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The guide has been revised to accommodate the adoption of "Physical Science Study Committee College Physics" as the basic textbook for this course. An introduction describes the scope and objectives of the course. Presented are suggestions for teaching the course, content, time allotment to topics, laboratory work, evaluation, materials and equipment, and use of community resources. Topics included in the course are discussed under the headings of "Optics and Waves," "Mechanics," and "Electricity and Atomic Structure." Appendices include suggestions for individual study, books, periodicals, and equipment. (BC)

GUIDE FOR TEACHING HONORS PHYSICS 1—2

San Diego City Schools
San Diego, California
1968

GUIDE FOR TEACHING HONORS PHYSICS 1-2

GRADE 12

Prepared by

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San Diego City Schools
San Diego, California
1955
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Unedited

PREFACE

This fifth edition of the Guide for Teaching Honors Physics 1-2 is a major revision of the former publication to accomodate the adoption of the Physical Science Study Committee College Physics: as the basic textbook material for the course.

It is expected that the honors course will be offered in San Diego City schools concurrently with other regular physics courses such as the PSSC Physics and the Harvard Project Physics. Materials for these courses are also referred to in the guide.

The publication is tentative and has not been edited. It will be used and evaluated by the teachers involved. Submission of constructive suggestions for its improvement are solicited and should be sent to the Science Specialist, Curriculum Services Division.

Wm. H. Stegeman

William H. Stegeman
Assistant Superintendent
Curriculum Services Division

TABLE OF CONTENTS

INTRODUCTION

Description of Course*

HONORS PHYSICS 1-2 (two-semester course--grade 12--prerequisites: successful completion or concurrent enrollment in "Trigonometry and Advanced Algebra 1-2" or a higher level mathematics course, superior academic standing; see District Procedure No. 5436-1)

Description of course:

The course content is similar to the regular course in physics, with a greater emphasis on modern physics. The laboratory approach of the Physical Science Study Committee is used in this course along with appropriate supplementary college-level materials.

Objectives of course:

The objectives of this higher level course in physics are essentially the same as stated for Physics 1-2 except that the greater opportunities for depth study and coverage of more advanced topics should result in great individual accomplishment in original problem solving, technical writing, and possible qualification for advanced placement in college through examination.

Instructional content or areas of emphasis:

Introduction	1-2 weeks
Optics and Waves	9-10 weeks
Mechanics	14-15 weeks
Electricity and Atomic Structure	10-11 weeks

Basic texts: Physical Science Study Committee, College Physics, 1968
Physical Science Study Committee, College Physics Laboratory Guide, 1968

Supplementary texts: White and Manning, Experimental College Physics, 3rd ed., 1954 (Laboratory Manual)
White, Modern College Physics, 5th ed., 1966

Guides: San Diego City Schools, Guide for Teaching Honors Physics 1-2, 1968 (Stock No. 41-P-6600)
Physical Science Study Committee, Instructors Guide for College Physics, 1968
San Diego City Schools, Handbook of Science Laboratory Practices and Safety, 1966

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*San Diego City Schools Digest of Secondary Schools Curriculum, published annually, San Diego, California

Objectives

This course is frequently the student's first introduction to the formal study of physics. It is not expected that he will emerge an expert in this vast area of science. Keeping this in mind, the teacher should seek to do the following:

-Stimulate intellectual curiosity, engender satisfaction in intellectual achievement, and cultivate the ability to think rationally.

-Help the student develpp an appreciation of ethical values which form the basis of life in a democracy and of the responsibilities and contributions of science to society.

-Provide the student with a frame of reference in which may be shown how knowledge is obtained experimentally and how the results can produce a theory through the application of the scientific method.

-Develop skills in the use of specific instruments and tools as required by the course.

-Demonstrate the application of mathematics as a tool in problem solving. The mathematics involved will include trigonometry and elementary calculus, along with the use of logarithms and the slide rule.

-Teach the use of graphing techniques for the correlation of experimental data from which empirical mathematical relationships may be developed.

-Give instruction in effective communication with written and oral reports, including vocational opportunities in physics.

Scope

The content of the Physical Science Study Committee (PSSC) college-level course has been chosen "not simply to cover physics, but to display the structure of the field." The topics which have been selected are explored more fully than in other beginning physics courses. Where desired, the teacher is encouraged to present a broader topical coverage by reference to supplementary materials which are available in our schools, such as White's Modern College Physics. To achieve a basic understanding of the conceptual framework of modern physics, the student is expected to:

-Study his PSSC texts and other materials provided.

-Use a more rigorous approach to the mathematical derivations as obtained from experimental physical data.

-Intelligently evaluate and understand physical problems through the application of basic principles of physics.

-Participate in laboratory investigations which involve independent thinking along with a mature analysis of collected data.

-Extend beyond the classroom his interest in physics by studying and doing research in areas which are not covered in the course. These student projects frequently become entries in the Greater San Diego Science Fair.

SUGGESTIONS FOR TEACHING

Course Content

It is the intention of this course to teach what physics is and to reveal its structure content. Most of the topics listed in the guide follow a sequential pattern and are all interdependent. The outline is intended as a guide in the selection of topics to be studied and in this context there will be found listed:

-Subject matter topics covered in the PSSC course in physics.

-Laboratory experiments which are normally done in each area of study.

-Films, texts, outside reading, and other references.

The subject matter topics are coded to the PSSC text, College Physics, which is the basic textbook for the course, and to Modern College Physics, 5th ed., which serves as a supplementary textbook. Other references may also be brought in wherever the teacher feels that they are appropriate.

The laboratory experiments are coded to the PSSC College Physics Laboratory Guide. References are also made to White and Manning's Experimental College Physics and to other sources which are specifically noted.

The visual aids have been selected to correlate with the topical outline. The type of aid is indicated along with running time or, in the case of film strips, with the number of frames.

The selections listed under "Outside Reading" are particularly suited to the topics in the guide. The student should be encouraged to consider these references as an integral part of the course, and reading assignments should be made by the teacher.

In addition to using the above instructional resources, the student is expected to participate in other experiences such as:

-Library work on special topics.
-Science projects or research.
-Field trips and listening to guest lecturers.
-Competitions in physics such as the annual NELC and NAPT exams.
-Student-built scientific equipment and apparatus.

Sequence of Topics and Time Allotment

The topic outline follows the PSSC course. For uniformity among the schools, it is recommended that the units "Introduction," "Optics and Waves," and "Mechanics" through Topic Outline 16 be covered during the first semester. The remainder of "Mechanics" and "Electricity and Atomic Structure" should be covered during the second semester.

Time allotment for each unit is not rigid but the following allocation of time is suggested:

SEMESTER I

Introduction, Topic Outlines 1-2, 1-2 weeks.

Optics and Waves, Topic Outlines 3-10, 9-10 weeks.

Mechanics, Topic Outlines 11-16, 7 weeks.

SEMESTER II

Mechanics, Topic Outlines 17-23, 7-8 weeks.

Electricity and Atomic Structure, Topic Outlines 23-36, 10-11 weeks.

Laboratory Work and Equipment

A list of suitable laboratory experiments related to course topics is a part of the topic outline. It is expected that the student will perform, on the average, at least one laboratory experiment per week. The activities listed have been taken from the PSSC College Physics Laboratory Guide, White and Manning's Experimental Physics, 3rd ed., and from other sources which will be duly noted. The choice of experiments has been made to provide the students with the following opportunities:

-To learn by means of actual observation some of the principles of physics.

-To do some independent thinking.

-To become familiar with modern measuring equipment.

-To learn the fundamentals of preparing a technical report on the results of a scientific study, the report to include critical analysis and clear presentation of the experimental results in graphical form, where possible, and as an algebraic statement.

Some of the experiments involve the use of equipment not available to each individual school. In order to conserve funds and storage space, the necessary equipment as listed in Appendix B will be made available on a circulating basis to be shared by the schools in each of three area "circuits" as follows:

East: Crawford, Lincoln, Morse, and Patrick Henry High Schools.
Central: Kearny, Hoover, Madison, and Clairemont High Schools.
West: La Jolla, Mission Bay, San Diego, and Pt. Loma High Schools.

Each teacher should arrange to pick up the equipment from one of the other schools on his circuit. At the end of the school year, the equipment is to be returned to the school responsible for its inventory control.

Conventional Usage

Since the mks system of units is rapidly replacing the cgs system, emphasis on the use of the newer system should be made throughout the course. A table of mks units and conversion factors will be made available to each student. It is recommended that the use of letter symbols and abbreviations follow those in the text.

Student Preparation

Students will be expected to spend approximately one hour in preparation for each class session. Reading and problem assignments should be made from the textbooks and laboratory manuals. Students should be encouraged to use the slide rule wherever possible in making their calculations.

Use of Community Resources

Special lectures and seminars will be arranged in cooperation with community agencies interested in the science education for the able student. Current lists of available speakers are maintained for the convenience of the teacher.

Naval Electronics Laboratory Center Science Achievement Awards

This is an annual competition open to the students of honors physics. Details of this program involving both team and individual competitions are announced in November. The exams and the awards program are normally held in April.

Evaluation of Student Progress

Evaluation of student progress should be in terms of the objectives of the course. The PSSC tests which parallel the development of the course serve as an excellent vehicle for evaluation of student achievement. The teacher is urged to make the various forms of these exams available to his students. Tests may be obtained from Testing Services, San Diego City Schools. Request: Tests of the PHYSICAL SCIENCE STUDY COMMITTEE.

The College Entrance Examination Board Pamphlet, "Achievement Tests"[1] contains an excellent discussion of test development and examples of test items.

Meetings of Teachers

Meetings of teachers of honors courses are held at stated intervals during the year for "in-service" training through demonstration of new equipment and materials, and to discuss:

-Annual plans.

-Techniques of instruction.

-Evaluation of the course.

-Future development of the course.

-Special activities for students.

Materials and Equipment

In Appendix B are listed recommendations concerning:

-Books and supplies on a one-per-pupil basis.

-Books and materials for classroom reference.

-Books which should be available in the library.

-Laboratory equipment available on circulating basis.

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1 College Entrance Examination Board. "Achievement Tests," latest edition. Los Angeles, California: Education Testing Service.

TOPIC OUTLINES

Key to Abbreviations Used in the Topic Outline

Ch. - Chapter

EBF - Encyclopedia Brittanica Film

ECP - Experimental College Physics

Fs - Filmstrip

HPP - Harvard Project Physics

McGH - McGraw Hill Co.

MCP - Modern College Physics

CPPSSC - College Physics Physical Science Study Committe

CPLG - College Physics Laboratory Guide

1. TIME, SPACE AND MATTER (3 days)

The tools of physics

-Microscope
-Telescope
-Laboratory balance
-Seismograph
-Cyclotron, etc.

The people of physics

-Scientists
-Engineers
-Artists, designers, and others
-Electricians, etc.

Time and its measurement

-Short time intervals
-Repetitive motions, the stroboscope
-Comparing times and counting units
-Large and small times

Space and its measurement

Matter

Limitations of measuring

Fractional error

Black boxes

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC CH. 1
Supplementary: MCP Ch. 1, 2

LABORATORY

CPLG: Exp. 1
Exp. 2
Exp. 3
ECP Exp. Ch. 2, Sig Figures etc; and Ch. 3, Sec. 1.
Vernier and micrometer devices.

VISUAL AIDS

Films:
Short Time Intervals, PSSC (21)
Time and Clocks, PSSC (28)
Long Time Intervals (21), PSSC
About Time; Parts I and II, A-T-T- (60)
The Micrometer, USDE (15)
Measuring Large Distances, PSSC (29)
Measuring Short Distances, PSSC (20)

Programmed Lesson: HPP, Measurement and Precision

SP-L 759-9492: The Starry Night

OUTSIDE READING

"Time Reversal," Scientific American, Vol. 196, Feb. 1957, p. 10.

Carnap, Rudolph. "Merits of the Quantitative Method" from: Philosophical Foundations of Physics, Basic Books Inc., N.Y., 1966, Ch. 11.

Holton, Gerald. "The Nature of Concepts" from: Introduction to Concepts and Theories in Physical Science, Addison-Wesley, Reading, Mass., 1952.

2. DATA, GRAPHS AND FUNCTIONS (4 days)

Tables and graphs

-Tabulation of data
-Graphical representation of data
-Analysis and formulation

Direct proportion and linear function

Power laws and similar figures

-Areas and volumes as examples of second and third power laws.

-Derivation of tables, graphs, and equations of these power laws.

The inverse-square relation and stellar distances

-Light intensity as a function of distance.

-Measuring relative intensity of a light source, using the inverse relationship.

-Light intensity as used in measuring star distances.

-Limitations of this method.

The exponential function

-Validity and limitations
-Validity and significance
-Exponential function and semi-log plots
-Power laws and log-log plots

Scaling - The Physics of Lilliput

-Relationship between strength and C.S. area.

-Surface area and linear dimensions

-Load versus strength problems in scaling up.

-Changes in behavior in systems which are scaled up or down.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC, Ch. 2
Supplementary: ECP, Ch. 1

LABORATORY

CPLG, Exp. 4 and Exp. 5

VISUAL AIDS

SP-L 759 The Cocks
Film:
Change of Scale, PSSC (23)

OUTSIDE READING

Dole, Stephen H. "An Appreciation of the Earth" from: Habitable Planets for Man, Blaisdell Pub. Co., Division of Ginn and Co., N.Y., 1964.

3. THE PROPAGATION OF LIGHT (4 days)

Sources of light

-Propagation of light
-Identification of sources of light

Interaction of light with matter

-The behavior of light in striking an object

-The transmission of light

-Transparent, colored and opaque objects

Reflection of light

-Light-sensitive objects

-Relative sensitivity of objects to light

-Some devices which can measure relative light intensities

-Invisible light

How light travels

-Light travels in straight lines; rectilinear propagation

-The bending of light

-Diffraction

-Propagation of light, its nature and speed

-Location of objects

INSTRUCTIONAL RESOURCES

TEXT

Basic: CPSSC, Ch. 3
Supplementary: MCP, Ch. 36

LABORATORY

ECP, Ch. 39, Section 39.1

VISUAL AIDS

Film:
Nature of Light, Coronet (11)

OUTSIDE READING

Young, Thomas. "Experiments and Calculations Relative to Physical Optics" from: Miscellaneous Works of Thomas Young, Vol. 1, edited by Geo. Peacock and John Murray, London, 1855, Ch. 9.

Michelson, A.A. "Velocity of Light" from: Studies in Optics, The University of Chicago Press, Chicago, 1927.

4. REFLECTION AND REFRACTION (5 days)

The ray diagram as a technique in understanding light behavior.

-Formation of shadows.
-Light rays and what they represent.
-The non-interaction of light rays.

The two laws of reflection.

-The incident and reflected ray and their plane of interaction.
-The angle of reflection compared to the angle of incidence.

Image formation in plane mirrors.

-Description of an image.
-Location of an image.
-The geometry involved in image location and size.
-Multiple images and their formation.

The incident ray, the refracted ray, and the normal; their relationship.

-Experimental evidence for refraction.
-Evaluation of experimental data on refraction.

The index of refraction, Snell's Law.

-Relationship between the angle of refraction and the angle of incidence.
-The absolute index of refraction.
-Methods of representing this relationship.

The reversibility of light and refraction.

-Passage of light from glass, water to air.
-Passage of light from water to glass.
-Total internal reflection.

Dispersion.

