What are your parents' or guardians' occupations?

20. After considering your interest, abilities, and values, is your career choice right for you? Why?

Name: ____________

Date: ____________

Period: ____________

INFORMATIONAL HANDOUT

OCCUPATIONS WITHIN THE ELECTRONICS TECHNICIAN WORK AREA

The Major Work Area designated electronics technician encompasses a vast group of technical people employed in a wide variety of occupational jobs. From a very broad viewpoint the job opportunities in electronics technology can be divided into the following markets:

Government Market	*Large dependence on contracts - defense plant activities!
Industrial Market	*A very large and broad employer of technicians with various backgrounds.
Consumer Market	*Third in dollar volume, however, the most stable field of employment in terms of job security.
Allied Fields	*Occupations not directly technical in terms of electronics theory.

Government Market:

Laboratories and factories under government contact utilize a large number of technicians especially in research and development, production design, manufacturing, calibration, test, maintenance, and troubleshooting. It is evident that some technicians will work at higher levels than others and that a given job classification may require specialized training and experience.

Name: ____________

Date: ____________

Period: ____________

Industrial Market:

Industrial electronics work includes computers, process-control, commercial installations, measuring equipment, medical electronic systems, nuclear products, instrumentation, closed-circuit television units, and office equipment. Approximately one half of the technicians employed by industry are assigned to process-control activities. The full potential of the computer market has not been realized owing to the lack of trained programmers to manage computer operations and the shortage of computer-maintenance technicians.

The communication area includes telephone, telegraph, teletype, radio, telemetry, television and microwave systems all of which require vast numbers of technicians to install and maintain the equipment.

The other areas mentioned under the industrial market also employ large numbers of technicians and at the present time are faced with similar "manpower" shortages.

Consumer Market:

This market includes such products as television receivers, radios, high-fidelty systems, tape players, citizen band units, etc. There are more self-employed technicians in this market than any other area. A very important consideration of the self-employed technician is that they are responsible for the entire operation of the business. They are the purchasing agent, the bookkeeper, the salesman, the cashier, the employer and the technician. Their success depends upon their ability in these areas as much as on their technical ability.

Allied Field Market.

Commercial employment as a electronic product salesperson is a good example of employment in an allied occupational field. The trained technician, for example, has a unique advantage over the non-technical person in merchandising elaborate equipment such as computers and other sophisticated equipment.

Other allied fields related to electronics technology are drafting, technical publication production, and creative writing.

***INDEED, an electronics technician does have a wide variety of technical jobs from which to choose. If you were to become an electronics technician what field or market would interest you?

?

SCORE:
GRADE:

Name: ____________________

Date: ____________________

Period: ____________________

ANSWER SHEET

EXAM LIII U15

	T A	F B	C	D		T A	F B	C	D		T A	F B	C	D		T A	F B	C	D
1.					26.					51.					76.				
2.					27.					52.					77.				
3.					28.					53.					78.				
4.					29.					54.					79.				
5.					30.					55.					80.				
6.					31.					56.					81.				
7.					32.					57.					82.				
8.					33.					58.					83.				
9.					34.					59.					84.				
10.					35.					60.					85.				
11.					36.					61.					86.				
12.					37.					62.					87.				
13.					38.					63.					88.				
14.					39.					64.					89.				
15.					40.					65.					90.				
16.					41.					66.					91.				
17.					42.					67.					92.				
18.					43.					68.					93.				
19.					44.					69.					94.				
20.					45.					70.					95.				
21.					46.					71.					96.				
22.					47.					72.					97.				
23.					48.					73.					98.				
24.					49.					74.					99.				
25.					50.					75.					100.				

*Show work for problems on back of answer sheet.

ANSWER KEY
UNIT 15

A. VOCABULARY - SCRAMBLED WORD

1. trades
2. major work area
3. apprenticeship
4. competency
5. union
6. inventory
7. world of work
8. aptitude
9. entry level jobs
10. cluster
11. occupation outlook handbook
12. qualifications
13. dictionary of Occupational Titles
14. cluster

B. INTEREST, ACTIVITIES, AND HOBBIES ASSESSMENT

(subjective evaluation)

C. PERSONAL PROFILE ANALYSIS

(subjective evaluation)

D. CAREER RESEARCH IN THE ELECTRICITY/ELECTRONICS AREA

(subjective evaluation)

E. INTERVIEW EVALUATION ASSIGNMENT

(subjective evaluation)

F. QUEST ACTIVITY

(subjective evaluation)