
Guides - Classroom Use - Guides (For Teachers) (052)

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Behavioral Objectives; Classroom Techniques; Computers; Electrical Occupations; *Electric Circuits; *Electricity; *Electronic Equipment; *Electronics; Equipment Utilization; Guidelines; *Industrial Arts; Instructional Materials; Job Skills; Learning Activities; Lesson Plans; Magnets; Mathematics Skills; Measurement Equipment; Measurement Techniques; Program Implementation; Resources; Robotics; Safety; Secondary Education; Semiconductor Devices; State Curriculum Guides; Teaching Methods; Trade and Industrial Education

Louisiana

This curriculum guide is designed to assist industrial arts teachers, counselors, and administrators in improving instruction in the areas of electricity and basic electronics. Included in the first part of the guide are a course flow chart, a course description, a discussion of target grade levels and prerequisites, course goals and objectives, an introduction, and a course outline. The next major section is a unit teaching guide consisting of units on the following topics: safety, mathematics skills, the nature of electricity, meters and measuring, residential electricity, direct-current circuits, magnetism, test equipment, alternating-current circuits, semiconductors, electronic devices, circuit fabrication, computers, robotics, industrial electricity and electronics, and careers. Appended to the guide are sample tests, a tool list, information on fire extinguishers, safety recordkeeping forms, a math review, formulas and conversions, worksheets on Ohm's Law and the Power Law, a tool identification sheet, instructions on house wiring and reading meters, sample lab exercises, and information sheets on robotics and the effects of current on the body. (MN)

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BASIC ELECTRICITY/ELECTRONICS (Industrial Arts)

VOCATIONAL EDUCATION

BULLETIN 1724

CURRICULUM GUIDE

DEPARTMENT OF EDUCATION

THOMAS G. CLAUSEN
State Superintendent

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This publication is a guide for the improvement of instruction in Industrial Arts Education for the State of Louisiana. It should be of benefit to industrial arts teachers, supervisors, counselors, and administrators. These operational guidelines will help local administrators, teacher educators, and industrial arts teachers determine the extent to which their programs are meeting the needs of our youth. Industrial Arts Education Programs must be organized to meet the needs of all students.

A constant concern for educators is the construction and revision of curriculum. Industry and technology are the core of industrial arts instruction. Both are constantly changing; therefore, a curriculum and instruction must change in order to provide students a realistic and accurate understanding of industry and its function in our complex technological society.

Thomas C. Clausen
State Superintendent of Education
ACKNOWLEDGEMENTS

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Elaine Webb, Ed.D.
Assistant Superintendent
Office of Vocational Education
CONTENTS

Foreword ................................................................. 1
Acknowledgements ................................................... 11
Course Flow Chart .................................................... 1
Course Description ................................................... 2
Target Grade Levels ................................................... 2
Prerequisite ................................................................... 2
Course Goals .............................................................. 2
Course Objectives ....................................................... 3
Introduction ............................................................... 4
Time Frame .................................................................. 5
Course Outline ........................................................... 5
Unit Teaching Guide .................................................... 23
Unit I Safety ................................................................ 27
Unit II Mathematics Review ........................................ 30
Unit III Nature of Electricity ......................................... 33
Unit IV Meters and Measuring ........................................ 36
Unit V Residential Electricity ......................................... 41
Unit VI Direct Current Circuits ....................................... 46
Unit VII Magnetism ..................................................... 49
Unit VIII Test Equipment .............................................. 53
Unit IX A.C. Circuits .................................................... 58
Unit X Semiconductor Fundamentals ............................. 60
Unit XI Electronic Devices .......................................... 70
Unit XII Circuit Fabrication ......................................... 74
Unit XIII Introduction to Computers ............................... 77
Unit XIV Robotics ........................................................ 81
Unit XV Industrial Electricity/Electronics ....................... 86
Unit XVI Careers ........................................................ 89
Appendix 1 Sample Tests ............................................... 132
Appendix 2 Tool List ................................................... 136
Appendix 3 Fire Extinguishers ....................................... 139
Appendix 4 Safety Recordkeeping ................................... 155
Appendix 5 Math Review ............................................... 170
Appendix 6 Formulas and Conversions ......................... 177
Appendix 7 Ohm's Law and Power Law Worksheets ....... 181
Appendix 8 Identification of Tools ................................ 189
Appendix 9 Graduations of a Rule ................................. 196
Appendix 10 Housewiring Materials .............................. 204
Appendix 11 Reading Meters ........................................ 208
Appendix 12 Sample Lab Exercisescs ......................... 215
Appendix 13 Printed Circuit Board Construction .......... 222
Appendix 14 Robotics ................................................... 227
Appendix 15 Body Effects of Current ............................ 229
Bibliography ............................................................... 233
Title:

Basic Electricity/Electronics

Course Description:

Basic Electricity/Electronics is designed as a one year introductory course and requires no previous knowledge of electricity or electronics. The course content is designed to make the student aware of the intricate relationship between our highly technological society and the fields of electricity and electronics. The student will gain a working knowledge of relevant theories and physical laws and their application. An awareness of practical devices will also be developed. The student will also gain practical hands-on learning experiences through the design, fabrication and testing of electrical and electronic circuits and devices.

Target Grade Level:

This course is designed for students in grades 10, 11 and 12.

Prerequisites:

General Industrial Arts (Algebra I desirable)

Course Goals:

In Basic Electricity/Electronics the student will become acquainted with the fields of electricity and electronics and their impact on society. The student will be exposed to the skills, techniques, tools, materials, and information related to electricity and electronics. The student will also be aware of the occupational and educational opportunities available upon completion of this course.

Course Objectives:

1. To develop in the student working knowledge of electricity and electronics.
2. To provide each student with the opportunity to explore those aspects of electricity and electronics that best meet his/her needs, aptitudes, or interest.
3. To provide the student an opportunity to apply science and math skills to practical situations.
4. To develop in the student the basic skills in the proper use of tools and equipment.
5. To develop in the student problem solving abilities and critical thinking.
6. To develop in the student a safety conscious attitude and safe work habits.
7. To provide the student the opportunity to explore occupational and educational opportunities in electricity, electronics, and related fields.

8. To develop in a student an awareness of the diverse nature of the field of electronics and its impact on society.

9. To inform the student so that he may become a wise consumer of electronic goods.

Introduction:

We are presently living in an electronic age. Electrical and electronic equipment warm and cool our homes, provide us light, entertain us, and make our work easier while making us more productive. In order to be wise consumers of electricity and wise users of electrical devices one must have some background knowledge in electricity. A substantial knowledge of electronics will assist the student in succeeding in future careers in Electricity/Electronics and many other areas.

This course was designed to provide the student with exposure to many areas of Electricity/Electronics. This exposure is broad-based though certainly not all inclusive. An in-depth study of more significant areas has been included so that depth of understanding may be achieved as well. This course was designed to be as technologically up-to-date as possible. However, the teacher should feel free to add material to this curriculum as changes in the state-of-the-art make additions necessary.
TIME FRAME

<table>
<thead>
<tr>
<th>Hours</th>
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<tr>
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<td>Unit 13</td>
<td>Introduction to Computer Literacy</td>
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<td>5</td>
<td>Unit 14</td>
<td>Robotics: An Introduction for Your Classroom</td>
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<td>10</td>
<td>Unit 15</td>
<td>Industrial Electricity/Electronics</td>
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<td>3</td>
<td>Unit 16</td>
<td>Careers</td>
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Total - 163 hours. The remaining 17 hours can be used for opening and closing school, projects, school activities or to place extra emphasis where the instructor deems necessary.
ELECTRICITY/ELECTRONICS
A COURSE OUTLINE

1. ELECTRICITY AND ELECTRONICS SAFETY

A. Personal Safety Practices
   1. State safety laws
   2. OSHA
   3. Electric shock
   4. Protection
   5. Effect of current on human body
   6. Housekeeping

B. Safety Hazards
   1. Hazardous conditions
   2. Ground fault
   3. Live circuits
   4. Chemicals
   5. Class of fires

C. Color Code
   1. Red
   2. Yellow
   3. Green
   4. Orange
   5. Purple

D. Mechanical Safety Tools
   1. Hand tools
   2. Power tools
   3. Meters
   4. Ladder use

E. Emergency Procedures (First Aid)
   1. Bleeding
      a. Blood spurts
      b. Blood flows
      c. Blood oozes
   2. Breaks or fractures
      a. Simple fractures
      b. Compound fractures
   3. Open wounds
      a. Minor cuts and abrasions
      b. Serious wounds
      c. Puncture wounds
4. Electrical shock
   a. Shut off the current quickly.
   b. Remove the victim.
   c. Check heart and lungs.
   d. Apply artificial respiration if necessary.
5. Equipment Failure
   a. Wrong-size or type
   b. Motor-driven equipment
   c. Portable electric tools
   d. Overloading
   e. Failure to positively lock out
   f. Disconnecting of electrical cords.
   g. Test equipment
6. Fire

II. MATHEMATICS REVIEW

Unit Objective - To review with students the mathematical skills needed in Electronics

A. Fractions

1. Addition of fractions
2. Subtraction of fractions
3. Multiplication of fractions
4. Division of fractions

B. Division of Decimal Numbers

1. Determining decimal place
2. Rounding off to desired place

C. Multiplication of Decimal Numbers

D. Scientific Notation

1. Expressing numbers in scientific notation
2. Converting scientific notation expressions
3. Adding and subtracting numbers expressed in scientific notation
4. Multiplying and dividing numbers expressed in scientific notation

E. Unit Prefixes

1. Prefixes
2. Abbreviations
3. Value
4. Conversions
F. Basic Algebra
   1. Solving equations
   2. Transforming equations
   3. Algebraic substitutions

G. Calculating Square Roots (optional)
   1. Square roots of decimal numbers
   2. Square root of numbers in scientific notation

III. NATURE OF ELECTRICITY

A. Energy and Work

B. Structure of Matter
   1. Compounds
   2. Elements
   3. Atoms
   4. Subatomic particles

C. Electric Fields
   1. Ions and ionization
   2. Static electricity
   3. Law of charges
   4. Measuring charges
   5. Industrial applications

D. Electrical Current
   1. Electron current
   2. Ion current
   3. Measuring current

E. Conductors and Insulators
   1. Properties of conductors
   2. Properties of insulators

F. Electrical Potential
   1. Determining electrical potential
   2. Measuring electrical potential
   3. Producing electrical potential

G. Resistance
   1. Specific resistivity
   2. Resistance and its measure
H. Ohm's Law

I. Power

1. What is power
2. Relation to voltage and current
3. Measuring power
4. Relationship to energy

IV. METERS AND MEASURING

A. Reading Meters

1. Analog meters
   a. Linear scale
   b. Logarithmic scale
2. Digital meters

B. Using Meters

1. Ammeters
2. Voltmeters
3. Ohmmeters
4. Multimeter
5. Meter error
   a. Loading
   b. Parallax error

C. Meter Care

1. Handling the meter
2. Setting and adjusting meters

V. RESIDENTIAL ELECTRICITY

A. Safety (Review from Topic I on safety)

1. First aid
2. Hazards
3. Personal
4. Grounding
5. Tools and equipment
6. Fires

B. Transmission and Distribution

1. Generating plant
2. High voltage transmission
3. Sub-station
4. Low voltage residential
C. Tools and Equipment--Basic

1. Screwdrivers
2. Pliers
   a. Long nose
   b. Bent nose
   c. Lineman (side cutters)
   d. Diagonal
3. Electrician's hammer
4. Wire strippers
   a. Adjustable
   b. Multipurpose
5. Rule
6. Wrenches
7. Threading tools
8. Awl
9. Drills
   a. Brace and bits
   b. Drill motor and bits
10. Saws
    a. Hack
    b. Hole
    c. Keyhole
    d. Reciprocal
11. Files
12. Soldering tools
    a. Soldering gun
    b. Soldering iron

D. Specialty Tools

1. Benders
   a. EMT
   b. Hickey
2. Pipe reamer
3. Pipe cutter
4. Plumb bob
5. Chisel
6. Knockout punches
7. Fish tape
8. Level
9. Meters
   a. Neon test light
   b. Volt-ohmmeter
   c. Ammeter
   d. Inductance couple meter
E. Wiring Equipment

1. Wire
   a. Cable types
   b. Sizing
   c. Insulation

2. Switches
   a. Single pole
   b. 3-way
   c. 4-way
   d. Dimmer
   e. Low voltage/push button

3. Receptacles
   a. Duplex 125v, 15 amp
   b. Dual voltage 125/250v, 20 amp
   c. Air conditioning 250 volt, 30 amp
   d. Range 125/250v, 50 amp
   e. Dryer 125/250v, 30 amp

4. Wall plate

5. Outlet boxes
   a. Handy
   b. Extension
   c. Octagon
   d. Square
   e. Box covers
   f. Switch

6. Conduit
   a. Rigid metallic
   b. Non-metallic
   c. Non-metallic sheathed
   d. Flexible conduit
   e. PVC

7. Electrical service
   a. Weather head or cap
   b. Race way
   c. Meter base
   d. Underground service
   e. System grounding
   f. Service entrance panel