-Refraction with prisms.
-Composition of white light.
-Index of refraction as related to wavelength.
-The prediction of light path through a prism, using Snell's law.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC Ch. 4
Supplementary: MCP Ch. 37, 38 and 39

LABORATORY

CPLG, Exp. 6 and Exp. 7

ECP, Ch. 40, Section 40.2, Part I

VISUAL AIDS

Fs 535 Light

OUTSIDE READING

Griffin, Donald R. "Echoes of Bars and Men" from: Science Study Series, Doubleday Anchor 1959.

Minnaert, M. Light and Color in the Open Air, Dover, 1954.

5. THE PARTICLE MODEL OF LIGHT (4 days)	INSTRUCTIONAL RESOURCES
Reflection and the particle model. -The two laws of reflection. -Ideal elastic collisions and the two laws of reflection. -Specular and diffuse reflection and the model particle. Refraction and the particle model. -The two laws of refraction and the particle model. -Limitations of the particle model. -Implications for refraction. Inverse square law and the particle model. -The unit of light intensity. -Explanation of the inverse square law by the particle model. Pressure of light; prediction by the particle model. Particle model and the absorption and heating of light. The limitations of the particle model. -Partial refraction and reflection. -Diffraction. -Limited value of a complicated model. -The speed of light and the particle model.	TEXTS Basic: CPPSSC, Ch. 5 LABORATORY CPLG, Exp. 8 VISUAL AIDS Films: The Pressure of Light, PSSC21 The Speed of Light, PSSC (23) OUTSIDE READING Jaffe, Bernard. "Michelson and Speed of Light" from: Science Study Series, Doubleday Anchor, 1960, Ch. 3. Maggie, William Francis. A Source Book in Physics. McGraw Hill, 1935.

6. INTRODUCTION TO WAVES (3 days)	INSTRUCTIONAL RESOURCES

Characteristics of a wave

-The disturbance of a "medium"

-Propagation

-Transportation

-Pulses

Waves on a coil spring

-Speed of a pulse

-Motion of a point versus the motion of a wave

-Graphing a pulse

-Superposition

Reflection and transmission

-Fixed-end reflection

-Free-end reflection

-Transmission in various media

-Idealization and approximations in the evaluation of pulses

The wave model of light

TEXTS

Basic: CPPSSC, Ch. 6

LABORATORY

CPEG: Exp. 9

VISUAL AIDS

Film:
Simple Waves, Bell Telephone (27)

Demonstration: Bell Telephone Wave Machine (40)

OUTSIDE READING

Maxwell, James Clark. "Action at a Distance" from: Scientific Papers of James Clark Maxwell, Vol. II, Cambridge University Press, Cambridge, England.

PSSC: "Introduction to Physics" from: Physics, D.C. Heath, Boston, 1965, Ch. 15.

Lindsay, Robert Bruce. "Wave Motion and Acoustics" from: General Physics for Students of Science, John Wiley and Sons, Inc., N.Y., 1940, Ch. 26.

7. WAVES AND LIGHT (10 days)	INSTRUCTIONAL RESOURCES

Water waves.

-Straight and circular pulses, their direction of propagation.
-Reflection of water waves.
-Crests and troughs.
-Water waves and the law of reflection.

The speed of propagation of a wave.

-Periodic waves.
-Frequency and period.
-Wavelength uniform speed and period.
-Speed as a function of wavelength and period.

Refraction and waves.

-Water waves and Snell's Law.
-Speed of a water wave dependent upon the depth of water.
-Index of refraction and the wave model.
-Reflection and refraction at the boundary between two depths of water.

Dispersion.

-Dispersion and the frequency of a wave.
-Different frequencies and color.

Diffraction.

-Definition.
-Relationship between wavelength and slit opening.
-Prediction of the wavelength of light.

TEXTS

Basic: CPPSSC, Ch. 7
Supplementary: MCP, Ch. 42 and Ch. 43

LABORATORY

CPLG, Exp. 10
Exp. 11
Exp. 12
Exp. 13

VISUAL AIDS

Demonstration: Sunset
Film:
Spectograph, McGraw Hill (20)

OUTSIDE READING

Benade, Arthur H. "Horns, String and Harmony," Science Study Series. Doubleday Anchor, 1960, Ch. 2 and Ch. 4.

Bonner, Francis T. and Phillip Melba, Principles of Physical Science, Addison Wesley, 1957, Ch. 16.

8. INTERFERENCE (5 days)	INSTRUCTIONAL RESOURCES

Periodic waves in one dimension.

-Interference on a spring.

-Reflection, refraction, and diffraction and the wave model.

-Nodes and interference.

Two-dimensional waves.

-Two-point source of waves.
-Nodal lines and their significance.

Wavelength, source separation, and angles.

-Calculating and interference pattern at a large distance from the source.

-Phases of a wave.

-Effect of "out-of-phase" sources on an interference pattern.

TEXTS

Basic: CPPSSC, Ch. 8
Supplementary: MCP, Ch. 44

LABORATORY

CPLG: Exp. 14
Exp. 15

VISUAL AIDS

Film:
Sound Waves in Air, PSSC, (35)

OUTSIDE READING

Lindsay, Robert Bruce, "Wave Motion and Acoustics" from: General Physics for Students of Science. John Wiley and Sons, Inc., N.Y., 1940.

Benade, Arthur H. "Ears, Architects of Harmony" from: Horns, Strings and Harmony. Doubleday and Co. 1940, Ch. 5.

9. LIGHT WAVES (10 days)

Physical factor related to interference.

-Interference patterns and the ripple tank.
-Nodal lines and wavelength.
-Measuring the wavelength.

Two-slit interference.

-Two-light sources in phase.
-Phase of light sources and interference patterns.
-Lasers.

Color and wavelength of light.

-White light and interference.
-Wavelength of the spectral colors in white light.

Diffraction.

-Superposition.
-Huygen's principle.
-Diffraction by a slit.
-Diffraction and resolution.

Interference in thin films.

-Two surfaces of a thin film and reflection.
-Reflected light and interference.
-Interference and transmitted light through thin films.
-Color effects in interference.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC, Ch. 9

Supplementary: MCP, Ch. 43
Ch. 44
Ch. 45

LABORATORY

CPLG: Exp. 16
Exp. 17
Exp. 18

VISUAL AIDS

Fs Ripple Tank and Waves (36)

OUTSIDE READING

Mack, J. E. and Martin, M. J. The Photographic Process. McGraw-Hill Book Co., 1939.

Weisskopf, Victor F. Knowledge and Wonder. Doubleday Anchor 1963, Science Study Series Ch. 3 and Ch. 9.

10. APPLIED OPTICS (6 days)

Curved mirrors.

-Curved mirrors and light focusing.
-Laws of reflection and curved mirrors.
-Parallel light rays and their behavior in reflection.
-Definition of and location of principle focus.

The reversibility of light.

-Definition of focal length.
-The searchlight and astronomical telescope and their use.
-The convergence of light by a set of prisms.

Lenses.

-Converging-diverging lenses.
-Image formation.
-Conjugate foci; lens maker's formula.

Image formation with parabolic mirrors.

-Ray diagrams.
-The light ray through the principal focus and its behavior.
-The geometry involved in reflection.
-Image position and size.
-Real and virtual images.

Optical instruments.

-The magnifier or simple microscope.
-The compound microscope.
-Refracting telescopes.
-Limitations of optical instruments.
-Abberations and resolutions.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC, Ch. 10

Supplementary: MCP, Ch. 39
Ch. 40
Ch. 41

LABORATORY

CPLG: Exp. 19
Exp. 20
Exp. 21
Exp. 22

ECP, Ch. 41

VISUAL AIDS

Films:
Introduction to Optics, PSSC (23)

Spherical Mirrors EBF (13)

OUTSIDE READING

Jenkins, Francis A. and White, Harvey E. Fundamental of Optic. McGraw Hill, 1957, Chs. 4, 5, 9, and 10.

Newton, Sir Isaac, Optics. 4th Ed. of 1730, Dover Pub. Co., N.Y., 1952.

11. MOTION ALONG A STRAIGHT LINE PATH (5 days)	INSTRUCTIONAL RESOURCES
Position and displacement along a line. -Coordinate system. -Negative and positive displacements. **Velocity.** -Constant velocity. -Varying velocity. **Position-tome graphs.** -Analysis for a steady velocity. -Analysis for a varying velocity. -Slope of a line and its significance. -Slope of a tangent line and instantaneous velocity. **Velocity-time graphs.** -Acceleration as interpreted from velocity-time graphs. -Results for motion with constant acceleration.	TEXTS Basic: CPPSSC, Ch. 11 Supplementary: MCP, Ch. 3 Ch. 4 LABORATORY CPLG: Exp. 23 Exp. 24 VISUAL AIDS Program lesson on displacement and position--HPP.

12. MOTION IN SPACE (4 days)	INSTRUCTIONAL RESOURCES
Position and displacement. -Addition and subtraction of displacements. -Multiplying vectors by numbers and scalars. Velocity vectors in space. -Compounds of vectors. Velocity changes and constant vector acceleration. Changing acceleration. Description of motion. -Frames of reference. Kinematics and dynamics. Speed of light.	TEXTS Basic: CPPSSC, Ch. 12 Supplementary: MCP, Ch. 7 Ch. 8 Ch. 12 LABORATORY CPLG, Exp. 25 VISUAL AIDS Programmed lesson in vectors--HPP.

13. NEWTON'S LAW OF MOTION (5 days)	INSTRUCTIONAL RESOURCES
Ideas about force and motion. -Force related to push or pull. -Net force and changes in motion. -Motion without force. Changes in velocity. -Constant force. -Changes in velocity and applied force. Mass and weight. -Inertial mass. -Inertial mass and gravitational mass. Newton's Law of motion. -The unit of force. -Changing forces and Newton's Law. -Addition of forces and net force. -Vector nature of Newton's Law. -Forces in nature.	TEXTS Basic: CPPSSC, Ch. 13 Supplementary: MCP, Ch. 6 LABORATORY CPLG: Exp. 26 VISUAL AIDS Films: Forces, PSSC (22) Inertia, PSSC (27) Inertial Mass, PSSC (20) OUTSIDE READING Murchie, Guy. Music of the Spheres, Houghton Mifflin, 1960, Ch. 10. Galileo, Galilei. Dialogues Concerning Two New Sciences, translated by H. Crew and A. de Salvio. Macmillan, 1914.

14. MOTION AT THE EARTH'S SURFACE (7 days)

Weight and the "gravitational field."

-The meaning of weight.
-Relationship between mass and weight.
-Weight of an object at the earth's surface.

Falling bodies.

-Gravitation.
-Free fall.
-Acceleration due to gravity.
-Air resistance.
-Terminal velocity.

Projectiles.

-Vertical and horizontal motion.
-Horizontal motion and constant velocity.
-Vector nature of Newton's Law of motion.
-Trajectory.

Constant force and instantaneous motion.

-A constant force perpendicular to the motion.
-Circular motion.
-Kinematics of circular motion.
-Satellite motion, artificial and natural.

Simple harmonic motion.

-Restoring force and displacement.
-Centripetal force and its components.
-Harmonic motion and Newton's Law.

Frames of reference.

-Experimental frames of reference.
-Inertial frame of reference.
-Accelerating frames of reference.
-Fictitious forces and accelerated frames of reference.
-Newton's Law and the earth's rotation.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC, Ch. 14

Supplementary: MCP, Ch. 5
Ch. 6

LABORATORY

CPLG: Exp. 27
Exp. 28
Exp. 29

ECP, Ch. 6, Section 6.1

Free Fall, Polaroid and Strobe

VISUAL AIDS

Films:
Falling Bodies, PSSC (30)
Deflecting Forces, PSSC (29)
Periodic Motion, PSSC (30)
Frames of Reference, PSSC (26)

OUTSIDE READING

Faraday, Michael. "The Force of Gravity," from: On the Various Forces of Nature. Viking Press, N.Y. 1960.

Dicke, R. N., Roll, P. G., and Weber, J. "Gravity Experiments" from: Modern Science and Technology. D. Van Nostrand Co., Princeton, N.J., 1965.

15. UNIVERSAL GRAVITATION AND THE SOLAR SYSTEM (7 days)	INSTRUCTIONAL RESOURCES

Motion in the heavens.

-The Greeks and astronomy.
-Motions of the moon.
-Heliocentric system of the solar system.
-A geo-centric system and Ptolemy.

The works of Copernicus and Tycho Brahe.

-The Copernican system.
-Arguments for the Copernican system.
-Arguments against the Copernican system.
-Historic consequences.
-Tycho Brahe and his observations.
-Tycho's compromise system.

The appearance of a new universe.

-Abandonment of uniform circular motion.
-Kepler's second law.
-Using Kepler's first two laws.
-Kepler's third law.
-Galileo's viewpoint and telescopic evidence.
-Galileo's arguments.

The unity of earth and sky.

-Newton's Principia.
-Newton's analysis; motion and a central force.
-The inverse square law of planetary force.
-Law of Universal Gravitation.
-Gravitation and planetary motion.

TEXTS

Basic: CPPSSC, Ch. 21

Supplementary: MCP, Ch. 9
Ch. 10

LABORATORY

CPLG: Exp. 30

VISUAL AIDS

Films:
Universal Gravitation, PSSC (28)
Eliptic Orbits, PSSC (18)

OUTSIDE READING

Toulmin, Stephen and Goodfield, June. "Copernicus, His Aim and His Theory" from: The Fabric of the Heavens. Harper and Row, N.Y., 1961, Ch. 6.

Feyman, R.P., Leighton, R. B. and Sands, M. "Universal Gravitation" from: The Feyman Lectures on Physics, Vol. 1. Addison-Wesley, Reading, Mass. 1963, Ch. 7.

Galileo: "The Starry Messenger" from: Discoveries and Opinion of Galileo by Stillman Drake. Doubleday and Co., Inc., 1957.

16. MOMENTUM AND THE CONSERVATION OF MOMENTUM (9 days)	INSTRUCTIONAL RESOURCES

Dynamics of motion.

-Impulse.

-Impulse as a vector.

-Momentum.

-The components of momentum.

-Momentum as a vector.

-Force and changes in momentum.

Changes in momentum through interaction of bodies.

-Explosions.

-Head-on collisions.

-Elastic and inelastic collisions.

-Glancing collisions.

-Law of conservation of momentum.

-Center of mass-quantity defined.

Action-reation forces.

-Isolating a body.

-Rocket flights into space.

-Forces in a system before launch.

-Vertical and inclined flight.

-Free flight.

TEXTS

Basic: CPPSSC, Ch. 16

Supplementary: MCP, Ch. 5
Ch. 13
Ch. 16
Ch. 17

LABORATORY

CPLG: Exp. 31
Exp. 32
Exp. 33

VISUAL AIDS

Film:
Law of Conservation of Momentum, Coronet (18)

OUTSIDE READING

Bondi, Hermann. Relativity and Common Sense. "Science Study Series." Doubleday Anchor, Chs. 1-4.

Holton, G. and Roller, D.H.D. Foundations of Modern Physics Science. Addison-Wesley, 1958, Ch. 17.

17. WORK AND ENERGY (7 days)	INSTRUCTIONAL RESOURCES

Work defined in physical terms.

-Energy transfer.

-Energy transfer and work performed.

-Fuel consumption.

-Work and force.

-Work and direction of applied force.

Kinetic energy.

-Energy in motion.

-The dynamical characteristics of kinetic energy.

Interaction of bodies.

-Transfer of kinetic energy.

-Simple collisions and K.E.

-Elastic collisions and the conservation of K.E.

-K.E. and momentum.

-Work and K.E., more than one force.

-Conservation of K.E. and inelastic collisions.

TEXTS

Basic: CPPSSC, Ch. 17.

Supplementary: MCP, Ch. 15
Ch. 16

LABORATORY

CPLG: Exp. 34

VISUAL AIDS

Films:
Elastic Collisions and Stored Energy, PSSC (25)

Momentun, Energy, and Center of Mass, PSSC (25)

OUTSIDE READING

Carnot, Sadi. "The Motive Power of Fire," an excerpt from the paper "Reflections on the Motive Power of Fire, and On Machines Fitted to Develop that Power" from: Reflections on the Motive Power of Fire. Dover Pub., N.Y., 1960.

Forbes, R.J. and Dijksterhuis, E.J. "The Steam Engine Comes of Age" from: A History of Science and Technology, Vol. 2. Penguin Books, Ltd., Harmondsworth, Middlesex, England, 1963, Ch. 20.

Thomson, William and Tait, P.G. "Energy" from: Good Words for 1862, Norman Macleod, Alexander Strachan and Co., London.

18. POTENTIAL ENERGY (8 days)	INSTRUCTIONAL RESOURCES

Potential energy and its use.

-The spring bumper.

-Conservation of mechanical energy.

-The elastic interaction of a mechanical spring.

-P.E. of a spring.

-Conservation of energy in a spring.

P.E. of two interacting bodies.

-Separation forces and total energy.

-P.E. and distance of separation.

-Stored P.E. in a force field.

Gravitational force field.

-Gravitational P.E. near the surface of the earth.

-Gravitational P.E. in general.

-Escape energy, escape velocity, and binding energy of satellites.

Mechanical energy and a complex system; conservation of mechanical energy.

TEXTS

Basic: CPPSSC, Ch. 18

MCP, Ch. 25

LABORATORY

CPLG: Exp. 35
Exp. 36
Exp. 37

VISUAL AIDS

Film:
Energy and Work, PSSC (28)

Fs 530 Energy, Today and Tomorrow (38F)

Fs 530 Energy (41D)

OUTSIDE READING

Feyman, R.P., Leighton, R.B. and Sands, M. "The Conservation of Energy" from: The Feyman Lectures on Physics, Vol. I. Addison-Wesley, Reading, Mass. 1963.

Gamow, George. "Gravity," Science Study Series. Doubleday Anchor, 1962.

19. ANGULAR MOMENTUM AND ITS CONSERVATION (9 days)	INSTRUCTIONAL RESOURCES

Angular momentum.

-Law of equal areas.

-Frame of reference and angular momentum.

-Energy, angular momentum, and trajectory.

The motion of satellites.

-Total energy and angular momentum.

-The vector nature of angular momentum.

Rigid bodies.

-Rotation of rigid bodies.

-Angular momentum of rigid bodies.

-Moment of inertia.

-Torque rate of change of angular momentum.

-Orbital angular momentum and spin.

TEXTS

Basic: CPPSSC, Ch. 19

Supplementary: MCP, Ch. 17
Ch. 19
Ch. 20
Ch. 21

LABORATORY

CPLG: Exp. 38
Exp. 39
Exp. 40

ECP, Ch. 12, Section 12.2

VISUAL AIDS

Film:
Angular Momentum--A Quantity, PSSC (26)

OUTSIDE READING

Shonle, John I. "Resource Letter CM-1 on the Teaching of Angular Momentum and Rigid Body Motion," American Journal of Physics, Vol, 33, No. 11, Nov., 1965.

Newton, Isaac. "Proposition I-The Law of Areas" from: Book I of Mathematical Principles of Natural Philosophy and his System of the World, Translated by Florian Cajori, University of Calif. Press, 1934.

20. HEAT, MOLECULAR MOTION AND CONSERVATION OF ENERGY (5 days)	INSTRUCTIONAL RESOURCES

Motions of small invisible particles.

-Gas pressure, Boltzmann's Constant, and molecules.

-Temperature and molecular K.E.

-Internal energy.

Mechanical energy of bulk motion and internal energy.

-Quantitative study of the conservation of mechanical to internal energy.

-Heat flow.

Quantitative relation of energy dissipation and temperature rise.

-Conservation of energy.

TEXTS

Basic: CPPSSC, Ch. 20

Supplementary: MCP Ch. 30

LABORATORY

CPLG: Exp. 41

ECP, Ch. 16 Sec. 16.1
Ch. 20 Sec. 20.1
20.2

VISUAL AIDS

Film:
Conservation of Energy PSSC (27)

Fs 539 Kinetic-Molecular Theory (59F)

OUTSIDE READING

Rogers, Eric M. "The Great Molecular Theory of Gases" from: Physics for the Inquiring Mind. Princeton Univ. Press, 1960.

Maxwell, Clark J. "On the Kinetic Theory of Gases" from: Theory of Heat. Longmann, Green, and Co., London, 1872, Ch. 22.

21. IRREVERSIBLE PROCESS (4 days)	INSTRUCTIONAL RESOURCES
Irreversible processes, examples of. An experiment with marbles. -Qualitative explanation of the marble experiment. -Basic ideas about probability. -States and distribution. Expansion of a gas. -Free expansion of a gas. -Quantitative aspects. -Density fluctuations. -Inelastic collisions and heat conduction.	TEXTS Basic: CPPSSC, Ch. 21. LABORATORY CPLG: Exp 42 VISUAL AIDS Film: Random Events, PSSC (17) OUTSIDE READING Feyman, Leighton and Sands, M. The Feyman Lectures on Physics. Addison-Wesley Pub. Co. Inc., Reading, Mass. 1963, Vol. I, Ch. 6.

22. ENTROPY (3 days)

Description of a physical system.

-The macroscopic state.

-Reversible process.

-The microscopic state.

-The gas oscillator.

-Adiabatic and isothermal processes.

Free expansion and isothermal expansion of an ideal gas.

Entropy

-Heat bath.

-Entropy changes in an inelastic collision.

-Entropy changes in heat conduction at constant volume.

-The entropy of an ideal gas when both volume and temperature change.

-Diffusion--the entropy of a perfect gas.

The Second Law of Thermodynamics.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC Ch. 22

Supplementary: MCP, Ch. 25

LABORATORY

None.

VISUAL AIDS

Film:
Mechanical and Thermal Energy
PSSC (22)

OUTSIDE READING

MacDonald, D.K.C. Near Zero.
Doubleday Anchor, Science Study Series, 1961.

23. SOME QUANTITATIVE FACTS ABOUT ELECTRICITY (5 days)	INSTRUCTIONAL RESOURCES

Electrostatic charges.

-Method of producing.

-Forces between charged bodies.

-Electrostatic forces and atomic charged particles.

-Kinds of charges.

-Charges in motion.

-Conductors and insulators.

The electroscope

-Detection of charge.

-Electrostatic induction.

Transfer of charge.

-Batteries.

-Electric currents.

-Conduction of gases--ionization.

-Cloud chamber.

-Conductivity of solutions.

-Electrons in metals.

-Diodes, electron guns, cathode-ray oscilloscopes.

TEXTS

Basic: CPPSSC, Ch. 23

Supplementary: MCP, Ch. 47

LABORATORY

CPLG: Exp. 43
Exp. 44

VISUAL AIDS

Demonstration in electrostatics (nature of demonstrations dependent upon equipment available)

Films:
Electroscope, EBF (11)

Electrostatics (11)

OUTSIDE READING

Ingalls, Albert G. "About Historic and Modern Machines for the Generation of Static Electricity" from: The Amateur Scientist. Scientific American Inc., 1955.

Weisskopf, Victor, F. Knowledge and Wonder. Doubleday Anchor Science Study Series, 1963.

24. COULOMB'S LAW AND THE ELEMENTARY ELECTRIC CHARGE (5 days)	INSTRUCTIONAL RESOURCES

Electrostatic force.

-Force and distance.

Force and charge.

-Electric force fields.

-Electric forces as vectors.

-Electric field patterns.

-Uniform force fields.

The Millikan experiment.

-Measuring small electrical forces.

-The fundamental natural unit of electric charge.

-Large electrical balance.

-Parallel plates and the electric field.

-Force between elementary charges.

Coulomb's Law and the constant of proportionality.

-Conservation of charge.

-The charge of an electron.

TEXTS

Basic: CPPSSC, Ch. 24

Supplementary: MCP, Ch. 50
Ch. 57

LABORATORY

CPLG: Exp. 45
Exp. 46

Millikan Oil Drop (Cenco)

VISUAL AIDS

Films:
Coulomb's Law, PSSC (24)

The Millikan Experiment, PSSC (70)
Coulomb's Force Constant, PSSC (34)
Electric Lines of Force, PSSC (7)
Discovery of the Electron, EBF (30)
Electronic Charge and Mass, EBF (30)

OUTSIDE READING

Cavendish, Henry. "Experimental Determination of the Law of Electric Force" from: The Electrical Researches of the Honourable Henry Cavendish, F.R.S. Cambridge Univ. Press, Cambridge, England, 1879.

Magie, William Francis. A Source Book in Physics. McGraw Hill, 1935, pp. 408-20.

25. ENERGY AND MOTION OF CHARGES IN ELECTRIC FIELDS (3 days)	INSTRUCTIONAL RESOURCES

Kinetic energy of a charged particle.

-Work and K.E.
-The speed of a charged particle.
-Measuring the speed of a charged particle.
-Mass of the electron and proton.
-The hydrogen atom.

Elementary charges in motion.

-Electric current.
-Electric current and number of charges.
-Constancy of current in a closed circuit.
-Current and electrolysis.

EMF.

-EMF of a battery.
-EMF and energy.
-EMF defined.
-Batteries in series.
-Total energy of a battery.

Interaction between elementary charged particles.

-Electric field.
-Electric potential.
-Potential difference.
-Components of potential difference.

Practical units of electricity.

-Volt, coulomb and ampere.
-Electrical energy--electron volt.
-Electrical power.

TEXTS

Basic: CPPSSC, Ch. 25

Supplementary: MCP, Ch. 48

LABORATORY

CPLG: Exp. 47
Exp. 48

ECP, Ch. 35, Sect. 35.1

VISUAL AIDS

Films:
Counting Electrical Charges in Motion, PSSC (23)

Elementary Charges and Transfer of K.E., PSSC (33.5')

E.M.F., PSSC (20)

Fs 537.2 Current Electricity
Part I (24F)
Part II (27F)
Part III (26F)

OUTSIDE READING

MacDonald, D.K.C. Near Zero, "Science Study Series." Doubleday Anchor, 1961, Ch. 3.

MacDonald, D.K.C. "The Relativity of Electricity and Magnetism" from: Faraday, Maxwell, and Kelvin. Doubleday Anchor Inc. 1964.

26. THE RUTHERFORD ATOM (3 days)	INSTRUCTIONAL RESOURCES

The Rutherford atom.

-Deflection of alpha particles.

-Trajectories of alpha particles in the electric field of a nucleus.

-Angular distribution of scattering.

TEXTS

Basic: CPPSSC, Ch. 26

Supplementary: MCP, Ch. 60

LABORATORY

Mechanical Particle Scattering, revolving equipment (district)

Alpha Particle Scattering; use only weak sources.

VISUAL AIDS

Films:
Rutherford Atom, PSSC (40)
Atomic Theory, UW (09)
Bohr Atom, EBF (30)

Fs 539.76 Structure of the Atom (49F)

OUTSIDE READING

Romer, Alfred. The Restless Atom, Science Study Series. Doubleday Anchor, 1960, Ch. 13.

Born, Max. The Restless Universe. Dover, 1951, Ch. 4.

Andrade, E.M. Rutherford and the Nature of the Atom, Science Study Series. Doubleday Anchor, 1964.

27. ELECTRIC CIRCUITS (3 days)	INSTRUCTIONAL RESOURCES

Electric field, potential and circuits.

-Potential difference and current flow.

-Electric field and current flow.

-Conductors and potential.

Measuring potential difference.

-Electrometers.

-Voltmeters.

-Current flow and measurement.

Elements of an electrical circuit.

-Definition of a circuit.

-Conservation of energy in a circuit.

-IR drops in a circuit.

-Series and parallel resistors.

-Kirchoff's Laws.

TEXTS

Basic: CPPSSC, Ch. 27

Supplementary: MCP, Ch. 49
Ch. 50

LABORATORY

CPLG: Exp. 49

VISUAL AIDS

Films:

Electric Potential Energy and Potential Difference, Parts I and II, PSSC (54)

Principles of Electricity, GE (20)

Series and Parallel Circuits, EBF, (10)

Fs 537 Elements of Electrical Circuits (86F)

Fs 537 Series and Parallel Circuits (86F)

OUTSIDE READING

Fink, Donald G. and Lutyens, David M. The Physics of Television, Science Study Series. Doubleday Anchor, 1960.

28. THE MAGNETIC FIELD (4 days)

The magnetic field.

-Detection and direction of a magnetic field, using a magnetic needle.
-Magnets and magnetic field.
-Electric currents and magnetic field.
-Hans Christian Oersted.

Nature of a magnetic field.

-Magnetic field strength.
-Magnitude of field and current flow.
-Vector nature of magnetic field.

Force and the magnetic field.

-The right-hand rule.
-The practical unit of the magnetic field.
-Force, current, and field.
-Meters and motors.

Current flow in a magnetic field.

-Force of a magnetic field.
-Magnetic field near a long straight wire.
-Uniform magnetic field.
-The mass of a charged particle and the magnetic field.
-Momentum of an alpha particle and the magnetic field.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC, Ch. 28

Supplementary: MCP, Ch. 51

LABORATORY

CPLG: Exp. 50
Exp. 51
Exp. 52

ECP, Ch. 23, Sec. 23.1

VISUAL AIDS

Films:
A Magnet Laboratory, PSSC (20)
Electrons in a Uniform Magnetic Field, PSSC (10)

Mass of the Electron, PSSC (18)

Magnetic Force, McGH (29)

OUTSIDE READING

MacDonald, D.K.C. "The Relationship of Electricity and Magnetism" from: Farady, Maxwell, and Kelvin, Science Study Series. Doubleday and Co., 1964.

Maxwell, James Clark "On the Induction of Electric Currents" from: A Treatise on Electricity and Magnetism, Vol. 2. Claredon Press, Oxford, 1881, Ch. 3.

29. ELECTROMAGNETIC INDUCTION AND ELECTROMAGNETIC WAVES (4 days)	INSTRUCTIONAL RESOURCES

Michael Faraday

-Induced currents in a wire loop.

-Induced current and velocity of a conductor.

-Relative velocity between loop and magnetic field.

Magnetic flux.

-Definition of "magnetic flux."

-Changing magnetic flux and its effects.

-Methods of producing an induced current.

Changes in magnetic flux.

-Induced EMF.

-Direction of the induced EMF.

-Len's Law and conservation of energy.

Electromagnetic waves.

-Electric fields around changing magnetic fluxes.

-Magnetic field around changing electric fields.

-Mechanism of electromagnetic radiation.

-The electromagnetic spectrum.

-Electromagnetic character of light waves.

TEXTS

Basic: CPPSSC, Ch. 29

Supplementary: MCP, Ch. 53
Ch. 54
Ch. 59

LABORATORY

CPLG: Exp. 53
Exp. 54

Franck-Hertz Experiment Cenco. May be used as a demonstration-laboratory session.

VISUAL AIDS

Film:
Electromagnetic Waves, PSSC (33)

OUTSIDE READING

Feyman, R.P., Leighton, R.B. and Sands, M. "Scientific Imagination" from: Feyman Lectures on Physics, Vol. 2 Addison-Wesley, Reading, Mass. 1963, Ch. 20.

Born, Max. "Electromagnetic Theory" from: Einstein's Theory of Relativity. Dover Publications Inc., N.Y. 1962, Ch. 5.

30. SPECIAL THEORY OF RELATIVITY (4 days)	INSTRUCTIONAL RESOURCES

Relativistic kinematics.