F. Wiring Techniques

1. Electrical service
2. Rough-in
3. Branch-circuit wiring
4. Finishing wiring
G. Load Determination

1. Current requirements
2. Lighting circuits
3. Speciality circuits

VI. DIRECT CURRENT CIRCUITS

A. Review of Ohm's Law

B. Series Circuits

1. Equivalent resistance
2. Voltage dividers
3. Kirchhoff's voltage law

C. Parallel Circuits

1. Equivalent resistance
2. Current dividers
3. Kirchhoff's current law
4. Conductance

D. Series-Parallel Circuits

1. Equivalent resistance
2. Voltage drops and current
3. Designing practical circuits

E. Advanced Analysis Techniques (Optional)

1. Bridge circuits
2. Mesh analysis
3. Delta-tee conversions
4. Loop analysis
5. Superposition
6. Thévenin and Norton networks

F. Capacitors

1. Capacitor action
2. Construction
3. Rating
   a. Working voltage
   b. Capacitance
   c. Tolerance
4. Types of capacitors
5. Transient response
   a. Charging the capacitor
   b. Discharging the capacitor
   c. Time constants
6. Capacitors in series
7. Capacitors in parallel

VII. MAGNETISM

A. History of Magnetism

B. Magnetic Theory
   1. Domains
   2. Poles, fields, and flux
   3. Law of magnetism

C. Magnetic Materials and Effect
   1. Ferromagnetic
   2. Paramagnetic
   3. Diamagnetic
   4. Magnetic shielding

D. Measuring Magnetism
   1. Magnetomotive force
   2. Flux density
   3. Intensity
   4. Reluctance
   5. Permeability

E. Electromagnetic Effect
   1. Relation to current
   2. Magnetism in coil of wire
   3. Electromagnetism
      a. Cores
      b. Strength
      c. Polarity
   4. Electromagnetic devices
      a. Solenoid
      b. Relays
      c. Circuit breakers
      d. Speakers
      e. Meters
      f. Bells, and buzzers
      g. Recording tape
F. Inductance

1. Induced EMF
2. Lenz's law
3. Measuring inductance
4. Effect of cores
5. Quality of coils
6. Transient response
7. Inductance in series
8. Inductance in parallel

VIII. TEST EQUIPMENT

A. Meter Fundamentals

1. Analog/pointer type
   a. D’Arsonval
   b. Iron vane
2. Digital/LED or LCD type
   a. Analog to digital conversion
      (1) Ramp method
      (2) Dual-slope method
      (3) Switched-resistor method
   b. Counting
3. Voltmeters
   a. Multipliers and ranging
   b. Types of voltmeters and uses
      (1) Volt-Ohm Milliammeter/VOM
      (2) Electronic Voltmeters/EVM
   c. AC measurements
4. Ammeters
   a. Meter shunts and ranging
   b. Types of ammeters
      (1) D’Arsonval
      (2) Iron vane
      (3) Hot wire meter
   c. Connections
5. Ohmmeter
   a. Series
   b. Shunt

B. Oscilloscopes

1. Construction
2. Operation
   a. Function of controls
   b. Calibration

C. Function/signal generator

1. Function generator uses
2. Signal generator uses

D. Transistor Tester
IX. AC CIRCUITS

A. Alternating Current Fundamentals

1. Waveforms
   a. Sine waves
   b. Square waves
   c. Ramp waves
   d. Triangle waves

2. Quantifying alternating currents
   a. Frequency
   b. Period
   c. Wavelength
   d. Peak value
   e. Peak to peak
   f. Effective or root-mean-square (RMS) value
   g. Average value
   h. Instantaneous value
   i. Harmonics

3. Polyphase current
   a. Wave forms
   b. Uses

4. Voltage, current and power relationships

B. Capacitive Circuits

1. Reactance
2. Phase shift
3. Impedance
4. Apparent power
5. Graphic analysis techniques

C. Inductive Circuits

1. Reactance
2. Phase shift
3. Impedance
4. Apparent power
5. Graphic analysis techniques

D. Transformers

1. Mutual inductance - Lenz's Law
2. Physical construction
3. Turns ratio
4. Isolation and autotransformers
5. Multi-voltage transformers
   a. Tapped
   b. Multiple coils
6. Transformer applications
7. Power losses and efficiency
E. Tuned Circuits

1. Resonance
2. Series tuned circuit
   a. Impedance curve
   b. Frequency
   c. Bandwidth and selectivity
3. Parallel tuned circuits
   a. Impedance curve
   b. Frequency response
   c. Bandwidth and selectivity
4. Filters and filtering
   a. High pass
   b. Low pass
   c. Band pass
   d. Band reject
   e. Frequency response and crossover

X. SEMICONDUCTOR FUNDAMENTALS

A. Semiconductor Materials

1. Pure semiconductors
2. Low temperature characteristics
3. High temperature characteristics
4. Doping semiconductors
5. N-type material
6. P-type material
7. Current in semiconductors

B. P-N Junction

1. Forming the junction
2. Depletion region
3. Barrier potential
4. Forward biased
5. Reverse biased
6. Avalanche breakdown

XI. ELECTRONIC DEVICES

A. Diodes

1. Characteristics of diodes
2. Types of diodes
   a. Rectifiers
   b. Switching
   c. Zener
   d. Light emitting diode
3. Diode ratings
4. Rectifier circuits
   a. Half-wave rectifier
   b. Full-wave rectifier
   c. Bridge rectifier
   d. Rectifier packaging
   e. Diode clamps and limiters
5. Power supplies
   a. Filtering
   b. Regulation
   c. Voltage multipliers
   d. Voltage converters and inverters

B. Transistors
1. Bi-polar junction transistors
   a. Operating theory
   b. Types of bi-polar transistor
   c. Uses of transistors
   d. Basic circuits
   e. Fabrication techniques
   f. Operating parameters and conduction curves
   g. Transistor testing
2. Field effect transistors
   a. Junction field effect transistors
   b. Depletion mode metal oxide semiconductors
   c. Enhancement mode metal oxide semiconductors
   d. Fabrication techniques
   e. Operating parameters

C: Transistor Amplifier Circuits
1. Circuit types
   a. Common-base
   b. Common-collector
   c. Common-emitter
   d. Common-source
2. Biasing and load lines
3. Frequency response
4. Distortion
5. Coupling and feedback
6. Transistor driver circuits
7. Transistor switching circuits

D. Thyristors
1. Silicon controlled rectifiers
   a. Construction
   b. DC operation
   c. AC operation
   d. Applications
2. TRIAC
   a. Construction
   b. Operation
   c. Applications

3. DIAC
   a. Construction
   b. Operation
   c. Applications

4. Unijunction transistor
   a. Construction
   b. Operation
   c. Applications

5. Thyristor ratings

E. Integrated Circuits

1. Fabrication techniques
   a. Monolithic I.C.'s
   b. Large scale integration I. C.'s
   c. Hybrid

2. Properties and ratings

3. Applications
   a. Digital I. C.'s
   b. Analog I. C.'s

4. Operational amplifiers
   a. Operational amplifiers
   b. Differential amplifiers
   c. Applications

F. Thermistors

1. Negative temperature coefficient thermistors
2. Uses
   a. Thermal compensation
   b. Heat sensing

3. Positive temperature coefficient thermistors

G. Opto-Electric Devices

1. Uses
   a. Isolation
   b. Communication
   c. Safety
   d. Limit distortion

2. Types
   a. Light-activated SCR
   b. Opto-isolators
   c. Infra-red light-emitting diodes
   d. Light-activated transistors
   e. Photoresistors
   f. Lasers
   g. Light-emitting diodes
XII. CIRCUIT FABRICATION

A. Schematic Diagrams

1. Understanding component symbols

B. Breadboarding

C. Printed Circuit Board

1. Materials
   a. Copper electroplating
   b. Gold plating
   c. Tin-lead plating
   d. Tin-nickel plating

2. Printing
   a. PC board cleaning
      (1) Chemical cleaning
      (2) Degreasing
      (3) Acid dipping
   b. Photoresists
   c. Screen printing
   d. Contact print
   e. Rub-off transfer

3. Etching
   a. Etching solutions
   b. Equipment and techniques
   c. Etching safety

4. Drilling

C. Soldering

1. Fluxes
2. Alloys
3. Soldering techniques

D. Wire Wrapping

E. Point-to-Point Wiring

XIII. INTRODUCTION TO COMPUTERS

A. History of Computational Machines

B. Processing Information in a Computer

1. Central processing unit (CPU)
2. Read-only-memory (ROM)
3. Random access memory (RAM)
C. Hardware

1. Classes of Computers
   a. Main frame
   b. Microcomputer
   c. Microprocessor

2. External Memory Devices
   a. Cassette
   b. Disc
   c. Hard disk
   d. Tape
   e. Card readers

3. Input/Output Devices
   a. Video monitors/CRT
      (1) Black and white
      (2) Green phosphorous
      (3) Color
   b. Modems
   c. Printers
      (1) Dot matrix
      (2) Daisy wheel
      (3) Continuous band/metal band
      (4) Ink-jet
   d. Joystick and paddles
   e. Keyboards
   f. Voice synthesizers

D. Software

1. Programming Languages
   a. Basic
   b. Pascal
   c. Fortran
   d. Cobol
   e. Assembler

2. Programming Logic

3. Software Sources
   a. Commercial
   b. User groups
   c. Self-generated

XIV. Robotics: An Introduction for Your Classroom

A. What Is Robotics

1. What Is a Robot
2. Components of a Robot
   a. Manipulator
   b. Controller
   c. Power source
3. Work envelope

B. Types of Robots

1. Non-servo controlled
2. Servo controlled
3. Remote controlled

C. Robot Applications

1. Industrial
   a. Spot welding
   b. Arc welding
   c. Assembly
   d. Material handling
2. Industrial Arts
   a. Spot welding
   b. Arc welding
   c. Electronic component assembly
   d. Machine loading and unloading
   e. Line production activities
      (1) Finishing process
      (2) Material handling
      (3) Assembly
      (4) Quality control
   f. Research and development activities
   g. Metal casting processes
      (1) Pouring
      (2) Shake-out
      (3) Mold venting
   h. Laboratory experimentation

D. Social Economic Impact

1. What cybernetics means to industry
2. Productivity levels

XV. INDUSTRIAL ELECTRICITY/ELECTRONICS

A. Generators

1. Theory of operation
   a. AC generators
   b. DC generators
2. Basic construction
3. Types of generators
4. Applications

B. Motors

1. Theory of operation
   a. DC motors
   b. AC motors
2. Types of motors
   a. DC
   b. AC
3. Motor construction
4. Motor ratings
5. Application
6. Motor starters
7. Care and maintenance
8. Over-current protectors

C. Resistance Devices
1. Resistance heaters
2. Arc welding
3. Carbon arc
   a. Electric arc furnaces
   b. Carbon arc lamps
   c. Carbon arc welding

D. Electrochemical Reactions
1. Electrolysis
   a. Production of chemicals
   b. Metal reclamation
2. Electroplating
3. Metal refinement

E. High Frequency Heating
1. Induction heating
2. Microwave heating

F. Lamps and Lighting
1. Incandescent lamps
2. Ionized gas lamps
   a. Noble gasses
   b. Metal vapors

XVI. CAREERS

A. Engineering
1. Nature of work
2. Where employed
3. Employment outlook

B. Technician
1. Television
2. Radio
3. Communications
C. Utilities
1. Power plant
2. Transmission and distribution
3. Consumer services

D. Telephone Companies
1. Installers and repair specialists
2. Operators
3. Central office installers
4. Line construction and maintenance

E. Manufacturing
1. Managerial
2. Technical
   a. Lab technicians
   b. Draftsmen
   c. Technicians
3. Assembly
4. Machining
5. Fabricating
6. Processing
7. Testing

F. Construction Electricians

G. Maintenance Electricians

H. Broadcasting

I. Teachers
## UNIT I: ELECTRICITY/ELECTRONICS SAFETY

### INTRODUCTION

**PURPOSE/RATIONALE/INTENTION**

The purpose of this unit is to introduce the importance of integrating safety as part of the Electricity/Electronics program. Students should be constantly reminded that safety must become an everyday consideration in this program and any industrial arts or vocational education laboratory.

With safety the first unit of this curriculum, it is our intent for safety to be reviewed and taught in every unit of the curriculum that is necessary.

### UNIT GOAL(S)

To make the student aware of the safety practices and hazards in working with electricity/electronics.