-A medium for light waves.

-Waves in a moving media.

-One-way measurement of light.

Michelson-Morley Experiment; the Michelson interferometer.

The Lorentz contraction.

-Twin source interference in a moving medium.

-A first-order experiment with light.

-The speed of light--a universal constant.

The Fizeau experiment.

Relativistic addition of velocities.

Time and frame of reference.

-Lorentz transformation.

-Time dilation.

-An experiment with muons.

-Length of moving objects.

-The twin paradox.

TEXTS

Basic: CPPSSC, Ch. 30

Supplementary: MCP, Ch. 12
Ch. 46

LABORATORY

CPLG: Exp. 55
Exp. 56
Exp. 57
Exp. 58

VISUAL AIDS

Film:
Time Dilation, PSSC (15)

OUTSIDE READING

Bronowski, J. "The Arrow of Time" from: Insight. Harper and Row, N.Y., 1964.

Ciardi, John. "My Father's Watch" from: As If. Rutgers, The State University, 1956.

Feyman, Leighton, and Sands, M. The Feyman Lectures on Physics, Vol. 1. Addison-Wesley Pub. Co., Inc., Reading, Mass, 1963, Ch. 15.

31. PHOTOS (3 days)

The graininess of light.

-X-rays
-Photon model of light.

Properties of photons.

-The photoelectric effect.

-Energy of photon and frequency.

-Photoelectric current and light intensity.

-Threshold wavelength.

-Photon momentum.

-Einstein's photoelectric equation.

-The orderliness of chance.

-Graininess and interference.

Reconciliation of particle and wave model of light.

-Electromagnetic waves and photons.

-Planck's constant.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC, Ch. 31

Supplementary: MCP, Ch. 61

LABORATORY

Project physics, Exp. 42

VISUAL AIDS

Films:
Photons, PSSC (18)

Photoelectric Effect, PSSC (21)

Pressure of Light, PSSC (21)

OUTSIDE READING

Born, Max. "Electromagnetic Theory" from: Einstein's the Theory of Relativity. Dover Pub. Inc., N.Y., 1962, Ch. 5.

32. SPEED, ENERGY AND MASS (3 days)	INSTRUCTIONAL RESOURCES

Mechanical behavior of particle at high speed and large exchanges of energy.

-The ultimate speed.

-Speed and K.E.

-Momentum.

-The momentum of photons, pressure of light.

-Compton scattering.

-Electron-position annihilation.

-Nuclear reactions and conservation of total energy.

-Mass and energy.

-Mass for photons.

TEXTS

Basic: CPPSSC Ch. 32

Supplementary: MCP, Ch. 75
Ch. 76

LABORATORY

None

VISUAL AIDS

Films:
Ultimate Speed, PSSC, (23)

Electron-Positron Annihilation, PSSC (19).

Photon Collisions and Atomic Waves, EBF (30)

OUTSIDE READING

Bertozzi, W. "Things That Go Faster Than Light," Scientific American, July, 1960.

Feyman, Leighton and Sands. The Feyman Lectures on Physics, Vol. 1. Addison-Wesley Pub. Inc., Reading, Mass. 1961, Ch. 16.

33. ATOMS AND SPECTRA (4 days)	INSTRUCTIONAL RESOURCES
The stability of atoms. -Frank-Hertz experiment; atomic energy levels. -Internal energy of the atom. Atomic spectra. -Excitation and emission. -Absorption spectra. -Energy loss and photon emission. -The hydrogen atom. -Energy levels of the hydrogen atom.	TEXTS Basic: CPPSSC, Ch. 33 Supplementary: MCP, Ch. 56 Ch. 58 Ch. 60 LABORATORY CPLG: Exp. 59 Exp. 60 VISUAL AIDS Films: The Frank-Hertz Experiment, PSSC (30) Light Sources and Their Spectra, EBF (30) Wavelength of Spectrum Lines, EBF (30) OUTSIDE READING Hoffman, Banesh. Strange Story of the Quantum, Dover Pub. 1959, Chs. 4, 5, and 8. Bitter, Francis. Magnets--The Education of a Physicist, Science Study Series. Doubleday Anchor, 1959, Chs. 3 and 7.

34. MATTER WAVES (3 days)	INSTRUCTIONAL RESOURCES
Particle and wave model of light. -de Brogbe's hypothesis. -Planck's constant. -Interference and de Brogbe's waves. -Helium atoms and neutrons. Light and matter. -Conservation of energy and momentum. -Newtonian approximations. -Standing waves. -A particle in a "box."	TEXTS Basic: CPPSSC, Ch. 34 Supplementary: MCP, Ch. 62 VISUAL AIDS Films: Matter Waves, PSSC (28) Interference of Photons PSSC (13) OUTSIDE READING Hughes, Donald J. The Neutron Story, Science Study Series. Doubleday Anchor, 1960.

35. ATOMS, MOLECULES AND NUCLEI (4 days)

Atomic structure.

-Hydrogen-like atoms--energy levels and size.

-Helium ion and helium atom.

-Lithium atom.

Electron binding.

-Absorption spectra.

-Ionization energies.

-Electron scattering.

-Size of atoms.

-Electron shells.

The Pauli principle; particles in a box.

Chemical binding.

The deuteron.

-The nuclear force.

-Complex nuclei.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC, Ch. 35

Supplementary: MCP, Ch. 66
Ch. 77

LABORATORY

None

VISUAL AIDS

Films:
Interference of Photons, PSSC (26)

Matter Waves, PSSC (17)

Fs 539.14 Composition of Atoms (49F)

Fs 539.7 What's in the Atom (41F)

Fs 539.76 Structure of the Atom (49F)

OUTSIDE READING

Hecht, Selig. Explaining the Atom, rev. ed. Viking Press.

Semat, Henry and Rapport, Samuel. Atomic Age Physics. Holt, Rinehart, and Winston. Chs. 6, 10.

36. CHANGE IN ATOMS AND NUCLEI (4 days)

Atomic and nuclear systems.

-Conservation of energy.

-Conservation of momentum and of angular momentum.

-Conservation of parity.

-Conservation of nucleons.

Atomic reactions.

-Atomic fission.

-Alpha decay.

-Lifetimes and barrier penetration.

-Alpha decay and barrier penetration.

-Lifetime and energy spread.

-Photon emission.

INSTRUCTIONAL RESOURCES

TEXTS

Basic: CPPSSC Ch. 36

Supplementary: MCP Ch. 78
Ch. 79
Ch. 80

VISUAL AIDS

Films:

Barrier Penetration--
Ripple Tank Wave Phenomenon
III, PSSC (26)

Inside the Nucleus and
Fission, EBF (30)

Nuclear Energy, EBF (30)

Atomic Energy, An Introduction, EBF (11)

Nuclear Reactor, MCGH (09)

OUTSIDE READING

Einstein, Albert and Infeld, Leopold. The Evolution of Physics, The Growth of Ideas from Early Concepts to Relativity and Quanta. Simon and Schuster, N.Y.

Faro, U. and Faro, L. Basic Physics of Atoms and Molecules. Wiley and Sons.

APPENDICES

APPENDIX A

Suggested Topics for Individual Study

MEASUREMENT

The history of the metric system

The origin of the units of the English system

The use of dimensional analysis in physics

Precise measurements in industry

Development of vernier scales

The ammonia clock

The work of the Naval Observatory

The standard meter measure in terms of wave length

Radio transmission of standard frequency and time signals

The history of the calendar

Present and future need for scientific personnel

Contributions of atomic energy to medicine, industry, and so forth

Contributions of electronics to transportation

Research in industry

The work of the United States Bureau of Standards

Government research agencies, Office of Naval Research, and so forth

MECHANICS

Perpetual motion machines

The Brachistochrone

Stresses in simple cranes and trussels

Forces acting on a sailboat

Streamlining in transportation

Friction measuring devices

Standards for non-slip surfaces

The forces on a moving automobile

Space stations

Space ships

The ultracentrifuge and its applications

Big Bertha

Rocket and missile design

Streamlining in transportation

Friction measuring devices

Standards for non-slip surfaces

The forces on a moving automobile

The Foucault pendulum

Theory of the gyroscope

The gyrocompass

The ship-stabilizing gyro

Elementary mechanics of billiards

Kepler's laws of planetary motion

The elastic properties of materials

Measurement of surface tension with tensiometer

Canal lock systems

Measurement of surface tension through capillary rise

Measurement of tensile and compressive strength

The action of "wetting agents"

Uses of principle hydraulic press

Capillarity in soils

The Bathysphere

The hydraulic ram

Water systems

Uses of the Bernoulli principle

High altitude flights

Uses of pneumatics

HEAT

The historical development of the kinetic theory of gases

The development of the temperature scales

High and low temperature measuring instruments

Thermal expansions in structures

Thermostatic controls

The human calorimeter

The bomb calorimeter

Modern fuels

Solar heating, furnaces, and so forth

Thermal conductivity measurements

Meterological instruments and data

Air conditioning

Modern gasoline and diesel engines

The gas refrigerator

Modern gas turbine

Early heat engines

WAVE MOTION AND SOUND

The physical pendulum

The history of the development of the musical scales

The history of the development of a musical instrument

Electronic musical instruments

Hearing tests and audiometry

The measurement of noise level

Velocity of sound measurements

Sonar

The production and application of ultrasonics

Architectural acoustics

Sound recording, hi-fidelity

LIGHT

Historical theories of light

The Michelson Morley experiment

The historical development of the method for determining the velocity of light

Applications of polarized light

Illumination requirements for home and industry

Stroboscopic effects and their uses

Color photography - still and motion pictures

The Palomar telescope

The deposition of films on glass

The pinhole camera

Optical illusions and mirages

Famous solar eclipses

Use of the spectrograph in industry

Light meters and their uses

Cameras and projectors

Lasers

ELECTRICITY AND MAGNETISM

Electrostatic generators

The electorstatic smoke eliminator

Lightning protection systems

The zerographic duplicating process

Theories of terrestial magnetism

Corrections to the magnetic compass

The degaussing and deperming of ships

Electroplating

Electrolytic refining of metals

Electrode potentials

Special primary cells and their uses

Storage batteries

The location of faults in telephone lines

The development of the telephone

The electric power plant

Anti-gravity devices

The Oudin coil

The lives of Faraday, Tesla, Edison, Steinmetz, and so forth

The electro-magnetic pump

MODERN PHYSICS

The lives of the atomic scientists

The development of the periodic table

The discovery of the various atomic particles

The x-ray microscope

X-rays and their uses

Radiation detectors and counters

The use of radio-active isotopes as tracers

Prospecting for radio-active minerals

The uses of phosphorescent and flourescent materials

The uses of infra-red radiation

Uses of ultra-violet light

Electronic instruments in medical practice

Guided missiles

Transistors and their uses

The magnetron

Micro-wave relay systems

Loran

Piezo-electricity and its uses

Long distance transmission of radio signals

The allocation of radio frequencies

The applications of radar to traffic control and enforcement

The uses of the photronic cell

The methods of separation of uranium

The Hanford project

The biological effects of cosmic rays

The trans-uranium elements

The military applications of atomic energy

The peacetime uses of atomic energy

Radiological effects of the atomic bomb

The atomic submarines

APPENDIX B

Books, Periodicals, and Equipment

Author	Title	Publisher
TEXT BOOKS		
Basic:		
PSSC	College Physics, First Edition.	D. C. Heath
PSSC	College Physics Laboratory Guide.	D. C. Heath
PSSC	Guide for Advanced Topics - 2nd edition.	D. C. Heath
Supplementary		
White	Modern College Physics - 4th/5th edition.	Van Nostrand
White and Manning	Experimental College Physics	McGraw Hill
CLASSROOM REFERENCE LIBRARY		
- - - - - - -	Science Study Series (Paperbacks)	Doubleday
Brown, Thomas	Foundations of Modern Physics	John Wiley & Sons
Chemical Rubber Co.	Handbook of Chemistry and Physics	Chemical Rubber Co.
Cifarri, Bernard	Experiments in College Physics, 2nd ed.	D. C. Heath
Glasstone, S.	Source Book on Atomic Energy, 2nd ed.	Van Nostrand
Knauss, Harold P.	Discovering Physics	Addison-Wesley
Ference, et al	Analytical Experimental Physics, 3rd ed.	Univ. of Chicago Press
Sears and Zemansky	University Physics, 2nd ed.	Addison-Wesley
Schaum, Daniel	Outline of Theory and Problems for Students of College Physics	Schaum Publishing Co.
Slater	Modern Physics	McGraw-Hill
Walter, M. J.	Discovering Physics by Experiment	Addison-Wesley

TEACHER REFERENCES:

Sutton, Richard	Demonstration Experiments in Physics	
Sears, Zemansky	University Physics	Addison-Wesley
Rogers, Eric	Physics for the Inquiring Mind	Princeton Press
Feynman,	Lectures on Physics, Vols. I & II	Addison-Wesley
Brown,	L. W. Taylor Manual of Advanced Undergrad Exp. in Physics	
Thomas	Calculus and Analytical Geometry	
Strong	Procedures in Experimental Physics	Prentiss Hall

PERIODICALS

American Journal of Physics	American Institute of Physics
American Scientist	Sigma Xi
Physics Teacher	
Physics Today	American Institute of Physics
Science	American Association for Advancement of Science
Science Newsletter	Science Service
Science Teacher	National Science Teacher Assoc.
Scientific American	Scientific American, Inc

SCIENTIFIC AMERICAN ARTICLES RELATING TO PHYSICS

1957	Title	Author
January	New Methods of Radio Transmission	Weisner
	Pions	Marshak
February	Atomic Clocks	Lyons
	Inertia	Sciama
March	Fresh Water from Salt	Jenkins
	The Child and Modern Physics	Piaget
	The Crab Nebula	Oort
April	The Overthrow of Parity	Morrison
	The Age of the Solar System	Brown
	Sun Clouds and Rain Clouds	Roberts
May	The Shortest Radio Waves	Gordy
	Diffusion in Metals	Cullity
June	A Rocket Around the Moon	Ehricke & Gamow
	Radiation Pressure	Henry
	Atoms Visualized	Müller
July	The Absorption of Radio Waves in Space	Lilley
	Elementary Particles	Gell-Mann & Rosenbaum
August	The Origin of Hurricanes	Malkus
	Electroluminescence	Ivey
	How Fishes Swim	Gray
	The Ear	Bekesy
	The Plasma Jet	Giannini
October	Salt and Rain	Woodcock
	Plasmoids	Bostick
November	Superconductivity	Matthias
December	Observations of Satellite I	Whipple & Hynek
	Fusion Power	Post
	Heinrich Hertz	Morrison

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1958	Title	Author
January	Tracking Satellites by Radio	Meugel & Herget
	Ultrahigh-Altitude Aerodynamics	Schaaf
	The Principle of Uncertainty	Gamow
February	Strong Magnetic Fields	Furth
	Ancient Temperatures	Emiliani
	The Discovery of Fission	Hahn
March	Particle Accelerators	Wilson
	Helmholtz	Crombie
April	Antimatter	Burbidge & Hoyle
	The Teaching of Elementary Physics	Michels
May	Tornadoes	Tepper
	A "Flying-Spot" Microscope	Montgomery & Bonner
	The Earth As a Dynamo	Rosenbaum & Elsasser
June	Superfluidity	Lifshitz
	Climate and the Changing Sun	Öpik
July	Prestressed Concrete	Lin
	More about Bat "Radar"	Griffin
August	Hot Spots in the Atmosphere of the Sun	Zirin
	Magnetic Resonance	Pake
September	Innovation in Physics	Dyson
	Innovation in Technology	Pierce
	The Encouragement of Science	Weaver
October	The Stellerator	Spitzer
	The Tails of Comets	Biermann & Lüst
November	The Revival of Thermo Electricity	Joffe
	Stellar Populations	Burbidge
	Drilling for Petroleum	Marsden
December	Non-Military Nuclear Explosions	Johnson & Brown
	The Maser	Gordon