### GENERAL UNIT OBJECTIVES

Upon completion of this unit, students should be able to:

1. Understand course content of personal and hazard safety.
2. Be familiar with first aid procedures.
3. Identify color codes.
4. Observe and comply with fire prevention practices.
5. Student must score at least 70 percent to pass unit test.
UNIT 1: ELECTRICITY/ELECTRONIC SAFETY  
5 hours

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the conclusion of this unit, the student should be able to:</td>
<td>A. Personal Safety Practices</td>
<td>*Take notes</td>
<td>*Present student with charts and safety rules.</td>
<td>Self made or local teacher supply.</td>
</tr>
<tr>
<td>Develop responsible behavioral attitudes required for electronics/electricity.</td>
<td>1. Statq safety laws</td>
<td>Explain electric shock and ways of prevention.</td>
<td>List laws on chalk board.</td>
<td>(#35), p. 4</td>
</tr>
<tr>
<td>Identify personal safety practices.</td>
<td>2. OSHA safety laws</td>
<td>Discuss current and its effects on the human body at 120 volt, 60 hertz (cycle).</td>
<td>*Chart of current and its effects on the human body.</td>
<td>(#26), p. 211</td>
</tr>
<tr>
<td>List personal protective devices.</td>
<td>3. Electric shock</td>
<td>Explain importance of good housekeeping.</td>
<td>Make chart and explain duties.</td>
<td>(#24), p. 14</td>
</tr>
<tr>
<td>Explain importance of good housekeeping.</td>
<td>4. Current and its effects on the human body</td>
<td>Safety hazards,</td>
<td></td>
<td>(#30), p. 20</td>
</tr>
<tr>
<td>Have a thorough understanding of electrical safety hazards and prevention measures.</td>
<td>5. Protection</td>
<td>A. head (all parts)</td>
<td></td>
<td>(#25), p. 7</td>
</tr>
<tr>
<td>List example of common unsafe acts that result in electrical accidents or injury.</td>
<td>b. clothes</td>
<td>B. Safety Hazards</td>
<td></td>
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</tr>
<tr>
<td>Identify appropriate types of fire extinguishers.</td>
<td>c. jewelry</td>
<td>1. Hazards condition</td>
<td></td>
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</tr>
<tr>
<td>List the location of fire alarms and explain the proper procedure to evacuate the lab/classroom in case of fire.</td>
<td>2. Ground fault</td>
<td>a. electrical tool</td>
<td></td>
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</tr>
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<td></td>
<td>b. safety device</td>
<td>c. reporting procedure</td>
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<td></td>
<td>3. Live circuits</td>
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<td>4. Chemicals</td>
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<td></td>
<td></td>
<td>a. group A atmosphere</td>
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<td>b. group B atmosphere</td>
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<td>c. group C atmosphere</td>
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<td></td>
<td>d. Group D atmosphere</td>
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<td></td>
<td>5. Fire safety</td>
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<tr>
<td></td>
<td>a. fire extinguishers</td>
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<td></td>
<td>(1) types</td>
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<td>(2) use</td>
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<td>(3) maintenance</td>
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<td>b. class of fires</td>
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<td>(1) class A</td>
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<td>(2) class B</td>
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<td></td>
<td>(3) class C</td>
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<td></td>
<td>(4) class D</td>
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<tr>
<td></td>
<td>Practice evacuation of lab/classroom in case of fire.</td>
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</tr>
<tr>
<td></td>
<td>List the location of fire alarms, and extinguishers.</td>
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<tr>
<td></td>
<td>Match the fire with the proper extinguisher.</td>
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<tr>
<td></td>
<td>Use your notebook.</td>
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<td></td>
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<td></td>
<td>*Use charts, overhead projector, and transparencies.</td>
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</tr>
</tbody>
</table>
## UNIT 1: ELECTRICITY/ELECTRONIC SAFETY (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify each color code.</td>
<td>Define and discuss tools, machines, equipment, and apparatus with color code section.</td>
<td>Explain where each color of the color code will be found.</td>
<td>(26), p. 9</td>
</tr>
<tr>
<td>Identify safety factors for all electrical tools.</td>
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<tr>
<td>List the most common unsafe acts.</td>
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</tr>
<tr>
<td>Identify the types of electrical meters and their safety rules.</td>
<td>List electrical/hand/power tools in notebook with safety rules.</td>
<td>Demonstration of safe and correct use.</td>
<td>(13), pp. 153-154</td>
</tr>
<tr>
<td></td>
<td>Discuss tool safety.</td>
<td>Stress grounding of power tools.</td>
<td>(22), pp. 370-373</td>
</tr>
<tr>
<td>List the common unsafe acts of ladder use.</td>
<td>Hands on experience with meters.</td>
<td>Identify the proper connection of polarity and ranges.</td>
<td>(24), pp. 207-213</td>
</tr>
<tr>
<td></td>
<td>Safety do's and don't.</td>
<td>Show film.</td>
<td>(5), pp. 83-84</td>
</tr>
<tr>
<td></td>
<td>Proper way to test equipment.</td>
<td></td>
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<tr>
<td></td>
<td>Observe polarity in dc circuit.</td>
<td></td>
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<tr>
<td></td>
<td>Selecting the dc ranges.</td>
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<tr>
<td>Define, discuss tools, machines, equipment, and apparatus with color code section.</td>
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<tr>
<td>Identify the proper connection of polarity and ranges.</td>
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<tr>
<td>Discuss parts and safe use.</td>
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</tr>
</tbody>
</table>

**Color Codes**
1. red
2. yellow
3. green
4. orange
5. purple

**Mechanical Safety Tools**
1. Hand tools
   a. appropriate tools for the job
   b. good condition
2. Power tools
   a. all power tools should be grounded
   b. excessive pressure should never be used with portable electrical tools
   c. extension cord
      1. plugging
      2. disconnect
3. Motors
   a. ammeter
   b. voltmeter
   c. ohmmeter
   d. multimeter
   e. wattmeter
   f. digital multimeter
4. Ladders
   a. step ladders
   b. extension

**Use charts, overhead projector, and transparencies.**
## UNIT I: ELECTRICITY/ELECTRONIC SAFETY (Continued)

### OBJECTIVES

- Understand the responsibility of emergency procedures.
- Identify when to act, and how to act.
- Identify equipment failure and take appropriate precautionary action.

### TOPICS

<table>
<thead>
<tr>
<th>E. Emergency Procedures</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bleeding</td>
<td>Discuss emergency procedures and some general first aid.</td>
<td>Identify bleeding, breaks, wounds, and electrical shock.</td>
<td>Invite a nurse to speak to students.</td>
</tr>
<tr>
<td>a. blood spurts</td>
<td></td>
<td></td>
<td>School library first aid information.</td>
</tr>
<tr>
<td>b. blood flows</td>
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<tr>
<td>c. blood oozes</td>
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<tr>
<td>2. Breaks or fractures</td>
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</tr>
<tr>
<td>a. simple fractures</td>
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<td></td>
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<tr>
<td>b. compound fractures</td>
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<tr>
<td>3. Open wounds</td>
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<tr>
<td>a. minor cuts and abrasions</td>
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<td>b. serious wounds</td>
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<tr>
<td>c. puncture wounds</td>
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<tr>
<td>4. Electrical shock</td>
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<tr>
<td>a. shut off the current</td>
<td></td>
<td></td>
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<tr>
<td>b. removing victim</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>c. artificial respiration</td>
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<tr>
<td>5. Equipment failure</td>
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<tr>
<td>a. wrong size or type</td>
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<tr>
<td>b. overloading</td>
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<td></td>
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<tr>
<td>c. test equipment</td>
<td></td>
<td></td>
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<tr>
<td>d. extension, cords</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### F. Review Unit

- Work study sheet

### G. Test on Unit

- Test on unit.
- Review test.
**UNIT II: MATHEMATICS REVIEW**

**INTRODUCTION**  
(PURPOSE/RATIONALE/INTENTION)

This unit is designed to review with the student those mathematical skills that will be used in this course. Proficiency in these areas is essential for success in electricity/electronics.

Special attention should be paid to operations involving unit prefixes as they are widely used throughout electricity/electronics texts and literature.

**UNIT GOAL(S)**

The goal of this unit is to review with the students the mathematical skills that will be applied throughout this course.

**GENERAL UNIT OBJECTIVES**

Upon completion of this unit the student will be able to:

1. Perform arithmetic function on fractions, whole numbers and decimal numbers.
2. Express numbers in scientific notation or by use of unit prefixes and be able to convert from one prefix to another.
3. Use rules of basic Algebra to solve equations.
4. Determine the square root of a number.
5. Student must score a minimum score of 70 percent on a unit test.
UNIT 11: MATHEMATICS REVIEW

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to perform arithmetic functions on fractions, scoring a minimum of 75 percent on unit test.</td>
<td>Fractions</td>
<td>Worksheets on all areas to review and practice skills</td>
<td>Demonstrate each skill to students.</td>
<td>(#37), p. 295</td>
</tr>
<tr>
<td>Students will be able to multiply and divide decimal numbers to 10 thousandths place and point off correctly.</td>
<td>Dividing Decimal Numbers</td>
<td></td>
<td></td>
<td>(#37), pp. 313, 315</td>
</tr>
<tr>
<td>Students will be able to express numbers in scientific notation and correct numbers expressed in scientific notation as decimal number.</td>
<td>Scientific Notation</td>
<td></td>
<td></td>
<td>(#37), pp. 307, 310</td>
</tr>
<tr>
<td>Students will be able to add, subtract, multiply and divide numbers expressed in scientific notation.</td>
<td>Unit Prefixes</td>
<td></td>
<td></td>
<td>(#37), p. 291</td>
</tr>
</tbody>
</table>

Resources:
- (#37), p. 295
- (#37), pp. 313, 315
- (#37), pp. 307, 310
- (#12), p. 26
- (#12), p. 27
UNIT II: MATHEMATICS REVIEW (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to solve equations for a given variable.</td>
<td>F. Basic Algebra</td>
<td></td>
<td></td>
<td>(#37), p. 123</td>
</tr>
<tr>
<td>Students will be able to use substitution principle in deriving equations.</td>
<td>1. Solving equations by the multiplication property of equality</td>
<td></td>
<td></td>
<td>(#37), p. 125</td>
</tr>
<tr>
<td>Students will be able to calculate the square root of a number to the thousandths place.</td>
<td>2. Solving equations by the division property of equality</td>
<td></td>
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<td>(#37), p. 113</td>
</tr>
<tr>
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<td>3. Transforming equations by division or multiplication</td>
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<td>4. Substitution of one value for another in an equation</td>
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<td>G. Square Roots</td>
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<td></td>
<td>1. Square roots of whole numbers</td>
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<td></td>
<td>2. Square roots of decimal numbers</td>
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<td>3. Square roots of numbers in scientific notation</td>
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<td>H. Unit Review</td>
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<td></td>
<td>I. Unit Test</td>
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</table>
## UNIT III. NATURE OF ELECTRICITY

### INTRODUCTION

(PURPOSE/RATIONALE/INTENTION)

This unit is intended to familiarize industrial arts students with the nature of electricity and to define electronics.

### UNIT GOAL(S)

To provide students with the fundamental knowledge of matter that allows electricity to exist.

### GENERAL UNIT OBJECTIVES

Upon completion of this unit, students should be able to:

1. Define electronics and list five different fields into which the broad field of electronics is divided.
2. Define DC, AC, molecule, element, atom, electron, proton, neutron, nucleus, and ion.
3. Define conductors and insulators and explain where they are used.
4. Define electrical quantities of charge, voltage, current, resistance, and power and mathematically relate them.
UNIT III. NATURE OF ELECTRICITY

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Energy and Work</td>
<td>A. Energy and Work</td>
<td>Note taking (in notebook)</td>
<td>Lecture</td>
<td>(12), pp. 7-8</td>
</tr>
<tr>
<td>B. Structure of Matter</td>
<td>B. Structure of Matter</td>
<td>Define properties of matter.</td>
<td>List properties to be defined.</td>
<td>(16), pp. 4-8</td>
</tr>
<tr>
<td>C. Electrical Fields</td>
<td>C. Electrical Fields</td>
<td>List some elements.</td>
<td>Check work on compounds and elements.</td>
<td></td>
</tr>
<tr>
<td>D. Electrical Current</td>
<td>D. Electrical Current</td>
<td>Draw a schematic diagram of an atom of hydrogen, etc.</td>
<td>Demonstrate static electricity.</td>
<td>(12), pp. 5</td>
</tr>
<tr>
<td>E. Conductors and Insulators</td>
<td>E. Conductors and Insulators</td>
<td>Discuss electrical fields.</td>
<td>Discuss electrical current.</td>
<td>(24), pp. 1-23</td>
</tr>
<tr>
<td>F. Electrical Potential</td>
<td>F. Electrical Potential</td>
<td>List and define types of static electricity.</td>
<td>Discuss current flowing past a point, in a specific length of time.</td>
<td>(21), pp. 1-176</td>
</tr>
<tr>
<td>G. Resistance</td>
<td>G. Resistance</td>
<td>Name types of charges.</td>
<td>Explain the flow of electrical charge from one point to another.</td>
<td>1-118</td>
</tr>
<tr>
<td>At the conclusion of this unit, the student should be able to:</td>
<td>Display awareness of electrical current and properties.</td>
<td>Explain substances which have large numbers of free electrons and very few free electrons.</td>
<td>Discuss electrical current.</td>
<td>(25), pp. 89-90</td>
</tr>
<tr>
<td>Identify matter in three different states.</td>
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</tr>
<tr>
<td>Understand basic building materials from which all matter is constructed.</td>
<td>Develop a working knowledge of good conductors and insulators.</td>
<td>Explain how resistance limits the flow of electrons through a circuit.</td>
<td>Describe electrical potential.</td>
<td>(24), pp. 115-118</td>
</tr>
<tr>
<td>Understand the function of a capacitor and how electrical potential is measured.</td>
<td></td>
<td></td>
<td>Describe sources of electricity.</td>
<td></td>
</tr>
<tr>
<td>Identify the roles of resistance in circuits: Descriptive length, cross sectional area, resistivity and temperature of a substance effect its resistance.</td>
<td></td>
<td></td>
<td>Describe resistance.</td>
<td>(12), pp. 21-23</td>
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<td>(5), pp. 49-50</td>
</tr>
</tbody>
</table>

*Use charts, overhead projector, and transparencies.
<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Ohm's law.</td>
<td>H. OHM'S LAW</td>
<td>Study the formulas:</td>
<td>Give student work sheet for</td>
<td>(*5), pp. 64-66</td>
</tr>
<tr>
<td>Write three equation forms of</td>
<td>1. Deriving Ohm's law</td>
<td>For voltage (V or V)</td>
<td>problem solving.</td>
<td></td>
</tr>
<tr>
<td>Ohm's law.</td>
<td>2. Using Ohm's law</td>
<td>For current (I)</td>
<td>(12), pp. 22</td>
<td></td>
</tr>
<tr>
<td>Understanding electrical power,</td>
<td>I. Power</td>
<td>For resistance (R)</td>
<td>(24), pp. 16-17</td>
<td></td>
</tr>
<tr>
<td>verify the three power equations.</td>
<td>1. What is power</td>
<td>Practice problems as directed by</td>
<td>*Identify power.</td>
<td>(24), pp. 20-22</td>
</tr>
<tr>
<td></td>
<td>3. Measuring power</td>
<td>Discuss three common equations for</td>
<td></td>
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<td></td>
<td>4. Relationship to energy</td>
<td>determining the power in a circuit.</td>
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<tr>
<td>J. Review Unit</td>
<td>Test</td>
<td>Test review</td>
<td></td>
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</tr>
<tr>
<td>I. Test</td>
<td>Test</td>
<td>Test</td>
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</tr>
</tbody>
</table>

*Identify power. Pass out review sheet.