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1959	Title	Author
January	Dying Stars	Greenstein
	The Atomic Nucleus	Feierls
February	Reactor Fuel Elements	Schumar
	How Water Freezes	Chalmers
March	Radiation Belts Around the Earth	Van Allen
	The Weak Interactions	Treiman
	Long Earthquake Waves	Oliver
April	The Solar System Beyond Neptune	Gingerich
	Aligned Crystals in Metals	Cullity
May	Nuclear Rockets	Newgard & Levoy
	Balloon Astronomy	Schwarzschild
	Experiments in Color Vision	Land
	Artificial Satellites and Relativity	Giuzborg
June	Rocket Astronomy	Friedman
	An Ancient Greek Computer	Price
	Junction-Diode Amplifier	Uhliv
July	Pulsating Stars and Cosmic Distances	Kraft
	The Exclusion Principle	Gamow
August	Satellites and the Earth's Atmosphere	Jastro
	The Radio Galaxy	Westerhout
	Ocean Waves	Bascom
September	Issue on Ionizing Radiation	
October	The Earth in the Sun's Atmosphere	Chapman
	Fuel Cells	Austin
November	Ultrahigh Pressures	Hall
	The Invention of the Electric Light	Josephson
	High Energy Cosmic Rays	Rossi
December	The Arms of the Galaxy	Bok
	The Flow of Matter	Reiner

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1960	Title	Author
January	The 600-foot Radio Telescope	McClain
	Breeder Reactors	Weinberg
	The Green Flash	O'Connell
February	The Magnetism of the Sun	Babcock
	Fracture in Solids	Gilman
	Cosmic Spherules and Meteoritic Dust	Pettersson
March	Interplanetary Navigation	Mickelwait
	Applications of Superconductivity	Bechhold
	The Nuclear Force	Marshok
April	Life Outside the Solar System	Huang
	The Mossbauer Effect	Benedetti
	Radiation and the Human Cell	Puck
May	The Exploration of the Moon	Jastro
June	Solar Particles and Cosmic Rays	Anderson
	Ferrites	Hogan
	Humphry Davy	Williams
July	The Force Between Molecules	Derjaguin
	The Zodiacal Light	Blackwell
	Metal Whiskers	Brenner
	Things That Go Faster Than Light	Rothman
August	Vertical-takeoff Aircraft	Campbell
	Radar Astronomy	Eshleman & Peterson
	The Structure of Liquids	Bernal
September	The Scientific Revolution	Butterfield
October	Optical Pumping	Bloom
	High Speed Impact	Charters
	The Physics of Woodwinds	Benade
	Count Rumford	Wilson
November	Fiber Optics	Kapany
	Superfluidity and "Quasi-Particles"	Reif
	The Age of the Solar System	Reynolds
December	Nonuniform Magnetic Fields	Pohl

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1961	Title	Author
January	Re-entry from Space	Becker
	Glass	Greene
	A New Scale of Stellar Distances	Wilson
	The Growth of Snow Crystals	Mason
February	Peculiar Galaxies	Burbidge
	The Celestial Palace of Tycho Brahe	Christenson
March	Electrical Propulsion in Space	Giannini
	Gravity	Gamow
	Lee Waves in the Atmosphere	Scorer
	Monomolecular Films	Ries
April	The Size of the Solar System	McGuire
	Ultrahigh-speed Rotation	Beams
May	The Temperature of the Planets	Mayer
	From Faraday to the Dynamo	Sharlin
June	Optical Masers	Schawlow
	Subdwarf Stars	Burbidge
	The Airborne Magnetometer	Jensen
July	The Moon	Penman
	Weather Satellites	Neiburger & Wexler
	Superconducting Computers	Ittner & Kraus
August	Astroblemes	Dietz
	The Reproduction of Sound	David
	Low-Altitude Jet Streams	Barad
September	Issue on Cells	
October	Communication Satellites	Pierce
	Observing Dislocation	Dash & Tweet
	The Magnetism of the Ocean Floor	Raff
November	The Two-Mile Accelerator	Ginzton & Kiuk
	Tektites	Barnes
	Maxwell's Color Photograph	Evans
	The Electrocardiogram	Scher
December	The Eötvös Experiment	Dicke
	Galvanomagnetism and Thermomagnetism	Angrist

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1962	Title	Author
January	Sonic Boom	Wilson
	Aftereffects in Perception	Prentice
	Hypernuclei	Telegdi
	Two-Phase Materials	Slayter
February	The Solar Chromosphere	Athay
	Physiological Effects of Acceleration	Rogers
	Wear	Rabinowicz
March	Radio Galaxies	Heeschen
	Ultrahigh Vacuum	Steinhertz & Redhead
	The Longest Electromagnetic Waves	Heirtzler
April	Exploding Stars	Kraft
	Paradox	Quine
	The Action of Adhesives	de Bruyne
	The Soaring Flight of Birds	Cone
May	Gamma Ray Astronomy	Kraushaar & Clark
	Experiments with Goggles	Kohler
	Exploding Wires	Bennett
June	The Detection of Underground Explosions	Leet
	Superconducting Magnets	Kunzler & Tanenbaum
	Computer Programs for Translation	Yngre
July	The Moon Illusion	Kaufman & Rock
	Telephone Switching	Feder & Spencer
August	The Spark Chamber	O'Neill
	Neutrino Astronomy	Morrison
September	The Antarctic and the Upper Atmosphere	Wright
	The Antarctic and the Weather	Rubin
October	Ancient Fluids in Crystals	Roedder
	Semiconductor Particle-Detectors	Bilaniuk
November	The Pleiades	Limber
	The Physics of Violins	Hutchins
	Neutron Radiograph	Berger
December	Desalting Water by Freezing	Snyder
	Atmospheric Tides	Butler
	The Conduction of Heat in Solids	Sproull
	Ultraviolet Radiation and Nucleic Acid	Deering

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1963	Title	Author
January	Resonance Particles	Hill
	The Evolution of Galaxies	Arp
	Why Do Roads Corrugate?	Mather
February	Rotation of Stars	Abt
	Shock Waves and High Temperature	McChesney
	The Clock Paradox	Bronowski
March	Organic Matter from Space	Mason
	Electric Location by Fishes	Lissmann
	The Two-Neutrino Experiment	Lederman
	Ball Lightning	Lewis
April	Planetary Nebulae	Liller
	The Synthetic Elements	Seaborg & Fritsch
May	The Physicist's Picture of Nature	Dirac
	Moiré Patterns	Oster & Nishijima
	Radiation Belts	O'Brien
June	The Ecological Effects of Radiation	Woodwell
	Noctilucent Clouds	Soberman
	Kilomegacycle Ultrasonics	Dransfeld
	Hydrogen in Galaxies	Roberts
July	Advances in Optical Masers	Schawlow
	The Voyage of Mariner II	James
	The Fermi Surface of Metals	Mackintosh
August	Observatories in Space	Berman
	The Strength of Steel	Zackay
September	Energy	Schurr
October	Conservation Laws	Feinberg & Goldhaber
	Chondrites and Chondrules	Wood
	After Images	Brindley
November	Plasmas in Solids	Bowers
	Architectural Acoustics	Knudsen
December	Vehicular Traffic Flow	Herman & Gardels
	Quasi-Stellar Radio Sources	Greenstein
	The Continuous Casting of Steel	Gallagher & Old
	Magnetic Monopoles	Ford

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1964	Title	Author
January	The Large Cloud of Magellan	Bok
	Boron	Massey
	The Origins of the Stear Engine	Ferguson
	Advances in Field Emission	Dyke
February	Tektites and Impact Fragments from the Moon	OKeefe
	Strongly Interacting Particles	Chew
March	All Weather Aircraft Landing	Brady
	The Circulation of the Upper Atmosphere	Newell
	Fast-Neutron Spectroscopy	Cronberg
	The Discovery of Stellar Aberration	Stewart
April	The Interaction of Light with Light	Giordmaine
	The Solar Wind	Parker
May	High Voltage Transmission	Barthold & Pfeiffer
	Dwarf Galaxies	Hodge
June	The Supersonic Transport	Bisplinghoff
	X-ray Astronomy	Friedman
	Magneto Thermoelectricity	Wolfe
July	Radiowaves from Jupiter	Franklin
August	Radio-emitting Flare Stars	Lovell
	Liquid Crystals	Ferguson
September	Probability	Kac
	Mathematics in the Physical Sciences	Dyson
October	The Omega-Minus Experiment	Fowler & Samios
	Micrometeorology	Sutton
November	Exploding Galaxies	Sandage
	The Solid State of Polyethylene	Wunderlich
	The Michelson-Morley Experiment	Shankland
December	Hurricane Modification	Simpson & Malkus
	Three-Pigment Color Vision	MacNichol
	Fluid Control Devices	Angrist

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1965	Title	Author
January	Infrared Astronomy by Balloon	Strong
	The Undercooling of Liquids	Turnbull
	Magnetic Resonance of High Pressure	Benedek
February	Superconductivity at Room Temperature	Little
	Fiber-reinforced Metals	Kelly
	The Age of the Orion Nebula	Vandervoort
March	The Structure of Crystal Surfaces	Germer
	The Magnetosphere	Cahill
	De Forest and the Triode Detector	Chipman
	Computer Experiments in Fluid Dynamics	Harlow
April	Intense Magnetic Fields	Kolm & Freeman
	The Discovery of Icarus	Richardson
	The Stirling Refrigeration Cycle	Köhler
May	The Luminescence of the Moon	Kopal
	High Pressure Technology	Zeitlin
	Molecular Beams	Frisch
June	Photography by Laser	Leith & Upatnieks
	The Magnetic Field of the Galaxy	Berge & Seielstad
	Corona Chemistry	Coffman & Browne
July	Hydroxyl Radicals in Space	Robinson
	Ultrastrong Magnetic Fields	Bitter
August	Infrared Astronomy	Murry & Westphal
	Nuclear Fission	Leachman
	Density Gradients	Oster
September	Issue on Urbanization	
October	Electrical Effects in Bone	Bassett
	Chance	Ayer
	Quantum Effects in Superconductors	Parks
November	Resonant Vibrations of the Earth	Press
	Microelectrons	Hittinger & Sparks
December	Violations of Symmetry in Physics	Wigner
	The Aurora	Akasoiu
	The Physics of the Piano	Blackham

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1966	Title	Author
January	Communication by Laser	Miller
	Ranger Missions to the Moon	Schurmeier
February	Neutrinos from the Atmosphere and Beyond	Reines
	Stress-corosion Failure	Swann
March	The Voyage of Mariner IV	James
April	Chemical Lasers	Pimentel
	The Photographs from Mariner IV	Leighton
	The Muonium Atom	Hughes
May	The Scientific Experiments of Mariner IV	Sloan
June	Locating Radio Sources with the Moon	Clarke
	Applications of the Coanda Effect	Reba
July	The Detection of Underground Explosions	Bullard
	Polarized Accelerator Targets	Shapiro
August	A Solid-State Source of Microwaves	Bowers
	The Origin of Cosmic Rays	Burbidge
	The Study of Sailing Yachts	Herreshoff & Newman
September	The Uses of Computers in Technology	Coons
	The Uses of Computers in Science	Oettinger
October	Night Blindness	Dowling
	Science in History, by J. D. Bernal	Pirie
	The Origins of the Copernican Revolution	Ravetz
November	Magnetic Fields on the Quiet Sun	Livingston
December	Noise	Beranek
	The Problem of the Quasi-Stellar Objects	Burbidge & Hoyle
	Progress Toward Fusion Power	Fowler & Post

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1967	Title	Author
January	Can Time go Backward?	Gardner
	Electric Currents in Organic Crystals	Pope
February	Reversals of the Earth's Magnetic Field	Cox, Dalrymple & Doell
	The Solvated Electron	Dye
March	The Origin of the Automobile Engine	Bryant
	The Surface of the Moon	Hibbs
	Advances in Superconducting Magnets	Sampson, Craig & Strongin
April	Antimatter and Cosmology	Alfvén
	Neutron-Activation Analysis	Wahl & Kramer
May	Ordinary Matter	Feinberg
	A Third-Generation of Breeder Reactors	Bump
	Light-Emitting Semiconductors	Morehead
	Vision and Touch	Rock & Harris
June	Liquid Lasers	Lempicki & Samelson
July	The Leakage Problem in Fusion Reactors	Chen
August	The Youngest Stars	Herbig
September	The Electrical Properties of Materials	Ehrenreich
	The Magnetic Properties of Materials	Keffer
	The Thermal Properties of Materials	Zinman
	The Nature of Metals	Cottrell
	The Solid State	Mott
October	The Shape of the Earth	King-Hele
	Interstellar Grains	Greenburg
November	Gravitational Collapse	Thorne
	Maxwell's Demon	Ehrenberg
December	The Vibrating String of the Pythagoreans	Helm
	Scattering High-Energy	Barger & Cline
	X-Ray Stars	Giacconi
	Zone Refining	Pfann

SCIENTIFIC AMERICAN ARTICLES (Cont.)

1968	Title	Author
January	Remote Sensing of Natural Resources	Colwell
	The Circulation of the Sun's Atmosphere	Starr et. al.
	Perpetual Motion Machines	Angust
February	The Arrival of Nuclear Power	Hogerton
	Advances in Holography	Pennington
March	Channeling in Crystals	Bassedt
	Pulse Code Modulation	Mayo
May	The Three Spectroscopics	Weisskopf
	The Heat Pipe	Eastman
	The Lunar Orbiter Mission to the Moon	Levin et. al.

LIBRARY REFERENCE MATERIALS--It is recommended that each school library should have a reference collection similar to the following list. The items marked with (*) are valuable teacher reference books.

AUTHOR	TITLE	PUBLISHER
Alter, D., et al	Pictorial Astronomy	Thomas Y. Crowell
Andrade, E. N.	Sir Issac Newton	Macmillan
Angelo, E., Jr.	Electronic Circuits	McGraw-Hill
Ashford, Theo. A.	From Atoms to Stars	Henry Holt Co.
Asimov, Isaac	Building Blocks of the Universe	Abelard Schuman Ltd.
Asimov, Isaac	Only A Trillion: Speculations and Explorations on the Marvel of Science	Abelard Schuman Ltd.
Asimov, Isaac	The Chemicals of Life	Abelard Schuman Ltd.
Barnett, Lincoln	The Universe and Dr. Einstein	Sloane
Behrens, Charles F.	Atomic Medicine	Nelson
Berkeley, E. C. and Wainwright, L.	Computers: Their Operation and Applications	Reinhold Pub.
Besancon, R. M.	Encyclopedia of Physics	Reinhold Pub.
Bishop, Amasa	Project Sherwood	Wesleyan Univ. Press
Bitter, Francis	Magnets	Wesleyan Univ. Press
Bohr, Niels	Atomic Physics and Human Knowledge	Wiley and Sons
Bonner, F. T. and Phillips, H.	Principles of Physical Sciences	Addison-Wesley
Boucher, Paul E.	Fundamentals of Photography (4th ed.)	Van Nostrand
Boys, C. V.	Soap Bubbles	Wesleyan Univ. Press
Bragg, Sir William	Concerning the Nature of Things	Dover
Burton, E. F. and Kohl, W. H.	The Electron Microscope	Reinhold

AUTHOR	TITLE	PUBLISHER
Carlin, B.	Ultrasonics	McGraw-Hill
Coggins, Jack	Rockets, Jets, Guided Missiles and Space Ships	Random House
*Coleman, James	Relativity for the Layman	Frederick Press
Cook, James G.	Electrons Go to Work	Dial
Cooper, M.	Inventions of Leonardo da Vinci	Macmillan
Courant, Richard and Robbins, Herbert	What is Mathematics?	Oxford U.P.
D'Abro, A.	The Rise of the New Physics	Dover
Dantzig, Tobias	Number, The Language of Science	Macmillan
Davis, Helen Miles	Science Exhibits	Science Service
*Davis, Helen Miles	Scientific Instruments You Can Make	Science Service
*Dean, Gordon	Report on the Atom	Alfred A. Knopf
*Eaton, James	Beginning Electricity	Macmillan
Eddington, A.	Nature of the Physical World	U. of Michigan
Editors of Scientific American	Scientific American Reader	Simon and Schuster
Einstein, Albert	Out of my Later Years	Philosophical Lib. (out of print)
*Einstein, Albert and Infeld, Leopold	The Evolution of Physics: The Growth of Ideas from Early Concepts to Relativity and Quanta	Simon and Schuster
Epstein, Beryl and Epstein, Samuel	The Rocket Pioneers: On the Road to Space	Messner, Julian
Evans	Experiments in Electronics	Prentice Hall
Faraday, M.	On the Various Forces of Nature	Crowell
Faro, U. and Faro, L.	Basic Physics of Atoms & Molecules, text ed.	Wiley

AUTHOR	TITLE	PUBLISHER
Faro, U.	Basic Physics of Atoms and Molecules	M. I. T.
*Fermi, Laura	Atoms in the Family: My Life with Enrico Fermi	Univ. of Chicago
Friend, J. Newton	Numbers: Fun and Facts	Scribner's
Gamow, George	Biography of Physics	Harper
Gamow, George	The Birth and Death of the Sun	Mentor Books
Gamow, George	Matter, Earth, and Sky	Prentiss Hall
Gamow, George	Mr. Thompkims Explores the Atom	Cambridge Univ.
Gamow, George	Mr. Thompkins in Wonderland	Cambridge Univ.
Gamow, George	Mr. Thompkins Learns the Facts of Life	Cambridge Univ.
Gamow, George	One, Two, Three--Infinity	Viking Press
Gamow, George and Stern, Marvin	Puzzle-Math	Viking Press
Garner, Louis	Transistor Circuits	Coyne
*Glasstone, Samuel	Sourcebook on Atomic Energy (2nd ed.)	Van Nostrand
Gray, Dwight E.	Radiation Monitoring in Atomic	Van Nostrand
Griffin, D. R.	Echoes of Bats and Men	Wesleyan Univ. Press
*Hannay, Norman B.	Semiconductors	Reinhold Pub.
*Hecht, Selig	Explaining the Atom (rev. ed.)	Viking Press
*Hogben, Lancelot	Mathematics for the Million (3rd ed.)	Norton, W. W.
Hogben, Lancelot	Science for the Citizen	Norton, W. W.
Holton, Gerald J. or Holton, Gerald J.	Introduction to Concepts and Theories in Physical Science (1952) / Foundations of Modern Physical Science (1958)	Addison-Wesley / Addison-Wesley

AUTHOR	TITLE	PUBLISHER
Hornung, Julius L.	Radar Primer	McGraw Hill
Hoyle, Fred	Frontiers of Astronomy	Mentor
Hoyle, Fred	The Nature of the Universe	Mentor
Jammer, M.	Concepts of Space	Harvard Press
Jeans, J. H.	The Growth of Physical Science	Cambridge Univ. Press, London
*Jenkins, F. A. and White, H. E.	Fundamentals of Optics, 3rd ed.	McGraw-Hill
Jungk, Robert	Brighter Than A Thousand Suns	Harcourt Brace
Kahn, Fritz	Design of the Universe	Crown Publishers
Landau, L. D.	What Is Relativity	Basic Books
Lemon, H. B.	From Galileo to the Nuclear Age	Univ. of Chicago Press
*Ley, Willie	The Conquest of Space	Viking Press
*Ley, Willie and Von Braun, W.	The Exploration of Mars	Viking Press
*Ley, Willie	Rockets, Missiles and Space Travel (rev. ed.)	Viking Press
Ley, Willie	Satellites, Rockets, and Outer Space	New American Library
*Lieber, T. C.	The Education of T. C. Mits	Norton, W. W.
*Lieber, Lillian R.	Einstein Theory of Relativity	Holt, Rinehart & Winst
*Lieber, Lillian R.	Infinity	Holt, Rinehart & Winst
Luhr, O.	Physics Tells Why	Ronald
MacCurdy, E.	Notebook of Leonardo da Vinci	Braziller
McLaughlin, Howie	Space Age Dictionary	
Meyer, Jerome S.	Fun with Mathematics	World Publisher
Messel, H.	Introduction to Modern Physics	St. Martins

AUTHOR	TITLE	PUBLISHER
Minnaert, M.	The Nature of Light and Color in Open Air	Dover Press
Moore, Patrick	The Story of Man and the Stars	Norton, W. W.
Mott, M. F. and Jones, H.	The Theory of the Properties of Metals and Alloys	Dover Press
Park, David	Contemporary Physics	Harcourt
*Payne-Gaposchkin, Cecelia	Stars in the Making	Harvard Univ.
Peierls, R. E.	The Laws of Nature	Charles Scribner
Pfeiffer, John	Changing Universe, The	Random House
Pierce, J. R.	Electrons, Waves and Messages	Doubleday
Reid, Constance	From Zero to Infinity	Thomas Y. Crowell
Ridenour, L.	Modern Physics for the Engineer	McGraw
*Rogers, E.	Physics for the Inquiring Mind	Princeton Univ. Press
Roberts, John	Heat and Thermodynamics, 5th ed.	Interscience
Rossi, B.	Cosmic Rays	McGraw
Santillana	Crime of Galileo	Univ. of Chicago
Scott, W. T.	The Physics of Electricity & Magnetism	Wiley
*Sears, F. W.	Mechanics, Wave Motion and Heat	Addison-Wesley
*Sears, F. W. and Zemansky, M. W.	University Physics	Addison-Wesley
*Semat, Henry	Introduction to Atomic and Nuclear Physics	Holt, Rinehart & Winston
*Semat, Henry	Physics in the Modern World	Holt, Rinehart & Winston
*Semat, Henry and White, H.	Atomic Age Physics	Holt, Rinehart & Winston
Skilling, H. H.	Exploring Electricity: Man's Unfinished Conquest	Ronald Press

AUTHOR	TITLE	PUBLISHER
Sutton, R.	Physics of Space	Holt
Swezey, Kenneth M.	Science Magic	McGraw Hill
Von Laue, M.	History of Physics	Academic
Weizsacker	Contemporary Physics	Braziller
Wilson, E.	An Introduction to Scientific Research	McGraw Hill
Wilson, M.	Energy	Silver Burdett
*Woodbury, David O.	The Glass Giant of Palomar	Dodd, Mead & Co.
*Wright, Helen and Rapport, Samuel, eds.	Great Adventures in Science	Harper
Young, M. E.	Radiological Physics	Academic Press
	Encyclopedia of Science and Technology	McGraw Hill
	Man, Rockets and Space	Julian Messner
	Mathematics of the Imagination	Simon and Schuster
	The Mighty Force of Research	McGraw Hill
	Yearbook of Science and Technology 1962	McGraw Hill
	Yearbook of Science and Technology 1963	McGraw Hill
	Yearbook of Science and Technology 1964	McGraw Hill

LIST OF PHYSICS EQUIPMENT TO BE SHARED BY SCHOOLS

The following equipment items have been provided on a circulatory basis among schools in each area.

DESCRIPTION	AREA AND SCHOOL HOLDING CUSTODY		
	WEST	CENTRAL	EAST
Alpha Ray Apparatus, Hoag, Welch 621A o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Alpha Ray Track Apparatus, Cenco 71245	Pt. Loma	Clairemont Hoover	Crawford Morse
Ballistic Pendulum, Blackwood Form	Pt. Loma	Clairemont Hoover Madison	Morse
Brenner Torque Demonstrator	I.A.D.C	I.A.D.C.	I.A.D.C
Canal Ray Tube, Wien, Cenco 71525	Mission Bay Pt. Loma	Hoover Madison	Morse
Choke & Resonance, Demonstration, Welch 2601B o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Diffusion Pump (High Vacuum)		Clairemont	
Electromagnetic demonstration set, Welch 2462 o/e	La Jolla Pt. Loma	Madison	Lincoln Morse
Inertial Masses, Cylindrical, Cenco 75305	Mission Bay	Kearny	Crawford
Interferometer, with Accessory Lamp, Michelson Cenco 71857, 71859-26	San Diego	Clairemont Madison	Crawford Morse
Mechanical Equivalent of heat apparatus, Welch 1684 o/e	La Jolla Pt. Loma	Madison	Lincoln Morse
Microwave Optics Equip., Cenco 80422, 80429-3 80429-4, 80434	Pt. Loma	Clairemont Hoover Madison	Morse
Nuclear Scattering Apparatus, Welch 615	Mission Bay	Kearny Madison	Lincoln Morse
Oil Drop Apparatus Kit, Welch 620 o/e	Pt. Loma	Clairemont Madison	Lincoln Morse

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West: La Jolla, Mission Bay, Point Loma, San Diego
Central: Clairemont, Hoover, Kearny, Madison
East: Crawford, Henry, Lincoln, Morse

LIST OF PHYSICS EQUIPMENT (Cont.)

DESCRIPTION	AREA AND SCHOOL HOLDING CUSTODY		
	WEST	CENTRAL	EAST
Photoelectric Relay, demonstration, Welch 2148g o/e	La Jolla Pt. Loma	Madison	Lincoln Morse
Power Supply, demonstration, Welch 2138 o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Power Unit, high voltage, for Oil Drop Apparatus, Welch 620K o/e	Pt. Loma	Clairemont	Lincoln Morse
Radio Receiver, demonstration, Welch 2620 o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Radio Transmitter, demonstration, Welch 2621 o/e	Pt. Loma	Clairemont Hoover Madison	Morse
Specific Charge of Electron Apparatus, Cenco 71264	Pt. Loma	Clairemont Madison	Lincoln Morse
Stroboscope, 480 to 60,000 vib/min., Welch 2154 o/e	Pt. Loma	Clairemont Kearny Hoover (2) Madison	Morse
Support, Rotating, ball bearing, Cenco 75265	Mission Bay	Kearny Madison	Crawford
Triode Demonstrator, Welch 2152 D	Pt. Loma	Clairemont Hoover	
Ultasonics, demonstration, Cenco 71870	Mission Bay San Diego	Madison	Crawford Morse
Voltmeter, for Oil Drop Apparatus, Welch 3087 o/e	Pt. Loma	Clairemont Madison	Lincoln Morse
Wave Demonstrator, Bell Labs		Clairemont Kearny	Crawford

APPENDIX C

Supplementary Materials

for Reproduction

Conversion Factors—Continued

	IN 1	THESE ARE	
Electric flux density	esu emu	$1/(12\pi \times 10^5)$ $10^5/4\pi$	coulomb m^{-2}
Permittivity	esu	8.854×10^{-12}	farad m^{-1}
Potential difference	statvolt (esu) abvolt (emu)	300 10^{-8}	volt
Capacitance	statfarad (esu) abfarad (emu)	$1/(9 \times 10^{11})$ 10^9	farad
Current	statamp (esu) abamp (emu)	$1/(3 \times 10^9)$ 10	amp
Magnetic flux density	gauss (emu) line in^{-2} esu	10^{-4} 1.550×10^{-5} 3×10^6	weber m^{-2}
Magnetic flux	maxwell (emu) esu	10^{-8} 3×10^2	weber
Resistivity	ohm cm ohm/mil ft	10^{-2} 1.662×10^{-9}	ohm m
Resistance	statohm (esu) abohm (emu)	9×10^{11} 10^{-9}	ohm
Magnetic field strength	amp turn cm^{-1} oersted (emu)	10^2 $10^3/4\pi$	amp turn m^{-1}
Permeability	emu	$4\pi \times 10^{-7}$	henry m^{-1}
Inductance	abhenry (emu) stathenry (esu)	10^{-9} 9×10^{11}	henry
Illuminance	lumen ft^{-2}	10.764	lumen m^{-2} (lux)
Luminance	lumen ft^{-2} steradian^{-1}	10.764	lumen m^{-2} steradian^{-1}

In 1935 the International Committee on Weights and Measures, the central authority on all questions of international scientific standards, legislated that the M. K. S. system of units be substituted for the C. G. S. system beginning January 1, 1940. Under this system the standards of mass and length are used as basic units. The principal feature of the M. K. S. system is that it legitimatizes the practical units of electricity and removes the need for further use of the electrostatic and electromagnetic units.

THE MKS SYSTEM

THE UNITS

CONCEPT	ASA STANDARD LETTER SYMBOL	MKS UNIT
MECHANICS		
Distance	s	meter
Area	A, S, σ	m^2
Volume	V	m^3
Time	t	second
Velocity	u, v	m sec^{-1}
Acceleration	a	m sec^{-2}
Angle	θ	radian
Solid angle	ω	steradian
Angular velocity	ω	radian sec^{-1}
Angular acceleration	α	radian sec^{-2}
Mass	m	kilogram
Force	F	newton
Weight	$w, F, (W)$	newton
Torque		newton m
Moment of inertia	I	kg m^2
Momentum	p	kg m sec^{-1}
Impulse		newton sec
Energy	E	joule
Power	P	watt
Pressure	p	newton m^{-2}
Density	$\rho, (D)$	kg m^{-3}
HEAT		
Quantity of heat	Q	joule
Specific heat capacity	c	joule kg^{-1} deg^{-1}
Conductivity	k	watt m^{-1} deg^{-1}
Diffusivity		m^2 sec^{-1}
Entropy	S	joule deg^{-1}

CONCEPT	ASA STANDARD LETTER SYMBOL	MKS UNIT
ELECTRICITY AND MAGNETISM		
Charge	q, Q	coulomb
Electric field strength	E	volt m^{-1}
Electric flux density	D	coulomb m^{-2}
Permittivity	ϵ	farad m^{-1}
Potential difference	V	volt
Capacitance	C	farad
Current	i, I	ampere
Current density	J	amp m^{-2}
Electrochemical equivalent	z	kg $coul^{-1}$
Magnetomotive force	$\mathcal{F}$	amp turn
Magnetic flux density	B	weber m^{-2}
Magnetic flux	Φ	weber
Magnetic pole strength	$p, (m)$	weber
Magnetic moment	m	weber m
Resistivity	ρ	ohm m
Resistance	$R, (r)$	ohm
Magnetic field strength	H	amp turn m^{-1}
Permeability	μ	henry m^{-1}
Inductance	L	henry
PHOTOMETRY		
Illuminance	E	lumen m^{-2}
Luminance	B	lumen m^{-2} steradian^{-1}
Luminous flux	F	lumen

Atomic Constants

(MKS Units, based on J. W. M. DuMond and E. Richard Cohen Report to National Research Council Committee on Constants and Conversion Factors of Physics, December, 1950).