Use charts, overhead projector, and transparencies.
### UNIT IV: MEASURING

#### INTRODUCTION
(PURPOSE/RATIONALE/INTENTION)

The purpose of this unit is to introduce the student to motors and measuring.

#### UNIT GOAL(S)

The student should be familiar with most types of motors and able to read the scale of that motor.

#### GENERAL UNIT OBJECTIVES

Upon completion of this unit the student should be able to:

1. Identify several types of motors.
2. Describe the operation of a multimeter.
3. Know the functions of and how to use both DC and AC meters.
4. Know the function of and how to use voltmeters, ohmmeters, and digital meters.
### UNIT IV. METERS AND MEASURING

**OBJECTIVES**

At the conclusion of this unit, the student should be able to:

- Interpret the reading of all motors and scales.
- Understand the operation of the digital meter and how to use it. Identify the functions and how to use an ammeter.
- Identify the functions and how to use a voltmeter.
- Identify motor error and ways to correct them.

**TOPICS**

<table>
<thead>
<tr>
<th>A. Reading Meters</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Analog motors</td>
<td><em>Use notebook (note taking)</em></td>
<td>Identify and read scales of an analog motor. Draw type of scale.</td>
<td>(#10), Unit 6, pp. 8-10</td>
</tr>
<tr>
<td>a. linear scale</td>
<td></td>
<td>List the function of a digital meter.</td>
<td></td>
</tr>
<tr>
<td>b. nonlinear scale</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2. Digital meters</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>a. reading numbers on a digital display</td>
<td></td>
<td>Demonstrate how the motors are read. Identify parts and controls.</td>
<td></td>
</tr>
<tr>
<td>b. five AC &amp; DC voltage and current ranges</td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Using Meters</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ammeters</td>
<td><em>Use notebook (note taking)</em></td>
<td>List ways in which you can use an ammeter. Include the operation.</td>
<td>(#10), Unit 6, pp. 16-17</td>
</tr>
<tr>
<td>a. accuracy range</td>
<td></td>
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<tr>
<td>b. accuracy fall off</td>
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<td></td>
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<tr>
<td>c. connection</td>
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</tr>
<tr>
<td>2. Voltmeter</td>
<td><em>Use notebook (note taking)</em></td>
<td>Discuss operation and the reading of the voltmeter.</td>
<td>(#18), Unit 6, pp. 16-17</td>
</tr>
<tr>
<td>a. one milliamperes use as a voltmeter</td>
<td></td>
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</tr>
<tr>
<td>b. multi-range voltmeter</td>
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<tr>
<td>c. connection</td>
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<td></td>
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<tr>
<td>3. Multimeter</td>
<td></td>
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</tr>
<tr>
<td>a. combination of meters</td>
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<tr>
<td>b. all meters have similar controls</td>
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<td>4. Ohmmeters</td>
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<tr>
<td>a. probes</td>
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<td>b. zero adjust</td>
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<td>c. connection</td>
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<tr>
<td>5. Meter error</td>
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<tr>
<td>a. loading error</td>
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<td>b. parallax error</td>
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</tr>
</tbody>
</table>

**RESOURCES**

- (#18), Unit 6, pp. 8-10
- (#10), Unit 6, pp. 16-17
- (#18), Unit 6, pp. 30-32
- (#18), Unit 6, pp. 41-43
<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify safety rules and cares in using meters.</td>
<td>C. Meter Care</td>
<td>Review safety (included). List procedures used in connecting meters, testing for full-scale deflection.</td>
<td>Propose questions about meter care after safety review on meters.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Handling meters</td>
<td></td>
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<tr>
<td></td>
<td>a. probes</td>
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<td></td>
<td>b. proper movement</td>
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<tr>
<td></td>
<td>2. Connecting meters</td>
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<td></td>
<td>3. Setting and adjusting</td>
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<td></td>
<td>D. Unit Review</td>
<td>Test review</td>
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<td></td>
<td>E. Unit Test</td>
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</tbody>
</table>

*Use charts, overhead projector, and transparencies.

*Pass out review sheet.
### UNIT V: RESIDENTIAL ELECTRICITY

#### INTRODUCTION
(PURPOSE/RATIONALE/INTENTION)

This unit is intended to familiarize the learner with residential electricity. The student will perform jobs, techniques, applications, and service installations.

Teachers should be aware of the importance of using the correct nomenclature, as well as the need for thoroughness in initial demonstration.

#### UNIT GOAL(S)

Students will be given the opportunity to explore, identify, and understand a variety of techniques, through handling tools, materials, and motors.

#### GENERAL UNIT OBJECTIVES

Upon completion of this unit, students should be able to:

1. State or list safety precautions to be observed when working with electricity. (Tool, circuit, etc.)
2. Demonstrate an understanding of load per circuit.
3. Identify material used in house wiring.
4. Pass unit test with a score of 70 percent or better.
### UNIT V: RESIDENTIAL ELECTRICITY

**OBJECTIVES**

At the conclusion of this unit the student should be able to discuss the importance of safety.

To understand the transmission of electricity from generating plant to home or large factories.

At the conclusion of this unit the student should be able to:

- Identify common hand tools used in electrical wiring.
- Know safe use of hand tools and specialty tools.

### TOPICS

#### A. Safety
1. First aid
2. Hazard
3. Personal
4. Grounding
5. Tool and equipment
6. Fires

#### B. Transmission System
1. Generating plant
   a. step up substation
   b. transformer
2. High voltage transmission
   a. large factories and stores
   b. transformer
3. Low voltage
   a. residential and small stores
   b. step down transformer
4. Household electrical system (planning)
   a. make blueprint
   b. symbols

#### C. Tools and Equipment (Basic)
1. Screwdrivers
   a. flat blade
   b. Phillips (cross point)
   c. stubby
2. Pliers
   a. long nose
   b. bent nose
   c. lineman pliers
   d. diagonal
   e. groove joint
   f. combination

### STUDENT ACTIVITIES

- Use notebook (note taking)
- Review rules that apply to house wiring.
- Discuss the need and importance of electricity. Sketch a diagram of the delivery of electricity from a generating plant to a home.
- Draw plans for house wiring.
- Use notebook (note taking)
- Discuss the use of tools.
- Use tools to perform simple tasks involved in house wiring.
- Use charts, overhead projectors, and transparencies.

### TEACHER ACTIVITIES

- Stress safety rules that apply to house wiring.
- Lecture the transmission system of electricity from the generating plant to home.
- Discuss the use of tools.
- Demonstrate and identify the parts of each tool.
- Stress the right tool for the right job.

### RESOURCES

- (#35), pp. 12-552
- (#36), pp. 5-14
- (#27), pp 517-14 and 210-8
- (#27), p. 250-45
- (#36), p. 7
- (#24), pp. 189-192
- (#20), pp. 365-368
- (#36), pp. 132-135
- (#31), p. 275
- (#20), pp. 189-192
- (#24), pp. 370-373
- (#20), pp. 365-368
UNIT V: RESIDENTIAL ELECTRICITY (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
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<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>3. Electrician hammer</td>
<td>Practice by measuring objects in the classroom.</td>
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<td>4. Wire strippers</td>
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<td></td>
<td>a. cable</td>
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<td></td>
<td>b. multipurpose</td>
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<td></td>
<td>c. adjustable</td>
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<td>5. Rule</td>
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<td>a. tape measure (retractable)</td>
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<td></td>
<td>b. folding</td>
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<td>6. Wrenches</td>
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<td></td>
<td>a. Allen</td>
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<td>b. open end</td>
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<td>c. box end</td>
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<td>d. adjustable</td>
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<td>7. Threading tools</td>
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<td></td>
<td>8. Punch and awls</td>
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<td>9. Drill and bits</td>
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<td></td>
<td>a. brace and bits</td>
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<td>b. drill motor and bits</td>
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<td>10. Saws</td>
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<td></td>
<td>a. hack</td>
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<td>b. hole</td>
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<td>c. keyhole</td>
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<td></td>
<td>d. reciprocal</td>
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<td>11. Files</td>
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<td></td>
<td>a. double cut</td>
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<td>b. single cut</td>
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<td></td>
<td>Identify the techniques of soldering and using a soldering iron or gun.</td>
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<td>12. Specialty tools</td>
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<td></td>
<td>1. Soldering</td>
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<tr>
<td></td>
<td>a. iron</td>
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<td></td>
<td>b. pencil</td>
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<td></td>
<td>c. gun</td>
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<td></td>
<td>Discuss the material used in soldering:</td>
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<td></td>
<td>flux</td>
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<td>acid flux</td>
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<td>rosin core</td>
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<td>tin and lead</td>
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<td>*Demonstrate by showing material for soldering.</td>
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<td></td>
<td>*Give measuring problem to class.</td>
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<td></td>
<td>*Use charts, overhead, projectors, and transparencies.</td>
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</tbody>
</table>

(36), pp. 144-148
**UNIT V: RESIDENTIAL ELECTRICITY** (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7. Pipe reamer</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 163-165</td>
</tr>
<tr>
<td></td>
<td>5. Pipe cutter</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#24), pp. 197-198</td>
</tr>
<tr>
<td></td>
<td>4. Bonders</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 166 &amp; 176</td>
</tr>
<tr>
<td></td>
<td>a. EMT</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#24), pp. 242-245</td>
</tr>
<tr>
<td></td>
<td>b. Hickey</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>c. heater (Plastic)</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>5. Plumb bob</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>6. Chisel</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>7. Knock out punches</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>8. Fish tape</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>9. Level</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>10. Motors</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>a. neon test light</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>b. volt ohmmeter</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>c. ammeter</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>d. multimeter</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>e. inductance couple meter</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>1. Wire</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>a. cable typo</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>b. size</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>c. insulation</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>2. Switches</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>a. single pole</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>b. 3-way</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>c. 4-way</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>d. dimmer</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>a. low voltage</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>3. Receptacles</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>a. duplex</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>b. dual voltage</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>c. air condition</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>d. range</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
<tr>
<td></td>
<td>e. dryer</td>
<td><em>Use notebook (notetaking)</em></td>
<td><em>List the name of meter on chalkboard or handout sheet.</em></td>
<td>(#36), pp. 183-187</td>
</tr>
</tbody>
</table>

At the conclusion of this unit, the student should be able to:

- Understand the purpose of insulation for wire.
- Name the types of switches and receptacles that are used for household electric service.

**Explain the application of motors in house wiring.**

**Review Unit IV, Motors and Measuring. Identify each meter and its purpose.**

**List the different types of wire and size. Identify the most common use of each type of wire.**

**List the switches found in your home and at school.**

**Discuss receptacle types and where they are used.**

**Use charts, overhead projectors, and transparencies.**
### UNIT V: RESIDENTIAL ELECTRICITY (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify types of wall plates.</td>
<td>4. Wall plates&lt;br&gt;a. single toggle&lt;br&gt;b. double toggle&lt;br&gt;c. single toggle and duplex receptacles&lt;br&gt;d. weatherproof plates</td>
<td>List advantages of wall plates.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand the use of boxes and their types.</td>
<td>5. Outlet boxes&lt;br&gt;a. handy&lt;br&gt;b. extension&lt;br&gt;c. octagon&lt;br&gt;d. square&lt;br&gt;e. box covers</td>
<td>List ways to use outlet boxes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand that conduit protects electrical wire.</td>
<td>6. Conduit&lt;br&gt;a. rigid metallic&lt;br&gt;b. nonmetallic&lt;br&gt;c. flexible&lt;br&gt;d. nonmetallic sheathed&lt;br&gt;e. P.V.C. (plastics)</td>
<td></td>
<td></td>
<td>(#24), pp. 196-198</td>
</tr>
<tr>
<td>Understand the purpose of the service panel.</td>
<td>7. Service Panel&lt;br&gt;a. weatherhead&lt;br&gt;b. mast&lt;br&gt;c. meter base&lt;br&gt;d. service entry&lt;br&gt;e. grounding system</td>
<td>Discuss the service drop.</td>
<td></td>
<td>(#24), pp. 192-196</td>
</tr>
<tr>
<td>Use and be familiar with the National Electric Code.</td>
<td></td>
<td></td>
<td></td>
<td>(#36), pp. 264-267</td>
</tr>
<tr>
<td>Understand the role of Underwriters’ Laboratories, the importance of UL approval and NEC.</td>
<td>F. Electric Service Wiring Techniques&lt;br&gt;1. Rough in&lt;br&gt;2. Branch circuit wiring&lt;br&gt;3. Moung electrical fixtures</td>
<td>Trace electricity from the distribution panel through the home by branch circuits, hook-up selected circuits and check applications using proper techniques.</td>
<td>Demonstrate electrical service from the service panel through Chapters 1-15 branch circuits.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>H. Review Unit for Test&lt;br&gt;1. Test on Unit</td>
<td>Test</td>
<td>Study sheet or questions</td>
<td>Study sheet or questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Review test</td>
<td>Administrator test</td>
<td>Administrator test</td>
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<td></td>
<td></td>
<td>Review test</td>
<td>Review test</td>
<td>Review test</td>
</tr>
</tbody>
</table>
**UNIT VI: DIRECT CURRENT CIRCUITS**

**INTRODUCTION**
(PURPOSE/RATIONALE/INTENTION)

This unit is designed to present to the student direct current circuit analysis techniques. Also included is a study of capacitors in direct current circuits.

**UNIT GOAL(S)**

The goal of this unit is to introduce basic and advanced techniques of circuit analysis involving resistance and capacitance.

**GENERAL UNIT OBJECTIVES**

Upon completion of this unit the student will be able to:

1. Determine the equivalent resistance of series, parallel, and series-parallel circuits.
2. Determine branch currents and load resistor voltage drops in series, parallel and series-parallel circuits.
4. Build practical circuits in order to test and confirm these laws.
5. Be able to use varied and advanced circuit analysis techniques.
6. Name several types of capacitors, how they are constructed and analyze DC circuits containing them.
7. Student must pass unit test with 70 percent or better.
### OBJECTIVES

Students will indicate the ability to work Ohm’s Law problems.

Students will be able to define and recognize series circuits.

Students will be able to calculate the equivalent resistance of series circuits.

Students will be able to state Kirchoff’s Voltage Law and Ohm’s Law, to calculate missing voltage drops in a series circuit.

Students will be able to apply principle of voltage division to series circuits.

Students will be able to calculate power use in series circuit.

Students will be able to design and construct a working series circuit to specifications.

Students will be able to define and recognize parallel circuits and list the major characteristics of parallel circuits.

### TOPICS

<table>
<thead>
<tr>
<th>A. Review Ohm’s Law.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Series Circuit</td>
</tr>
<tr>
<td>1. Definition of series circuit</td>
</tr>
<tr>
<td>2. Current in series circuit</td>
</tr>
<tr>
<td>3. Equivalent series resistance</td>
</tr>
<tr>
<td>4. Voltage drops in series circuits</td>
</tr>
<tr>
<td>5. Kirchoff’s Voltage Law</td>
</tr>
<tr>
<td>6. Potency of voltage drops</td>
</tr>
<tr>
<td>7. Voltage dividers a. Voltage division</td>
</tr>
<tr>
<td>b. Loaded-voltage dividers</td>
</tr>
<tr>
<td>8. Power in series circuits a. power used by individual components</td>
</tr>
<tr>
<td>b. total power used by series circuits</td>
</tr>
<tr>
<td>9. Designing series circuits a. apply the laws to real world</td>
</tr>
<tr>
<td>b. troubleshooting the circuit</td>
</tr>
<tr>
<td>C. Parallel Circuits</td>
</tr>
<tr>
<td>1. Definition of parallel circuits</td>
</tr>
<tr>
<td>2. Voltage drops on parallel circuits</td>
</tr>
<tr>
<td>3. Branches</td>
</tr>
<tr>
<td>4. Conductance</td>
</tr>
</tbody>
</table>

### STUDENT ACTIVITIES

| Work problems as class. |
| Have students draw series circuits. |
| Students calculate total resistance of given circuits. |
| Students work problems involving voltage drops and Kirchoff’s Law. Students confirm Kirchoff’s Law using lab exercises. |
| Students work problems involving voltage division. Confirm voltage division using lab exercises. |
| Design and build two and three component series circuits to given specifications. |

### TEACHER ACTIVITIES

| Review Ohm’s Law application. Work problems on board. |
| Draw several series circuits on board. Give examples of practical series circuits. Demonstrate method for calculating. Construct circuit and use ohmmeter to indicate property of equivalent resistance. Discuss Kirchoff’s laws in lab exercise. |
| Demonstrate problems on chalkboard and explain. |
| Draw simple parallel circuit on board and use to demonstrate principles. Build simple parallel circuit and use to demonstrate principles. |

### RESOURCES

(12), p. 35
(16), p. 40
(12), pp. 53-83
(16), p. 55
(12), p. 88
(16), p. 56
(12), p. 89
(16), p. 120
(16), p. 63
(12), p. 87
(12), p. 79
(12), p. 85
**VI: DIRECT CURRENT CIRCUITS (Continued)**

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student will be able to determine the equivalent resistance, branch currents, and power use of parallel circuits.</td>
<td>5. Equivalent resistance</td>
<td>Work problems involving parallel circuits.</td>
<td>Pass out and explain what is expected in lab activity.</td>
<td>(*16), p. 78</td>
</tr>
<tr>
<td>7. Total current</td>
<td>Students will build parallel circuit to specifications.</td>
<td></td>
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<tr>
<td>8. Power in parallel circuits</td>
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<td></td>
</tr>
<tr>
<td>a. total power</td>
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<tr>
<td>b. power consumed by individual components</td>
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<tr>
<td>9. Kirchhoff's current law</td>
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<tr>
<td>Determine voltage drops, branch currents and power use in series-parallel circuits.</td>
<td>D. Series-Parallel Circuits</td>
<td></td>
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</tr>
<tr>
<td>1. Equivalent resistance by series and parallel rules on portions of circuit</td>
<td>Students will wire a series-parallel exercise to confirm laws.</td>
<td></td>
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</tr>
<tr>
<td>2. Equivalent resistance by Ohm's law ( R_{eq} = \frac{V}{I} )</td>
<td>Design and build circuit to specifications.</td>
<td>Pass out lab activity.</td>
<td></td>
<td>(*16), p. 122</td>
</tr>
<tr>
<td>3. Voltage drops on series strings, components, or branches</td>
<td></td>
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</tr>
<tr>
<td>4. Power use by components</td>
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<tr>
<td>5. Designing loaded voltage dividers</td>
<td></td>
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</tr>
<tr>
<td>Students will analyze bridge circuits to determine resistance, voltages, or currents.</td>
<td>E. Advanced Analysis Techniques</td>
<td>Work problems involving bridge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. defining bridge circuits</td>
<td>Perform lab exercise to confirm laws.</td>
<td></td>
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</tr>
<tr>
<td>b. calculating total resistance</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>c. balanced bridge</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>d. calculating missing resistance in balanced bridge</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>e. calculating voltage drops and currents in bridge circuits</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
### VI. DIRECT CURRENT CIRCUITS (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to: Analyze two-mesh circuits by mesh analysis.</td>
<td>2. Mesh Analysis a. mesh currents b. mesh circuits c. simultaneous equations d. writing mesh equations</td>
<td>Work problems involving mesh analysis techniques.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyze tee circuits and convert Delta to Tee and Tee to Delta.</td>
<td>3. Delta-Tee circuits a. Toe circuits b. Delta circuits c. Delta-Toe conversions d. Tee-Delta conversions</td>
<td>Work analysis problems involving skills of Delta-Tee transformations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyze circuit by loop analysis.</td>
<td>4. Loop analysis a. loop currents b. writing loop equations c. solving for voltage drops d. solving for currents</td>
<td>Work loop analysis problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students will be aware of superposition, Thevenin, and Norton methods of circuit analysis.</td>
<td>5. Other techniques a. superposition b. Thevenin theorem c. Norton's theorem</td>
<td>Students perform each type of analysis with simple example problems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students will be able to explain capacitor action.</td>
<td><strong>F. Capacitance</strong> 1. Dielectric field 2. Electrostatic induction 3. Charging and discharging of capacitors 4. Capacitors a. capacitor construction b. dielectric values c. effects of physical construction on value</td>
<td>Demonstrate capacitors ability to store charge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explain how the basic capacitor is constructed.</td>
<td>5. Capacitor ratings a. capacitance value b. how capacitance determined c. working voltage d. tolerance e. polarity f. capacitor color coding</td>
<td>Dissect several types of capacitors. NOTE: Some oil filled and electrolytic capacitors contain potential hazardous liquids.</td>
<td></td>
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</tr>
<tr>
<td>Students will be able to explain the ratings of capacitors and their significance in actual circuits.</td>
<td></td>
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</tbody>
</table>
### VI: DIRECT CURRENT CIRCUITS (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name several types of capacitors and their general uses.</td>
<td>6. Types of capacitors&lt;br&gt;   a. capacitor types&lt;br&gt;   b. variable capacitors&lt;br&gt;   c. types of dielectrics</td>
<td>Build capacitor circuits and measure changing times, graph capacitor voltages, and determine time constants.</td>
<td>Show students different types of capacitors and discuss their characteristics.</td>
<td>(12), p. 238</td>
</tr>
<tr>
<td>Explain the transient response curves of capacitors, calculate time constants, and explain their importance.</td>
<td>7. Transient response&lt;br&gt;   a. transient response--charging&lt;br&gt;   b. transient response--discharging.</td>
<td>Build R.C. circuit using series and parallel capacitor connections and measure time constants and voltage distribution.</td>
<td>Draw transient response on board or overhead projector and discuss charging and discharging.</td>
<td>(5), p. 151</td>
</tr>
<tr>
<td>Determine the total capacitance and working voltage of series and parallel capacitor circuits.</td>
<td>8. Basic capacitor circuits&lt;br&gt;   a. total capacitance in series and parallel&lt;br&gt;   b. voltage division in series&lt;br&gt;   c. voltage ratings in series&lt;br&gt;   d. total capacitance in parallel&lt;br&gt;   a. voltage ratings in parallel</td>
<td></td>
<td>Discuss fully series and parallel connections and the voltage distribution.</td>
<td>(12), p. 238</td>
</tr>
<tr>
<td>C. Unit Review</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. Unit Test</td>
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</tbody>
</table>
## UNIT VII: MAGNETISM

### INTRODUCTION
(PURPOSE/RATIONALE/INTENTION)

The purpose of this unit is to introduce the student to magnetism. Electric current produces magnetic fields and magnetic fields produce electric current.

### UNIT GOAL(S)

To make the student aware of the theories and principles used in dealing with magnetic devices.

### GENERAL UNIT OBJECTIVES

Upon completion of this unit, the student should be able to:
1. Identify how you got magnets.
2. Understand permeability.
3. Understand the term magnetic domain and why the crystals are positioned in a north-south direction.
## UNIT VII: MAGNETISM

### OBJECTIVES

At the conclusion of this unit the student should be able to:

1. Classify magnets according to the method by which they obtain their magnetic field.
2. Demonstrate an understanding of the observed phenomenon of magnetic theory.
3. Name the basic building material for magnets.
4. Define and understand the terms and formulas used in magnetic circuits.
5. Develop a working knowledge of electromagnetic relation to electricity.

### TOPICS

<table>
<thead>
<tr>
<th>A. History of Magnetism</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Magnets</td>
</tr>
<tr>
<td>2. Artificial magnets</td>
</tr>
<tr>
<td>a. shape</td>
</tr>
<tr>
<td>b. material use</td>
</tr>
<tr>
<td>c. method used to obtain magnet field</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Magnetic Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Permeability</td>
</tr>
<tr>
<td>a. flux</td>
</tr>
<tr>
<td>b. poles</td>
</tr>
<tr>
<td>2. Domain</td>
</tr>
<tr>
<td>3. Law of magneto-motive force</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. Magnetic Materials and Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ferromagnetic</td>
</tr>
<tr>
<td>2. Diamagnetic</td>
</tr>
<tr>
<td>3. Magnetic shielding</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D. Measuring Magnetism</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Magnetomotive force</td>
</tr>
<tr>
<td>2. Flux density</td>
</tr>
<tr>
<td>3. Intensity</td>
</tr>
<tr>
<td>4. Reluctance</td>
</tr>
<tr>
<td>5. Permeability</td>
</tr>
<tr>
<td>6. Retentivity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E. Electromagnetic Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Relation to current</td>
</tr>
<tr>
<td>2. Magnetism in coil of wire</td>
</tr>
<tr>
<td>3. Electromagnetic devices</td>
</tr>
<tr>
<td>a. solenoid</td>
</tr>
<tr>
<td>b. relay</td>
</tr>
<tr>
<td>c. circuit breakers</td>
</tr>
<tr>
<td>d. speakers</td>
</tr>
<tr>
<td>e. meters</td>
</tr>
<tr>
<td>f. recording tape</td>
</tr>
</tbody>
</table>

### STUDENT ACTIVITIES

- **Note taking**
  - Discuss magnetism history.
  - Identify shapes and material used in classifying magnets.

- **Classroom instruction**
  - Explain what is meant by magnetic flux, permeability, and magneto-motive force.
  - Discuss magnetomotive force and reluctance for making a temporary magnet.
  - Discuss places where magnetic shielding is necessary.
  - Identify ways to measure magnets.
  - State the principle of electromagnetic induction.
  - Use compass to indicate magnetic field around wire.

- **Practice exercises**
  - Use charts, overhead projector, and transparencies.

### TEACHER ACTIVITIES

- **Lecture and discussion**
  - Discuss magnetism history.
  - Identify shapes and material used in classifying magnets.
  - Show shape of field around magnet using iron filings on white paper.
  - Demonstrate the strength of magnetic materials.
  - Lecture
  - Use compass to indicate magnetic field around wire.
  - Discuss the operation of several electromagnetic devices, including solenoids and doorbells.

### RESOURCES

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-
## UNIT VII: MAGNETISM (Continued)

### OBJECTIVES

- Define induction, inductance, and counter EMF.
- Describe the factors which determine inductance.