F	Faraday	$(9.65194 \pm 0.00007) \times 10^7$ coul equiv^{-1} (physical scale)
N_0	Avogadro's number	$(6.02544 \pm 0.00011) \times 10^{26}$ (physical scale)
h	Planck's constant	$(6.62377 \pm 0.00018) \times 10^{-34}$ joule sec
m	Electron mass	$(9.10721 \pm 0.00025) \times 10^{-31}$ kgm
e	Electronic charge	$(1.601864 \pm 0.000024) \times 10^{-19}$ coul
e/m	Specific electronic charge	$(1.758897 \pm 0.000032) \times 10^{11}$ coul kgm^{-1}
α	Fine structure constant	$(7.29698 \pm 0.00005) \times 10^{-3}$
$h/(mc)$	Compton wavelength	$(2.426067 \pm 0.000032) \times 10^{-12}$ m
a_0	First Bohr radius	$(0.529151 \pm 0.000003) \times 10^{-10}$ m
σ	Stefan-Boltzmann constant	$(5.6699 \times 0.0009) \times 10^{-8}$ joule m^{-2} deg^{-4} sec^{-1}
$c_1 = 8\pi hc$	First radiation constant	$(4.99071 \pm 0.00014) \times 10^{-24}$ joule m
$c_2 = hc/k$	Second radiation constant	$(1.43868 \pm 0.00006) \times 10^{-2}$ m deg
$\lambda_{max}T$	Wien displacement law constant	$(0.289757 \pm 0.000012) \times 10^{-2}$ m deg
μ_B	Bohr magneton	$(0.927120 \pm 0.000022) \times 10^{-23}$ amp m^2
H^+/mN_0	Ratio, proton mass to electron mass	1836.139 ± 0.034
mc^2	Energy equivalent of electron mass	(0.510969 ± 0.000010) Mev
k	Boltzmann constant	$(1.38026 \pm 0.00006) \pm 10^{-23}$ joule deg^{-1}
c	Velocity of light	$(2.997902 \pm 0.000009) \times 10^8$ m sec^{-1}
R_∞	Rydberg constant for infinite mass	(10973732.3 ± 1.0) m^{-1}
R	Universal gas constant	$(8.31665 \pm 0.00034) \times 10^3$ joule mol^{-1} deg^{-1}
V_0	Standard volume of ideal gas	(22.4207 ± 0.0004) m^3 mol^{-1}

Conversion Factors

A conversion factor is a dimensionless ratio used to make a change in units. Thus the conversion factor

$$\frac{12 \text{ in}}{1 \text{ ft}}$$

(read, "There are 12 inches in 1 foot") may be used to convert 10 feet to inches by direct multiplication and cancellation of the units, feet. To convert 15 inches to feet we evidently must invert the conversion factor to produce the desired result and multiply by

$$\frac{1 \text{ ft}}{12 \text{ in}}$$

(read, "In 1 foot there are 12 inches").

When the conversion factor is used incorrectly we notice immediately that the desired cancellation of units is not obtained and this is the signal to invert the factor.

To convert lb ft^{-3} to kg m^{-3} we proceed as follows:

$$1 \frac{\text{lb}}{\text{ft}^3} \times \frac{453.59 \text{ gm}}{1 \text{ lb}} \times \frac{1 \text{ kg}}{1000 \text{ gm}} \times \frac{(1 \text{ ft})^3}{(30.480 \text{ cm})^3} \times \frac{(100 \text{ cm})^3}{(1 \text{ m})^3} = 16.018 \text{ kg m}^{-3}.$$

The conversion factor is the

$$\frac{16.018 \text{ kg m}^{-3}}{1 \text{ lb ft}^{-3}}.$$

To convert mi to yd, proceed as follows:

$$1 \text{ mi} \times \frac{1609.4 \text{ m}}{1 \text{ mi}} \times \frac{1 \text{ yd}}{0.9144 \text{ m}} = 1760 \text{ yd}.$$

The conversion factor is:

$$\frac{1760 \text{ yd}}{1 \text{ mi}}$$

	IN 1	THERE ARE	
Distance	Angstrom unit	10^{-10}	meter
	cm	10^{-2}	
	in.	2.5400×10^{-2}	
	ft	0.30480	
	yd	0.91440	
	km	10^3	
	mi	1609.4	
Velocity	ft sec^{-1}	0.30480	meter sec^{-1}
	mi hr^{-1}	0.44704	
Mass	gm	10^{-3}	kilogram
	slug	14.594	
	lb (mass)	0.45359	
Force and weight	dyne	10^{-5}	newton
	poundal	0.13826	
	lb (force)	4.4482	
Energy	erg	10^{-7}	joule
	kwh	3.6×10^6	
	cal	4.182	
	ft lb	1.356	
	Btu	1055	
Power	erg sec^{-1}	10^{-7}	watt
	cal sec^{-1}	4.182	
	Btu hr^{-1}	0.2930	
Pressure	dyne cm^{-2}	10^{-1}	newton m^{-2}
	lb in^{-2}	6.895×10^3	
	atm	1.013×10^5	
	cm Hg	1333	
Density	gm cm^{-3}	10^3	kg m^{-3}
	lb ft^{-3}	16.018	
Specific heat	cal gm^{-1} deg^{-1}	4182	joule kg^{-1} deg^{-1}
	Btu lb^{-1} (°F)$^{-1}$	4182	
Charge	statcoul (esu)	3.333×10^{-10}	coulomb
	abcoul (emu)	10	
Electric field strength	volt cm^{-1}	10^2	volt m^{-1}
	dyne statcoul^{-1} (esu)	3×10^4	

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES	
1 H 1.00797														1 H 1.00797	2 He 4.0026	2
3 Li 6.939	4 Be 9.0122									5 B 10.811	6 C 12.01115	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183	2 8
11 Na 22.9898	12 Mg 24.312									13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948	2 8 8
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80	2 8 18 8
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9044	54 Xe 131.30	2 8 18 18 8
55 Cs 132.905	56 Ba 137.34	57 *La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)	2 8 18 32 18 8
87 Fr (223)	88 Ra (226)	89 †Ac (227)																

*Lanthanum Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97

Actinium Series

90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (253)	103 Lw (257)

ATOMIC WEIGHTS CORRECTED TO 1961
MOST STABLE KNOWN ISOTOPES SHOWN IN PARENTHESES.

87

10 — Common Logarithms of Numbers — 54

N	0	1	2	3	4	5	6	7	8	9
10	0 000	043	086	128	170	212	253	294	334	374
11	414	453	492	531	569	607	645	682	719	755
12	0 792	828	864	899	934	969	*004	*038	*072	*106
13	1 139	173	206	239	271	303	335	367	399	430
14	461	492	523	553	584	614	644	673	703	732
15	1 761	790	818	847	875	903	931	959	987	*014
16	2 041	068	095	122	148	175	201	227	253	279
17	304	330	355	380	405	430	455	480	504	529
18	553	577	601	625	648	672	695	718	742	765
19	2 788	810	833	856	878	900	923	945	967	989
20	3 010	032	054	075	096	118	139	160	181	201
21	222	243	263	284	304	324	345	365	385	404
22	424	444	464	483	502	522	541	560	579	598
23	617	636	655	674	692	711	729	747	766	784
24	802	820	838	856	874	892	909	927	945	962
25	3 979	997	*014	*031	*048	*065	*082	*099	*116	*133
26	4 150	166	183	200	216	232	249	265	281	298
27	314	330	346	362	378	393	409	425	440	456
28	472	487	502	518	533	548	564	579	594	609
29	624	639	654	669	683	698	713	728	742	757
30	4 771	786	800	814	829	843	857	871	886	900
31	4 914	928	942	955	969	983	997	*011	*024	*038
32	5 051	065	079	092	105	119	132	145	159	172
33	185	198	211	224	237	250	263	276	289	302
34	315	328	340	353	366	378	391	403	416	428
35	441	453	465	478	490	502	514	527	539	551
36	563	575	587	599	611	623	635	647	658	670
37	682	694	705	717	729	740	752	763	775	786
38	798	809	821	832	843	855	866	877	888	899
39	5 911	922	933	944	955	966	977	988	999	*010
40	6 021	031	042	053	064	075	085	096	107	117
41	128	138	149	160	170	180	191	201	212	222
42	232	243	253	263	274	284	294	304	314	325
43	335	345	355	365	375	385	395	405	415	425
44	435	444	454	464	474	484	493	503	513	522
45	532	542	551	561	571	580	590	599	609	618
46	628	637	646	656	665	675	684	693	702	712
47	721	730	739	749	758	767	776	785	794	803
48	812	821	830	839	848	857	866	875	884	893
49	902	911	920	928	937	946	955	964	972	981
50	6 990	998	*007	*016	*024	*033	*042	*050	*059	*067
51	7 076	084	093	101	110	118	126	135	143	152
52	160	168	177	185	193	202	210	218	226	235
53	243	251	259	267	275	284	292	300	308	316
54	7 324	332	340	348	356	364	372	380	388	396
N	0	1	2	3	4	5	6	7	8	9

Prop. Parts

n \ d	43	42	41	40
1	4.3	4.2	4.1	4
2	8.6	8.4	8.2	8
3	12.9	12.6	12.3	12
4	17.2	16.8	16.4	16
5	21.5	21.0	20.5	20
6	25.8	25.2	24.6	24
7	30.1	29.4	28.7	28
8	34.4	33.6	32.8	32
9	38.7	37.8	36.9	36

n \ d	39	38	37	36
1	3.9	3.8	3.7	3.6
2	7.8	7.6	7.4	7.2
3	11.7	11.4	11.1	10.8
4	15.6	15.2	14.8	14.4
5	19.5	19.0	18.5	18.0
6	23.4	22.8	22.2	21.6
7	27.3	26.6	25.9	25.2
8	31.2	30.4	29.6	28.8
9	35.1	34.2	33.3	32.4

$\log e = 0.4343$

n \ d	35	34	33	32
1	3.5	3.4	3.3	3.2
2	7.0	6.8	6.6	6.4
3	10.5	10.2	9.9	9.6
4	14.0	13.6	13.2	12.8
5	17.5	17.0	16.5	16.0
6	21.0	20.4	19.8	19.2
7	24.5	23.8	23.1	22.4
8	28.0	27.2	26.4	25.6
9	31.5	30.6	29.7	28.8

$\log \pi = 0.4971$

n \ d	31	30	29	28
1	3.1	3	2.9	2.8
2	6.2	6	5.8	5.6
3	9.3	9	8.7	8.4
4	12.4	12	11.6	11.2
5	15.5	15	14.5	14.0
6	18.6	18	17.4	16.8
7	21.7	21	20.3	19.6
8	24.8	24	23.2	22.4
9	27.9	27	26.1	25.2

n \ d	27	26	25	24
1	2.7	2.6	2.5	2.4
2	5.4	5.2	5.0	4.8
3	8.1	7.8	7.5	7.2
4	10.8	10.4	10.0	9.6
5	13.5	13.0	12.5	12.0
6	16.2	15.6	15.0	14.4
7	18.9	18.2	17.5	16.8
8	21.6	20.8	20.0	19.2
9	24.3	23.4	22.5	21.6

Prop. Parts

55 — Common Logarithms of Numbers — 99

Prop. Parts

n \ d	23	22	21	20
1	2.3	2.2	2.1	2
2	4.6	4.4	4.2	4
3	6.9	6.6	6.3	6
4	9.2	8.8	8.4	8
5	11.5	11.0	10.5	10
6	13.8	13.2	12.6	12
7	16.1	15.4	14.7	14
8	18.4	17.6	16.8	16
9	20.7	19.8	18.9	18

n \ d	19	18	17	16
1	1.9	1.8	1.7	1.6
2	3.8	3.6	3.4	3.2
3	5.7	5.4	5.1	4.8
4	7.6	7.2	6.8	6.4
5	9.5	9.0	8.5	8.0
6	11.4	10.8	10.2	9.6
7	13.3	12.6	11.9	11.2
8	15.2	14.4	13.6	12.8
9	17.1	16.2	15.3	14.4

n \ d	13	14	13	12
1	1.5	1.4	1.3	1.2
2	3.0	2.8	2.6	2.4
3	4.5	4.2	3.9	3.6
4	6.0	5.6	5.2	4.8
5	7.5	7.0	6.5	6.0
6	9.0	8.4	7.8	7.2
7	10.5	9.8	9.1	8.4
8	12.0	11.2	10.4	9.6
9	13.5	12.6	11.7	10.8

n \ d	11	10	9	8
1	1.1	1	0.9	0.8
2	2.2	2	1.8	1.6
3	3.3	3	2.7	2.4
4	4.4	4	3.6	3.2
5	5.5	5	4.5	4.0
6	6.6	6	5.4	4.8
7	7.7	7	6.3	5.6
8	8.8	8	7.2	6.4
9	9.9	9	8.1	7.2

n \ d	7	6	5	4
1	0.7	0.6	0.5	0.4
2	1.4	1.2	1.0	0.8
3	2.1	1.8	1.5	1.2
4	2.8	2.4	2.0	1.6
5	3.5	3.0	2.5	2.0
6	4.2	3.6	3.0	2.4
7	4.9	4.2	3.5	2.8
8	5.6	4.8	4.0	3.2
9	6.3	5.4	4.5	3.6

Prop. Parts

N	0	1	2	3	4	5	6	7	8	9
55	7 404	412	419	427	435	443	451	459	466	474
56	482	490	497	505	513	520	528	536	543	551
57	559	566	574	582	589	597	604	612	619	627
58	634	642	649	657	664	672	679	686	694	701
59	709	716	723	731	738	745	752	760	767	774
60	7 782	789	796	803	810	818	825	832	839	846
61	853	860	868	875	882	889	896	903	910	917
62	924	931	938	945	952	959	966	973	980	987
63	7 993	*000	*007	*014	*021	*028	*035	*041	*048	*055
64	8 062	069	075	082	089	096	102	109	116	122
65	129	136	142	149	156	162	169	176	182	189
66	195	202	209	215	222	228	235	241	248	254
67	261	267	274	280	287	293	299	306	312	319
68	325	331	338	344	351	357	363	370	376	382
69	388	395	401	407	414	420	426	432	439	445
70	8 451	457	463	470	476	482	488	494	500	506
71	513	519	525	531	537	543	549	555	561	567
72	573	579	585	591	597	603	609	615	621	627
73	633	639	645	651	657	663	669	675	681	686
74	692	698	704	710	716	722	727	733	739	745
75	751	756	762	768	774	779	785	791	797	802
76	808	814	820	825	831	837	842	848	854	859
77	865	871	876	882	887	893	899	904	910	915
78	921	927	932	938	943	949	954	960	965	971
79	8 976	982	987	993	998	*004	*009	*015	*020	*025
80	9 031	036	042	047	053	058	063	069	074	079
81	085	090	096	101	106	112	117	122	128	133
82	138	143	149	154	159	165	170	175	180	186
83	191	196	201	206	212	217	222	227	232	238
84	243	248	253	258	263	269	274	279	284	289
85	294	299	304	309	315	320	325	330	335	340
86	345	350	355	360	365	370	375	380	385	390
87	395	400	405	410	415	420	425	430	435	440
88	445	450	455	460	465	469	474	479	484	489
89	494	499	504	509	513	518	523	528	533	538
90	9 542	547	552	557	562	566	571	576	581	586
91	590	595	600	605	609	614	619	624	628	633
92	638	643	647	652	657	661	666	671	675	680
93	685	689	694	699	703	708	713	717	722	727
94	731	736	741	745	750	754	759	763	768	773
95	777	782	786	791	795	800	805	809	814	818
96	823	827	832	836	841	845	850	854	859	863
97	868	872	877	881	886	890	894	899	905	908
98	912	917	921	926	930	934	939	943	948	952
99	9 956	961	965	969	974	978	983	987	991	996
N	0	1	2	3	4	5	6	7	8	9