### TOPICS

- F. Inductance
  1. Induced EMF
  2. Lenz's Law
  3. Measuring inductance
  4. Effect of cores
  5. Quality of coils
  6. Transient response
  7. Time constants
  8. Inductance in series
  9. Inductance in parallel

### STUDENT ACTIVITIES

- List the unit of inductance.
- Describe the factors which determine inductance.
- Draw the schematic symbols for inductor.
- Construct RL circuit and determine changing rates and time constants experimentally.

### TEACHER ACTIVITIES

- Demonstrate inductive kick by using large inductor and neon bulb. Switch low voltage DC on and off to flash neon bulb.

### RESOURCES

- Unit 8, pp. 6-8
- Unit 8, pp. 9-11

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4. Test Review

H. Test

- Test
  - Review test
<table>
<thead>
<tr>
<th>UNIT VIII: TEST EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INTRODUCTION</strong></td>
</tr>
<tr>
<td>(PURPOSE/RATIONALE/INTENTION)</td>
</tr>
<tr>
<td>This unit is intended to familiarize students with the most common test equipment and its proper use. Teachers should be aware of the importance of using the correct nomenclature, as well as the need for thoroughness in initial demonstrations.</td>
</tr>
<tr>
<td><strong>UNIT GOAL(S)</strong></td>
</tr>
<tr>
<td>Students will be given maximum opportunity to identify, select, and handle a variety of electronic test equipment.</td>
</tr>
<tr>
<td><strong>GENERAL UNIT OBJECTIVES</strong></td>
</tr>
<tr>
<td>Upon completion of this unit the learner will be able to name the various types of test equipment and describe the use of each by completing the unit test. Learner must score at least 70 percent to pass. Demonstrate an understanding of motor construction and oscilloscope fundamentals.</td>
</tr>
</tbody>
</table>
### OBJECTIVES

The learner will be able to read, calibrate, and measure electrical quantities using the analog or digital volt, amp, and ohmmeters.

### TOPICS

<table>
<thead>
<tr>
<th>A. Test Equipment</th>
<th>B. Ammeter</th>
<th>C. Voltmeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Meter movement analog</td>
<td>a. d'Arovnal movement</td>
<td>a. extending the range</td>
</tr>
<tr>
<td>1. construction</td>
<td>2. operation</td>
<td>1. calculating the multiplier</td>
</tr>
<tr>
<td>2. operation</td>
<td>b. teet-band movement</td>
<td>2. multi-range voltmeters</td>
</tr>
<tr>
<td>c. iron vane</td>
<td>1. radial vane</td>
<td>b. loading effect of voltmeters</td>
</tr>
<tr>
<td>2. concentric vane</td>
<td>d. thermocouple</td>
<td>c. typical connections</td>
</tr>
<tr>
<td>1. operation</td>
<td>2. construction</td>
<td>d. typical voltmeters AC &amp; DC</td>
</tr>
<tr>
<td>3. electrical characteristics</td>
<td>3. Voltmeter</td>
<td>e. scales</td>
</tr>
<tr>
<td>a. computing shunt resistance to increase the range of the ammeter</td>
<td>a. extending the range</td>
<td>1. DC</td>
</tr>
<tr>
<td>b. scales</td>
<td>b. loading effect of voltmeters</td>
<td>&amp; AC</td>
</tr>
<tr>
<td>1. Linear</td>
<td>c. typical connections</td>
<td></td>
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</tbody>
</table>
### OBJECTIVES

**The learner will be able to identify the components, features, controls, and measure using the oscilloscope. They will also learn to:**
- avoid damage to the scope
- properly adjust and calibrate the scope
- connect the scope with minimal disturbance to the quantity being observed.

### TOPICS

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>a. scale calibration</td>
<td>a. VOM</td>
<td>a. integrating techniques</td>
</tr>
<tr>
<td>b. creating higher and lower ranges</td>
<td>b. DC voltmeter</td>
<td>(1) single-slope A/D conversion</td>
</tr>
<tr>
<td>c. shunt ohmmeter</td>
<td>c. millimeter</td>
<td>(2) dual-slope integration</td>
</tr>
<tr>
<td>d. measurements</td>
<td>d. analog to digital conversion</td>
<td>(3) voltage to frequency</td>
</tr>
<tr>
<td>e. scales</td>
<td>e. non-integrating techniques</td>
<td>(4) charge balance</td>
</tr>
<tr>
<td>b. Introducing techniques</td>
<td>(1) linear-ramp conversion</td>
<td>c. non-integrating techniques</td>
</tr>
<tr>
<td>(1) single-slope A/D conversion</td>
<td>(2) dual-slope integration</td>
<td>(1) linear-ramp conversion</td>
</tr>
<tr>
<td>(2) dual-slope integration</td>
<td>(3) voltage to frequency</td>
<td>d. signal processor</td>
</tr>
<tr>
<td>(4) charge balance</td>
<td>(4) charge balance</td>
<td>e. displays</td>
</tr>
</tbody>
</table>

### STUDENT ACTIVITIES

<table>
<thead>
<tr>
<th>Read section on ohmmeters.</th>
<th>Read section on VOM.</th>
<th>Read section covering oscilloscopes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer programmed review questions.</td>
<td>Answer programmed review questions.</td>
<td>Answer programmed review questions.</td>
</tr>
<tr>
<td>Do lab activity which requires the reading of different resistances.</td>
<td>Do lab activity involving each section of the volt-ohm-millimeter.</td>
<td>Display wave forms using scope.</td>
</tr>
<tr>
<td>Demonstrate proper use in reading ranges and scales of the ohmmeter.</td>
<td>Explain the range switching sockets and ohm control.</td>
<td>Demonstrate the proper handling, use, and operation.</td>
</tr>
<tr>
<td>Demonstrate the operation, function, and reading of the volt-ohm-millimeter.</td>
<td>Complete programmed review questions.</td>
<td>Demonstrate the proper handling, use, and operation.</td>
</tr>
</tbody>
</table>

### TEACHER ACTIVITIES

| Demonstrate proper use in reading ranges and scales of the ohmmeter. | Explain the range switching sockets and ohm control. | Demonstrate the proper handling, use, and operation. |
| Complete programmed review questions. | Complete a lab activity which demonstrates learner's comprehension of meter. | Complete a lab activity which demonstrates learner's comprehension of meter. |

### RESOURCES

<table>
<thead>
<tr>
<th>(#23), pp. 1-50 to 1-63</th>
<th>(#23), pp. 1-64 to 1-73</th>
<th>(#23), pp. 2-6 to 2-28</th>
</tr>
</thead>
</table>
## UNIT VIII: TEST EQUIPMENT (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display a wave form (or a selected portion thereof) and measure its characteristics (amplitude, period, frequency). Determine the relationship between two waveforms such as phase shift. Display wave forms (Lissajous figures). Interpret the results of oscilloscope measurements taking the limitations of the scope into account. The learner will be able to use and identify the waveforms of functions and signal generators.</td>
<td>Function/Signal Generator</td>
<td>Read section covering function/signal generator. Test waveform.</td>
<td>Complete lab activity to demonstrate how the output frequency and voltage can be checked.</td>
<td>(19) pp. 5-111 to 5-125</td>
</tr>
<tr>
<td>The learner will be able to develop a working knowledge of the use and function of a transistor tester. The learner will be able to identify the type of transistor and transistor leads using a transistor tester.</td>
<td>Transistor Tester</td>
<td>Be able to use this piece of test equipment (if lab equipped). Read chapter. Complete programmed review questions.</td>
<td>Demonstrate use and operation of a function generator.</td>
<td>(19) pp. 5-69</td>
</tr>
<tr>
<td></td>
<td>Unit Review</td>
<td></td>
<td></td>
<td>(19) pp. 6-12 to 6-19</td>
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<td></td>
<td>Unit Exam</td>
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</tbody>
</table>
### UNIT IX. A.C. CIRCUITS

#### INTRODUCTION
(PURPOSE/RATIONALE/INTENTION)

This unit is designed to present to the student alternating current circuit analysis techniques. Also included is a study of alternating current fundamentals and transformers.

#### UNIT GOAL(S)

The goal of this unit is to introduce vector analysis techniques for alternating current circuits that contain resistors, capacitors, and inductors.

#### GENERAL UNIT OBJECTIVES

Upon completion of this unit the student will be able to:

- Identify specific quantity measurements of AC waveform and convert from one to another where appropriate.
- Analyze RL, RC, and RLC circuits for reactance, impedance, phase angle, true power, and power factor.
- Determine the resonant frequency and frequency response curves of RLC circuits.
- Build various types of filter circuits to specific requirements.
- Explain the operation and applications of transformers.
<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to identify basic waveforms by their shape.</td>
<td>A. Alternating Current Fundamentals</td>
<td>Students take notes in notebook.</td>
<td>Display example waves on oscilloscope or draw on board.</td>
<td>(#12), p. 147</td>
</tr>
<tr>
<td>Student will be able to define alternating current quantities and convert measurements where appropriate.</td>
<td></td>
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<td>(#16), pp. 314, 329</td>
</tr>
<tr>
<td>Students will be able to sketch three phase alternating current waveforms and give application and advantages of polyphase circuits.</td>
<td></td>
<td></td>
<td></td>
<td>(#16), pp. 317–322</td>
</tr>
<tr>
<td>Student will be able to define the terms in-phase and out-of-phase as they relate to alternating currents.</td>
<td></td>
<td></td>
<td></td>
<td>(#12), pp. 148–151</td>
</tr>
</tbody>
</table>

**A. Alternating Current Fundamentals**

1. Waveforms
   - sine wave
   - square wave
   - ramp (sawtooth) wave
   - triangle wave
2. A.C. Quantities
   - frequency
   - period
   - wavelength
   - peak value
   - peak-to-peak value
   - effective (RMS)
   - average value
   - instantaneous value
   - harmonious

**B. Polyphase A.C.**

1. Two-phase waveform
2. Three-phase waveform
3. Uses of polyphase current
4. Advantages of polyphase current
5. Polyphase distribution systems

**C. Phase relationship**

1. In-phase voltage and currents
2. Out-of-phase voltage and currents
3. Power in A.C. circuits that are in-phase
4. Power in A.C. circuits that are out-of-phase

**Teacher Activities**

- Draw waveforms and show what each quantity represents.
- Have students convert from one quantity to another. Examples: Find wavelength of 1 MHz signal. Demonstrate changing of one quantity to another.
- Draw waveforms on board or use overhead transparencies to indicate phase relationships.
- Draw out-of-phase signals (voltage and current) and discuss areas of positive and negative power.
### UNIT IX: A.C. CIRCUITS (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPOICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to define and calculate capacitive reactance for a given circuit.</td>
<td>Capacitive Circuits</td>
<td>Students graph capacitive reactance versus frequency.</td>
<td>Discuss reactance and how it is determined.</td>
<td>(#12), p. 339</td>
</tr>
<tr>
<td>Students will be able to analyze circuits involving resistance and capacitive reactance.</td>
<td>Capacitors in A.C.</td>
<td>Build R.C. circuits, applying a variety of frequencies. Measure voltage drops and use oscilloscope display phase relationship between capacitor and resistor.</td>
<td>Analyze R.C. circuits.</td>
<td>(#10), p. 95</td>
</tr>
<tr>
<td>Students will be able to define and calculate inductive reactance for a given circuit.</td>
<td>Inductive Circuits</td>
<td>Students graph inductive reactance versus frequency.</td>
<td>Demonstrate process of A.C. circuit analysis using vectors.</td>
<td>(#10), p. 100</td>
</tr>
<tr>
<td>Students will be able to analyze numerically and vectorally circuits involving resistance and inductive reactance.</td>
<td>Inductive reactance</td>
<td>Build R.L. circuits applying a variety of frequencies, measure voltage drops and display phase relation between inductor and resistor.</td>
<td>Discuss reactance in R.L. circuits and how it is determined.</td>
<td>(#12), p. 191</td>
</tr>
<tr>
<td></td>
<td>Mutual reactance</td>
<td></td>
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<td>(#16), p. 499</td>
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<tr>
<td></td>
<td>Apparent power</td>
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<td></td>
<td>True power</td>
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<td></td>
<td>Power factor</td>
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<td></td>
<td>Vector analysis of R.L. circuits</td>
<td></td>
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<tr>
<td>Students will be able to explain the basic operating principles of the transformer.</td>
<td>Transformers</td>
<td>Using coils and cores indicate affect of coupling of coils.</td>
<td>Show actual transformers to class.</td>
<td>(#12), p. 360</td>
</tr>
<tr>
<td>Students will be able to explain the basic physical construction of transformers.</td>
<td>Mutual inductance</td>
<td></td>
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<td>(#12), p. 205</td>
</tr>
<tr>
<td></td>
<td>Transformer construction</td>
<td></td>
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<td>(#5), p. 106</td>
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<tr>
<td></td>
<td>Primary</td>
<td></td>
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<td>(#10), p. 92</td>
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<tr>
<td></td>
<td>Secondary</td>
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<tr>
<td></td>
<td>Cores</td>
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<tr>
<td>UNIT IX: A.C. CIRCUITS (Continued)</td>
<td>TOPICS</td>
<td>STUDENT ACTIVITIES</td>
<td>TEACHER ACTIVITIES</td>
<td>RESOURCES</td>
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</tr>
</tbody>
</table>
| Students will be able to use turn ratio to analyze transformer circuits. | 1. Ratio: 
   a. turn ratio  
   b. voltage ratio  
   c. current ratio | Solve problem using turn ratio of transformer. | Discuss turn ratio and demonstrate solving problems by turn ratio. | (#12), p. 205 |
| Students will be able to explain how multiple voltage transformers function. | 5. Multi-voltage transformers: 
   a. tapped secondaries  
   b. tapped primary  
   c. multiple secondaries  
   d. multiple primaries  
   e. variable taps  
   f. auto transformers | Discuss how taps split voltage. | Show tapped transformers | (#16), p. 363 |
| Students will be able to give several uses of transformers. | 6. Transformer uses: 
   a. voltage transformation  
   b. isolation  
   c. impedance matching  
   d. signal splitting/inversion  
   e. coupling | | | (#5), p. 108 |
| Students will be able to name the losses of power in a transformer and methods of minimizing power losses. | 7. Power losses/cure: 
   a. coil resistance/over-winding  
   b. eddy currents/laminating  
   c. hysteresis/special alloys | Students calculate then experimentally determine resonant frequency of circuit. | Demonstrate determining resonance. | (#12), p. 212 |
| Students will be able to define and calculate resonant frequency of an LC circuit. | E. Tuned Circuits: 
   1. Resonance | Student build series RLC circuit and examine voltage drops and currents at frequencies above, below, and near resonance. | Discuss performance of circuits | (#16), p. 366 |
| Students will be able to analyze RLC circuits and graph the frequency response curves. | 2. Series tuned circuit: 
   a. impedance  
   b. frequency response  
   c. apparent power  
   d. power factor  
   e. phase angle  
   f. voltage drop  
   g. line currents  
   h. flywheel effect  
   i. Q (figure of merit)  
| | | | | (#10), p. 109 |
### UNIT IXI - A.C. CIRCUITS (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Students will be able to draw the four major filters, explain how each works and sketch the frequency response of each.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>UNIT</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Parallel tuned circuits</td>
<td></td>
<td>Students build parallel RLC circuit and examine voltage drops and currents at frequencies above, near, and below resonant frequency.</td>
<td>Discuss performance of circuit above, below, and near resonant frequency.</td>
<td>(#10), p. 111; (#12), p. 269</td>
</tr>
<tr>
<td>b. Frequency response</td>
<td></td>
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<tr>
<td>d. Bandwidth</td>
<td></td>
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<tr>
<td>e. Phase angle</td>
<td></td>
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<tr>
<td>f. Voltage drops</td>
<td></td>
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<tr>
<td>g. Line currents</td>
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<tr>
<td>h. Figure of merit - Q</td>
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<tr>
<td>6. Filters</td>
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<tr>
<td>a. High pass</td>
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<tr>
<td>b. Low pass</td>
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<tr>
<td>c. Band pass</td>
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<tr>
<td>d. Band reject</td>
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<tr>
<td>5. Combination filters</td>
<td></td>
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</tr>
<tr>
<td>a. Notch filters</td>
<td></td>
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<tr>
<td>b. Crossovers</td>
<td></td>
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<tr>
<td>c. Bypass capacitor filter</td>
<td></td>
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<thead>
<tr>
<th>F. Unit Review</th>
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<tr>
<th>G. Unit Test</th>
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</thead>
</table>

**BEST COPY AVAILABLE**
UNIT X: SEMICONDUCTOR FUNDAMENTALS

INTRODUCTION (PURPOSE/RATIONALE/INTENTION)

This unit is to familiarize the learners with the type of semiconductor materials, applications, and theory of operation.

UNIT GOAL(S)

Students will be given maximum opportunity to identify and select semiconductor materials.

GENERAL UNIT OBJECTIVES

Upon completion of this unit, the learner will be able to name the various types of semiconductor materials and their applications by scoring at least 70 percent to pass.
### Objectives

The learner will be able to understand the importance, advantages and disadvantages of semiconductors.

### Topics

<table>
<thead>
<tr>
<th>A. Semiconductor Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pure semiconductors</td>
</tr>
<tr>
<td>a. carbon</td>
</tr>
<tr>
<td>b. germanium</td>
</tr>
<tr>
<td>c. silicon</td>
</tr>
<tr>
<td>2. Low temperature characterististics</td>
</tr>
<tr>
<td>3. High temperature characterististics</td>
</tr>
<tr>
<td>4. Doping semiconductors</td>
</tr>
<tr>
<td>5. N-type materials</td>
</tr>
<tr>
<td>6. P-type materials</td>
</tr>
<tr>
<td>7. Current in semiconductance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. P-N Junction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Forming junction</td>
</tr>
<tr>
<td>2. Depletion region</td>
</tr>
<tr>
<td>3. Barrier potential</td>
</tr>
<tr>
<td>4. Forward biased</td>
</tr>
<tr>
<td>5. Reverse biased</td>
</tr>
<tr>
<td>6. Avalanche breakdown</td>
</tr>
<tr>
<td>7. Charge carrier recombination</td>
</tr>
</tbody>
</table>

### Student Activities

- Read section covering semiconductor materials through high temperature characteristics.
- Take notes.
- Understand what takes place with doping.
- Be able to distinguish the difference between N-type and P-type.
- Read material covering this section.
- Take notes.

### Teacher Activities

- Lecture
- Read material covering this section.
- Take notes.

### Resources

- (21), pp. 1-10 to 1-20
- (21), pp. 17-20
- (21), pp. 2-5 to 2-13
**UNIT XII: ELECTRONIC DEVICES**

**INTRODUCTION**
(PURPOSE/RATIONALE/INTENTION)

This unit is designed to familiarize the student in semiconductor devices and typical circuit applications.

The emphasis should be placed upon typical applications and actual circuit operation rather than the process of circuit design.

As this area is ever changing the teacher is encouraged to add material whenever it is appropriate.

**UNIT GOAL(S)**

The goal of this unit is to present to the student the area of semiconductor devices and their applications.

Upon the completion of this unit the student will be able to:

- Name several types of diodes, explain their operation and state a typical use of each.
- Construct circuits using diodes such as power supplies and voltage multipliers.
- Explain the operation of diode circuits.
- Name two types of bipolar transistors and explain the operating theory of each.
- Name three types of field effect transistors and explain the operating theory of each.
- Name four different circuit types and the basic characteristics of each.
- Explain the operating parameters of transistor circuits.
- Construct basic small signal amplifiers from given circuit diagram.
- Name several biasing and stabilizing methods for transistor amplifiers.
- Name three thyristor devices, explain their operation and give applications for each.
- Construct thyristor circuits to specifications.
- Demonstrate an understanding of device rating and physical packaging designs.
- Briefly explain fabrication of integrated circuits.

**GENERAL UNIT OBJECTIVES**
**GENERAL UNIT OBJECTIVES**

Construct simple circuits using I.C.'s to specifications.
Name several uses of I.C.'s.
Name several uses of operational amplifiers.
Construct op-amp circuits to specifications.
Name several opto-electrical devices and applications of each.

<table>
<thead>
<tr>
<th>UNIT GOAL(S)</th>
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</table>

**UNIT XI: ELECTRONIC DEVICES (Continued)**

**INTRODUCTION**
(PURPOSE/RATIONALE/INTENTION)

<table>
<thead>
<tr>
<th>UNIT GOAL(S)</th>
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</table>
## UNIT XII: ELECTRONIC DEVICES

### OBJECTIVES

- **20 hours**

#### STUDENT ACTIVITIES

- **Construct circuit using diode and measure voltage drops and current in forward bias, reverse bias, and with AC applied.**
- **Students use ohmmeter to test diodes.**
- **Construct series circuit with resistor and zener diode and examine the operation characteristics.**
- **Use curve tracer to display characteristic curve of each type.**
- **Show actual diodes and markings—use manufacturers data sheets as source of rating information.**
- **Construct rectifier circuits; display outputs on oscilloscope.**

#### TEACHER ACTIVITIES

- **Display characteristic curve on curve tracer if available.**
- **Use curve tracer to display characteristic curve of each type.**
- **Show actual diodes and markings—use manufacturers data sheets as source of rating information.**
- **Construct rectifier circuits; display outputs on oscilloscope.**

### TOPICS

<table>
<thead>
<tr>
<th>A. Diodes</th>
<th>1. Characteristics of diode</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. reverse bias</td>
<td></td>
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<tr>
<td>b. leakage</td>
<td></td>
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<tr>
<td>c. breakdown voltage</td>
<td></td>
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<tr>
<td>d. forward bias</td>
<td></td>
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<tr>
<td>e. turn on voltage</td>
<td></td>
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<tr>
<td>f. forward bias current</td>
<td></td>
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<td>g. dynamic resistance</td>
<td></td>
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<td>h. characteristic curve</td>
<td></td>
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<tr>
<td>i. testing diodes—ohmmeter</td>
<td></td>
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<tr>
<td>j. recombination of carriers</td>
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</table>

<table>
<thead>
<tr>
<th>2. Types of diodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. rectifier</td>
</tr>
<tr>
<td>b. switching</td>
</tr>
<tr>
<td>c. zener</td>
</tr>
<tr>
<td>d. light emitting diode</td>
</tr>
<tr>
<td>e. crystal diode</td>
</tr>
<tr>
<td>f. selenium diode</td>
</tr>
<tr>
<td>g. schematic symbols</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. peak inverse voltage</td>
</tr>
<tr>
<td>b. forward bias current</td>
</tr>
<tr>
<td>c. zener voltage</td>
</tr>
<tr>
<td>d. power dissipation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Cathode markings</th>
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</thead>
<tbody>
<tr>
<td>a. half-wave rectifier</td>
</tr>
<tr>
<td>b. full-wave rectifier</td>
</tr>
<tr>
<td>c. bridge rectifier</td>
</tr>
<tr>
<td>d. diode clipper</td>
</tr>
<tr>
<td>e. diode clamper</td>
</tr>
</tbody>
</table>

### RESOURCES

- (31).p. 18
- (14).p. 178
- (10).p. 210
- (16).p. 630
- (6).pp. 179, 192
- (31).p. 23
- (4).p. 298
- (31).p. 31
## Unit XI: Electronic Devices (Continued)

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Topics</th>
<th>Student Activities</th>
<th>Teacher Activities</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student will be able to name several methods of filtering and regulating D.C. power supplies.</td>
<td>6. Diode packaging</td>
<td>Connect different filter circuits to rectifier network—observe effect on output waveform.</td>
<td>Indicate process of determining percent ripple—discuss method of eliminating ripple.</td>
<td>(15), p. 101</td>
</tr>
<tr>
<td></td>
<td>7. Filtering</td>
<td>a. capacitor</td>
<td>(31), p. 37</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>b. R-C filter</td>
<td>(4), p. 486</td>
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<td></td>
<td></td>
<td>c. L-C filter</td>
<td>(10), p. 293</td>
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<tr>
<td></td>
<td>8. Regulation</td>
<td>a. bleeder resistor</td>
<td>Indicate process of determining percent ripple—discuss method of eliminating ripple.</td>
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<tr>
<td></td>
<td></td>
<td>b. Zener diode</td>
<td>(31), p. 43</td>
<td></td>
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<td></td>
<td></td>
<td>c. I.C. regulations</td>
<td>(4), p. 491</td>
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<td>d. transistor regulator</td>
<td>(25), p. 186</td>
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<td>9. Voltage multiplier</td>
<td>a. half-wave doubler</td>
<td>Construct voltage doublers.</td>
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<td>b. full-wave doubler</td>
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<td>c. triplers</td>
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<td></td>
<td></td>
<td>d. use of multipliers</td>
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<td></td>
<td>10. Voltage converters</td>
<td>a. DC to AC inverters</td>
<td>Discuss DC voltage conversion methods and uses.</td>
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<td></td>
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<td>b. DC to DC converters</td>
<td>(45), p. 254</td>
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<td></td>
<td></td>
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<td>(4), p. 501</td>
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<td>Draw simplified diagram on board to aid in explanation.</td>
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<td>11. Transistors</td>
<td>Use overhead or board to show how produced.</td>
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<td></td>
<td>1. Bipolar transistors</td>
<td>a. regions</td>
<td>Show several types of case styles.</td>
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<td></td>
<td></td>
<td>b. doping levels</td>
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<td>c. lead currents</td>
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<td>d. biasing junctions</td>
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<td>e. back injection</td>
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<td>f. current gain</td>
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<td>2. Types of bipolar transistors</td>
<td>a. NPN</td>
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<td>b. PNP</td>
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<td>3. Fabrication techniques</td>
<td>a. regions</td>
<td></td>
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<td>b. grown junction</td>
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<td>c. alloy junction</td>
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<td>d. epitaxial base</td>
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<tr>
<td>OBJECTIVES</td>
<td>TOPICS</td>
<td>STUDENT ACTIVITIES</td>
<td>TRAINER ACTIVITIES</td>
<td>RESOURCES</td>
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<tr>
<td>Name and draw diagram on the three basic transistor circuits.</td>
<td>4. Transistor Circuits</td>
<td>Draw circuit configurations on board. Give examples of where each is used.</td>
<td>Resources: (10), p. 220 (31), p. 60</td>
<td></td>
</tr>
<tr>
<td>Students will be able to read listing of transistor operating parameters, interpret the information and apply information to actual circuits.</td>
<td>3. Operating parameters</td>
<td>Read manufacturers data sheets and interpret.</td>
<td>Resources: (31), p. 64 (8), p. 98</td>
<td></td>
</tr>
<tr>
<td>Students will be able to define cut-off and saturation as they apply to transistors.</td>
<td>6. Transistor data</td>
<td>Discuss use of data in designing circuits. Discuss sources of this data.</td>
<td>Resources: (31), p. 64 (8), p. 98</td>
<td></td>
</tr>
<tr>
<td>Students will be able to test transistor to determine if it is good with transistor tester or ohmmeter.</td>
<td>7. Operating ranges</td>
<td>Demonstrate the use of each to entire class.</td>
<td>Resources: (31), p. 67 (8), p. 102</td>
<td></td>
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<tr>
<td>Students will be able to define gain of an amplifier.</td>
<td>8. Transistor testing</td>
<td></td>
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<tr>
<td>Students will be able to build from a schematic basic amplifier circuits and test each for gain and phase relationship.</td>
<td>Transistor Amplifier Circuits 1. Gain</td>
<td>Build and test basic amplifier circuits.</td>
<td>Resources: (31), p. 77 (8), p. 210 (16), p. 639</td>
<td></td>
</tr>
</tbody>
</table>
# UNIT 31: ELECTRONIC DEVICES (Continued)

## OBJECTIVES

Student will be able to define biasing and use load lines on characteristic curves to determine biasing network.