SAN DIEGO CITY SCHOOLS
Curriculum Services Division

Trigonometry Table - Four-Place Values of Functions and Radians

Degrees	Radians	Sin	Cos	Tan	Cot		
0° 00′	.0000	.0000	1.0000	.0000	—	1.5708	90° 00′
10	029	029	000	029	343.8	679	50
20	058	058	000	058	171.9	650	40
30	.0087	.0087	1.0000	.0087	114.6	1.5621	30
40	116	116	.9999	116	85.94	592	20
50	145	145	999	145	68.75	563	10
1° 00′	.0175	.0175	.9998	.0175	57.29	1.5533	89° 00′
10	204	204	998	204	49.10	504	50
20	233	233	997	233	42.96	475	40
30	.0262	.0262	.9997	.0262	38.19	1.5446	30
40	291	291	996	291	34.37	417	20
50	320	320	995	320	31.24	388	10
2° 00′	.0349	.0349	.9994	.0349	28.64	1.5359	88° 00′
10	378	378	993	378	26.43	330	50
20	407	407	992	407	24.54	301	40
30	.0436	.0436	.9990	.0437	22.90	1.5272	30
40	465	465	989	466	21.47	243	20
50	495	494	988	495	20.21	213	10
3° 00′	.0524	.0523	.9986	.0524	19.08	1.5184	87° 00′
10	553	552	985	553	18.07	155	50
20	582	581	983	582	17.17	126	40
30	.0611	.0610	.9981	.0612	16.35	1.5097	30
40	640	640	980	641	15.60	068	20
50	669	669	978	670	14.92	039	10
4° 00′	.0698	.0698	.9976	.0699	14.30	1.5010	86° 00′
10	727	727	974	729	13.73	981	50
20	756	756	971	758	13.20	952	40
30	.0785	.0785	.9969	.0787	12.71	1.4923	30
40	814	814	967	816	12.25	893	20
50	844	843	964	846	11.83	864	10
5° 00′	.0873	.0872	.9962	.0875	11.43	1.4835	85° 00′
10	902	901	959	904	11.06	806	50
20	931	929	957	934	10.71	777	40
30	.0960	.0958	.9954	.0963	10.39	1.4748	30
40	989	987	951	992	10.08	719	20
50	.1018	.1016	948	.1022	9.788	690	10
6° 00′	.1047	.1045	.9945	.1051	9.514	1.4661	84° 00′
10	076	074	942	080	9.255	632	50
20	105	103	939	110	9.010	603	40
30	.1134	.1132	.9936	.1139	8.777	1.4573	30
40	164	161	932	169	8.556	544	20
50	193	190	929	198	8.345	515	10
7° 00′	.1222	.1219	.9925	.1228	8.144	1.4486	83° 00′
10	251	248	922	257	7.953	457	50
20	280	276	918	287	7.770	428	40
30	.1309	.1305	.9914	.1317	7.596	1.4399	30
40	338	334	911	346	7.429	370	20
50	367	363	907	376	7.269	341	10
8° 00′	.1396	.1392	.9903	.1405	7.115	1.4312	82° 00′
10	425	421	899	435	6.968	283	50
20	454	449	894	465	6.827	254	40
30	.1484	.1478	.9890	.1495	6.691	1.4224	30
40	513	507	886	524	6.561	195	20
50	542	536	881	554	6.435	166	10
9° 00′	.1571	.1564	.9877	.1584	6.314	1.4137	81° 00′
		Cos	Sin	Cot	Tan	Radians	Degrees

Degrees	Radians	Sin	Cos	Tan	Cot		
9° 00′	.1571	.1564	.9877	.1584	6.314	1.4137	81° 00′
10	600	593	872	614	197	108	50
20	629	622	868	644	084	079	40
30	.1658	.1650	.9863	.1673	5.976	1.4050	30
40	687	679	858	703	871	1.4021	20
50	716	708	853	733	769	992	10
10° 00′	.1745	.1736	.9848	.1763	5.671	1.3963	80° 00′
10	774	765	843	793	576	934	50
20	804	794	838	823	485	904	40
30	.1833	.1822	.9833	.1853	5.396	1.3875	30
40	862	851	827	883	309	846	20
50	891	880	822	914	226	817	10
11° 00′	.1920	.1908	.9816	.1944	5.145	1.3788	79° 00′
10	949	937	811	974	066	759	50
20	978	965	805	.2004	4.989	730	40
30	.2007	.1994	.9799	.2035	4.915	1.3701	30
40	036	.2022	793	065	843	672	20
50	065	051	787	095	773	643	10
12° 00′	.2094	.2079	.9781	.2126	4.705	1.3614	78° 00′
10	123	108	775	156	638	584	50
20	153	136	769	186	574	555	40
30	.2182	.2164	.9763	.2217	4.511	1.3526	30
40	211	193	757	247	449	497	20
50	240	221	750	278	390	468	10
13° 00′	.2269	.2250	.9744	.2309	4.331	1.3439	77° 00′
10	298	278	737	339	275	410	50
20	327	306	730	370	219	381	40
30	.2356	.2334	.9724	.2401	4.165	1.3352	30
40	385	363	717	432	113	323	20
50	414	391	710	462	061	294	10
14° 00′	.2443	.2419	.9703	.2493	4.011	1.3265	76° 00′
10	473	447	696	524	3.962	235	50
20	502	476	689	555	914	206	40
30	.2531	.2504	.9681	.2586	3.867	1.3177	30
40	560	532	674	617	821	148	20
50	589	560	667	648	776	119	10
15° 00′	.2618	.2588	.9659	.2679	3.732	1.3090	75° 00′
10	647	616	652	711	689	061	50
20	676	644	644	742	647	032	40
30	.2705	.2672	.9636	.2773	3.606	1.3003	30
40	734	700	628	805	566	974	20
50	763	728	621	836	526	945	10
16° 00′	.2793	.2756	.9613	.2867	3.487	1.2915	74° 00′
10	822	784	605	899	450	886	50
20	851	812	596	931	412	857	40
30	.2880	.2840	.9588	.2962	3.376	1.2828	30
40	909	868	580	994	340	799	20
50	938	896	572	.3026	305	770	10
17° 00′	.2967	.2924	.9563	.3057	3.271	1.2741	73° 00′
10	996	952	555	089	237	712	50
20	.3025	979	546	121	204	683	40
30	.3054	.3007	.9537	.3153	3.172	1.2654	30
40	083	035	528	185	140	625	20
50	113	062	520	217	108	595	10
18° 00′	.3142	.3090	.9511	.3249	3.078	1.2566	72° 00′
		Cos	Sin	Cot	Tan	Radians	Degrees

Degrees	Radians	Sin	Cos	Tan	Cot		
18° 00′	.3142	.3090	.9511	.3249	3.078	1.2566	72° 00′
10	171	118	502	281	047	537	50
20	200	145	492	314	018	508	40
30	.3229	.3173	.9483	.3346	2.989	1.2479	30
40	258	201	474	378	960	450	20
50	287	228	465	411	932	421	10
19° 00′	.3316	.3256	.9455	.3443	2.904	1.2392	71° 00′
10	345	283	446	476	877	363	50
20	374	311	436	503	850	334	40
30	.3403	.3338	.9426	.3541	2.824	1.2305	30
40	432	365	417	574	798	275	20
50	462	393	407	607	773	246	10
20° 00′	.3491	.3420	.9397	.3640	2.747	1.2217	70° 00′
10	520	448	387	673	723	188	50
20	549	475	377	706	699	159	40
30	.3578	.3502	.9367	.3739	2.675	1.2130	30
40	607	529	356	772	651	101	20
50	636	557	346	805	628	072	10
21° 00′	.3665	.3584	.9336	.3839	2.605	1.2043	69° 00′
10	694	611	325	872	583	1.2014	50
20	723	638	315	906	560	985	40
30	.3752	.3665	.9304	.3939	2.539	1.1956	30
40	782	692	293	973	517	926	20
50	811	719	283	.4006	496	897	10
22° 00′	.3840	.3746	.9272	.4040	2.475	1.1868	68° 00′
10	869	773	261	074	455	839	50
20	898	800	250	108	434	810	40
30	.3927	.3827	.9239	.4142	2.414	1.1781	30
40	956	854	228	176	394	752	20
50	985	881	216	210	375	723	10
23° 00′	.4014	.3907	.9205	.4245	2.356	1.1694	67° 00′
10	043	934	194	279	337	665	50
20	072	961	182	314	318	636	40
30	.4102	.3987	.9171	.4348	2.300	1.1606	30
40	131	.4014	159	383	282	577	20
50	160	041	147	417	264	548	10
24° 00′	.4189	.4067	.9135	.4452	2.246	1.1519	66° 00′
10	218	094	124	487	229	490	50
20	247	120	112	522	211	461	40
30	.4276	.4147	.9100	.4557	2.194	1.1432	30
40	305	173	088	592	177	403	20
50	334	200	075	628	161	374	10
25° 00′	.4363	.4226	.9063	.4663	2.145	1.1345	65° 00′
10	392	253	051	699	128	316	50
20	422	279	038	734	112	286	40
30	.4451	.4305	.9026	.4770	2.097	1.1257	30
40	480	331	013	806	081	228	20
50	509	358	001	841	066	199	10
26° 00′	.4538	.4384	.8988	.4877	2.050	1.1170	64° 00′
10	567	410	975	913	035	141	50
20	596	436	962	950	020	112	40
30	.4625	.4462	.8949	.4986	2.006	1.1083	30
40	654	488	936	.5022	1.991	054	20
50	683	514	923	059	977	1.1025	10
27° 00′	.4712	.4540	.8910	.5095	1.963	1.0996	63° 00′
		Cos	Sin	Cot	Tan	Radians	Degrees

Degrees	Radians	Sin	Cos	Tan	Cot		
27° 00′	.4712	.4540	.8910	.5095	1.963	1.0996	63° 00′
10	741	566	897	132	949	966	50
20	771	592	884	169	935	937	40
30	.4800	.4617	.8870	.5206	1.921	1.0906	30
40	829	643	857	243	907	879	20
50	858	669	843	280	894	850	10
28° 00′	.4887	.4695	.8829	.5317	1.881	1.0821	62° 00′
10	916	720	816	354	868	792	50
20	945	746	802	392	855	763	40
30	.4974	.4772	.8788	.5430	1.842	1.0734	30
40	.5003	797	774	467	829	705	20
50	032	823	760	505	816	676	10
29° 00′	.5061	.4848	.8746	.5543	1.804	1.0647	61° 00′
10	091	874	732	581	792	617	50
20	120	899	718	619	780	588	40
30	.5149	.4924	.8704	.5658	1.767	1.0559	30
40	178	950	689	696	756	530	20
50	207	975	675	735	744	501	10
30° 00′	.5236	.5000	.8660	.5774	1.732	1.0472	60° 00′
10	265	025	646	812	720	443	50
20	294	050	631	851	709	414	40
30	.5323	.5075	.8616	.5890	1.698	1.0385	30
40	352	100	601	930	686	356	20
50	381	125	587	969	675	327	10
31° 00′	.5411	.5150	.8572	.6009	1.664	1.0297	59° 00′
10	440	175	557	048	653	268	50
20	469	200	542	088	643	239	40
30	.5498	.5225	.8526	.6128	1.632	1.0210	30
40	527	250	511	168	621	181	20
50	556	275	496	208	611	152	10
32° 00′	.5585	.5299	.8480	.6249	1.600	1.0123	58° 00′
10	614	324	465	289	590	094	50
20	643	348	450	330	580	065	40
30	.5672	.5373	.8434	.6371	1.570	1.0036	30
40	701	398	418	412	560	1.0007	20
50	730	422	403	453	550	977	10
33° 00′	.5760	.5446	.8387	.6494	1.540	.9948	57° 00′
10	789	471	371	536	530	919	50
20	818	495	355	577	520	890	40
30	.5847	.5519	.8339	.6619	1.511	.9861	30
40	876	544	323	661	501	832	20
50	905	568	307	703	1.492	803	10
34° 00′	.5934	.5592	.8290	.6745	1.483	.9774	56° 00′
10	963	616	274	787	473	745	50
20	992	640	258	830	464	716	40
30	.6021	.5664	.8241	.6873	1.455	.9687	30
40	050	688	225	916	446	657	20
50	080	712	208	959	437	628	10
35° 00′	.6109	.5736	.8192	.7002	1.428	.9599	55° 00′
10	138	760	175	046	419	570	50
20	167	783	158	089	411	541	40
30	.6196	.5807	.8141	.7133	1.402	.9512	30
40	225	831	124	177	393	483	20
50	254	854	107	221	385	454	10
36° 00′	.6283	.5878	.8090	.7265	1.376	.9425	54° 00′
		Cos	Sin	Cot	Tan	Radians	Degrees

Degrees	Radians	Sin	Cos	Tan	Cot		
36° 00′	.6283	.5878	.8090	.7265	1.376	.9425	54° 00′
10	312	901	073	310	368	396	50
20	341	925	056	355	360	367	40
30	.6370	.5948	.8039	.7400	1.351	.9338	30
40	400	972	021	445	343	308	20
50	429	995	004	490	335	279	10
37° 00′	.6458	.6018	.7986	.7536	1.327	.9250	53° 00′
10	487	041	969	581	319	221	50
20	516	065	951	627	311	192	40
30	.6545	.6088	.7934	.7673	1.303	.9163	30
40	574	111	916	720	295	134	20
50	603	134	898	766	288	105	10
38° 00′	.6632	.6157	.7880	.7813	1.280	.9076	52° 00′
10	661	180	862	860	272	047	50
20	690	202	844	907	265	.9018	40
30	.6720	.6225	.7826	.7954	1.257	.8988	30
40	749	248	808	.8002	250	959	20
50	778	271	790	050	242	930	10
39° 00′	.6807	.6293	.7771	.8098	1.235	.8901	51° 00′
10	836	316	753	146	228	872	50
20	865	338	735	195	220	843	40
30	.6894	.6361	.7716	.8243	1.213	.8814	30
40	923	383	698	292	206	785	20
50	952	406	679	342	199	756	10
40° 00′	.6981	.6428	.7660	.8391	1.192	.8727	50° 00′
10	.7010	450	642	441	185	698	50
20	039	472	623	491	178	668	40
30	.7069	.6494	.7604	.8541	1.171	.8639	30
40	098	517	585	591	164	610	20
50	127	539	566	642	157	581	10
41° 00′	.7156	.6561	.7547	.8693	1.150	.8552	49° 00′
10	185	583	528	744	144	523	50
20	214	604	509	796	137	494	40
30	.7243	.6626	.7490	.8847	1.130	.8465	30
40	272	648	470	899	124	436	20
50	301	670	451	952	117	407	10
42° 00′	.7330	.6691	.7431	.9004	1.111	.8378	48° 00′
10	359	713	412	057	104	348	50
20	389	734	392	110	098	319	40
30	.7418	.6756	.7373	.9163	1.091	.8290	30
40	447	777	353	217	085	261	20
50	476	799	333	271	079	232	10
43° 00′	.7505	.6820	.7314	.9325	1.072	.8203	47° 00′
10	534	841	294	380	066	174	50
20	563	862	274	435	060	145	40
30	.7592	.6884	.7254	.9490	1.054	.8116	30
40	621	905	234	545	048	087	20
50	650	926	214	601	042	058	10
44° 00′	.7679	.6947	.7193	.9657	1.036	.8029	46° 00′
10	709	967	173	713	030	999	50
20	738	988	153	770	024	970	40
30	.7767	.7009	.7133	.9827	1.018	.7941	30
40	796	030	112	884	012	912	20
50	825	050	092	942	006	883	10
45° 00′	.7854	.7071	.7071	1.000	1.000	.7854	45° 00′
		Cos	Sin	Cot	Tan	Radians	Degrees