Name methods of coupling multi-stage amplifiers, the advantages and disadvantages of each.

Students will be able to name the classes of amplifiers and give the approximate biasing points and uses of each.

Briefly explain the use of the transistor as a switch or indicator/relay driver.

Students will be able to explain the construction of the silicon-controlled rectifier and its operation in a circuit.

## TOPICS

### Biasing method
- load line
- quiescent point
- feedback method
- voltage divider method
- bias stabilization method

### Coupling methods
- capacitor
- transformer
- direct
- Darlington pair transistors

### Feedback

### Distortion

### Amplifier classes
- class A
- class B
- class AB
- class C

### Switching and driver circuits
- single transistor
- common emitter drivers
- Darlington drivers
- switching speeds
- emitter follower drivers and switches

### Thyristors
- Silicon-controlled rectifier
  - construction
  - terminals
  - symbol
  - volt-ampere characteristics
  - circuit connection
  - DC operation
  - AC operation
  - testing with ohmmeter
  - ratings

### Student Activities

- Use characteristic curves and load line to determine operating range.

- Discuss which would be best method under various conditions such as small signal, audio work, high frequency, signal splitting, etc.

- Construct transistor relay or lamp driver circuits.

- Construct silicon-controlled rectifier or SCR light dimmer circuit.

- Tent response of SCR in circuit.

- Draw construction on board.

- Show actual SCR's.

- Draw volt-ampere characteristics on board or use curve tracer.

## TEACHER ACTIVITIES

- Use class discussion.

- Discuss use of each class.

- Draw construction on board.

## RESOURCES

- (31), p. 83
- (5), p. 212
- (16), p. 651
- (31), p. 97
- (31), p. 115
- (31), p. 191
- (31), p. 237
- (8), p. 232
- (4), p. 258
**UNIT XI: ELECTRONIC DEVICES (Continued)**

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student will be able to name applications of the silicon-controlled rectifiers.</td>
<td>SCR applications&lt;br&gt;a. switching&lt;br&gt;b. wave shaping</td>
<td>Construct TRIAC controlled light dimmer/motor speed control.</td>
<td>Draw construction of TRIAC on board.</td>
<td>(88), p. 229</td>
</tr>
<tr>
<td></td>
<td>SCR applications&lt;br&gt;a. switching&lt;br&gt;b. wave shaping</td>
<td></td>
<td>Show actual TRIAC's.</td>
<td>(31), p. 241</td>
</tr>
<tr>
<td>Explain the construction of the TRIAC and its operation in the circuit.</td>
<td>3. TRIAC&lt;br&gt;a. construction&lt;br&gt;b. terminals&lt;br&gt;c. symbols&lt;br&gt;d. volt-ampere characteristics&lt;br&gt;[e. circuit]</td>
<td></td>
<td>Draw volt-ampere characteristics on board or use curve tracer.</td>
<td>(84), p. 261</td>
</tr>
<tr>
<td></td>
<td>Unijunction transistor and its operation in the circuit.</td>
<td>4. DIAC&lt;br&gt;a. construction&lt;br&gt;b. terminals&lt;br&gt;c. symbols&lt;br&gt;d. volt-ampere characteristics&lt;br&gt;[e. circuit]</td>
<td>Draw DIAC construction on board.</td>
<td>(80), p. 242</td>
</tr>
<tr>
<td>Explain the construction of the unijunction transistor and its operation in the circuit.</td>
<td>5. Unijunction transistor&lt;br&gt;a. construction&lt;br&gt;b. terminals&lt;br&gt;c. symbols&lt;br&gt;d. volt-ampere characteristics&lt;br&gt;[e. circuit]</td>
<td>Construct unijunction relaxation oscillator circuit to exhibit operating characteristics.</td>
<td>Draw unijunction construction on board.</td>
<td>(88), p. 243</td>
</tr>
<tr>
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<td>Show actual DIAC's to class.</td>
<td>(31), p. 244</td>
</tr>
<tr>
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<td></td>
<td>Draw DIAC volt-ampere characteristics on board or use curve tracer to display.</td>
<td>(88), p. 265</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Show actual unijunction operating characteristics on board or use curve tracer to display.</td>
<td>(31), p. 72</td>
</tr>
</tbody>
</table>
**OBJECTIVES**

Students will be able to briefly describe the fabrication of integrated circuits.

Student will be able to use manufacturers' data to properly connect I.C.'s in a circuit.

---

**TOPICS**

E. **Integrated Circuits**

1. Fabrication of circuits
   - photo lithography
   - preparing silicon disc
   - fabricating diodes and transistors
   - fabrication of resistor
   - fabrication of capacitors
   - probe testing
   - packaging

2. Integration types
   - monolithic I.C.
   - thin film
   - hybrid I.C.
   - thick film
   - moderate scale integration
   - large scale integration
   - DQSY and TTL characteristics

3. Package styles
   - flat pack
   - dual in-line-DIP
   - TO style
   - pin determination

4. I.C. circuit construction
   - pin numbering
   - supply voltage
   - ground pins
   - unused pins
   - I.C. sockets

---

**STUDENT ACTIVITIES**

- Develop handout on fabrication techniques.
- Discuss integration levels as a function of semiconductor technology—point out historical references.
- Show students package styles with example I.C.'s.
- Give handout to students indicating pin numbering system, supply voltage, and special handling considerations of different I.C.'s.
<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to name several applications of integrated circuits.</td>
<td>5. Analog I.C.'s a. amplifier b. oscillator c. timers d. voltage regulators e. phase-lock loops</td>
<td>Students build I.C. controlled square-wave generator.</td>
<td>Students build I.C. L.E.D. flasher.</td>
<td>Heath: Electronics Circuits, Exp. #6 similar.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Build active filter circuit using op-amps. Heathkit #8 (Electronics circuits.)</td>
<td>Use curve tracer to display volt-ampere characteristics of thermistors.</td>
<td>(#10), p. 395</td>
</tr>
<tr>
<td></td>
<td>8. Operational amplifiers a. differential amplifier b. split power supplies c. operating characteristics d. circuit connections e. operational amplifier applications f. summing and integrating amplifiers</td>
<td></td>
<td></td>
<td>(#5), p. 49</td>
</tr>
</tbody>
</table>
UNIT XI: ELECTRONIC DEVICES (Continued)

### OBJECTIVES

Student will be able to name several types of optoelectric devices, explain briefly their operation, and give application of each.

### TOPICS

G. Optoelectric Devices
1. Definition
2. General uses
   - isolation of circuits
   - communication
   - safety
   - counting and reading
   - light level controls
   - lower distortion
3. Light-activated silicon controlled rectifier
4. opto-isolators
5. infra-red LED
6. photoresistors
7. photo diodes
8. LED
9. laser

### STUDENT ACTIVITIES

H. Unit Review

I. Unit Test

### TEACHER ACTIVITIES

### RESOURCES

(10), p. 426
(84), p. 263
(31), p. 245
**UNIT XI: CIRCUIT FABRICATION**

**INTRODUCTION**
(PURPOSE/RATIONALE/INTENTION)

The purpose of this unit is to provide students with a working knowledge of fabrication techniques and in the process of making printed circuit boards and other type circuit construction.

**UNIT GOAL(S)**

- The student should be able to identify and select the processes and materials in making a printed circuit board.

**GENERAL UNIT OBJECTIVES**

Upon completion of this unit the learner will be able to demonstrate knowledge of the processes, techniques, and safety practices used in making printed circuit boards, by scoring at least 70 percent on unit test to pass.
UNIT XII: CIRCUIT FABRICATION

2 hours

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upon completion of this unit the learner will be able to list the processes, techniques, and safety practices used in the making of a printed circuit board.</td>
<td>A. Schematic Diagrams</td>
<td>Set up a simple circuit on a breadboard and be able to complete the following: Trace a signal flow through the circuit. Pass out sheet(s) with schematic components and supplies.</td>
<td>(77), p. 11-14</td>
<td></td>
</tr>
<tr>
<td>The learner will be able to understand electronic components and their symbols in electronic schematic diagrams.</td>
<td>1. Understanding electrical and electronic symbols</td>
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<td>2. Identify symbols</td>
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<td></td>
<td>3. Breadboarding</td>
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</table>

Note: They bear little resemblance in location to the wires in the actual circuit. The schematic usually "proceeds" from left to right following the current flow. The schematic identifies each component by a letter and number, such as R1, R2, C1, and so on, for reference purposes. Values of the components are shown on the schematic, but no other labeling is used.
<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
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<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
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</thead>
<tbody>
<tr>
<td>The learner should be able to identify the materials involved in a PC board.</td>
<td>B. Printed Circuit Boards</td>
<td>List and describe each of the different types of circuit boards.</td>
<td>Display different types of PC Boards.</td>
<td>(14), pp. 5-20 to 5-22</td>
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<tr>
<td></td>
<td>1. Materials</td>
<td></td>
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<td></td>
<td>a. copper electroplating</td>
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<td></td>
<td>b. gold plating</td>
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<td></td>
<td>c. tin-lead plating</td>
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<td></td>
<td>d. tin-nickel plating</td>
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<td>2. Printing</td>
<td>Given a PC board the student will be able to go through the proper steps in cleaning it.</td>
<td>Demonstrate steps involved in cleaning a PC board.</td>
<td>(20), pp. 1-38</td>
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<td>a. PC board cleaning: industry related cleaning procedures</td>
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<td></td>
<td>(1) chemical cleaning</td>
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<td>(2) degreasing</td>
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<td>(3) acid dipping</td>
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<td>b. photore sist</td>
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<td>(1) negative acting</td>
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<td>(2) positive acting</td>
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<td>c. silk screen printing</td>
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<td>(1) screen preparation</td>
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<td>(2) screen inks</td>
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<td>(3) problems</td>
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<td>d. contact print</td>
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<td>e. rub-off transfer</td>
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<td>f. etch resistant inks</td>
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<td>3. Etching</td>
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<td>a. etching solutions</td>
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<td>(1) cupric chloride</td>
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<td>(2) ammonium persulfate</td>
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<td>(3) ferric chloride</td>
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<td>b. equipment and techniques</td>
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<td>(1) plastic and glass trays</td>
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<td>(2) plastic utensils for stirring</td>
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<td>(3) rock the tray to agitate solution</td>
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</tbody>
</table>

The learner will be able to clean a PC board.

The learner will be able to use one of the following circuit pattern transfer methods. (Note: limited only by equipment available in the lab.)

The learner should be able to set up and etch circuit board.
## UNIT XII: CIRCUIT FABRICATION (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
</table>
| Learner should be able to pass safety test with no less than 100 percent. | c. safety precautions  
(1) rubber gloves  
(2) goggles  
(3) lab coat or apron  
(4) running water | Be able to list all safety precautions. | | |
| Properly use and set up drilling operations. | 4. Drilling  
a. drill type (carbide or high speed)  
b. speed  
c. pressure | Discuss safety using drill and drill sizes. | Give demonstration. | (#20), pp. 5-6 |
| Learner should be able to select and solder proficiently. | 5. Soldering  
1. Rosin core flux  
2. 60/40 ratio (tin to lead mixture)  
3. Contact time between board and component  
4. Cold solder joints | Discuss and practice making good solder joints. | Give demonstration. | (#20), pp. 5-35 to 5-40 |
| Learner should become aware of how and when D and E should be used. | 7. Wire Wrapping  
F. Point-to-Point Wiring  
P. Unit Review  
R. Unit Exam | Discuss and take notes. | Give demonstration. | |
The purpose of this unit is to provide the students with a working vocabulary of terms, equipment, and processes in the use of a microcomputer.

UNIT GOAL(S)

The goal of this unit is to make the learner knowledgeable and be able to interact with microcomputers.

GENERAL UNIT OBJECTIVES

The learner will be able at the completion of this unit to list components, devices, and terms used in microcomputers. A score of at least 70 percent on the unit test is needed to pass.
The learner should be able to understand a block diagram showing how information is processed in a computer.

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>The learner should be able to understand the different types of memory storage devices.</td>
<td>A. History of Computational Machines</td>
<td>Read section in book. Take notes. If computers are present in school, take a look inside one.</td>
<td>Lecture Discuss and show students how information is processed using a block diagram and possibly a microcomputer.</td>
<td>(#22), pp. 334 to 338 (#29), pp. 33-40</td>
</tr>
<tr>
<td>The learner should be able to understand the different types of memory storage devices.</td>
<td>B. Processing information 1. Central processing unit (CPU) 2. Random access memory (RAM) 3. Read only memory (ROM)</td>
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<tr>
<td>The learner will be able to identify accessories, software types and sources.</td>
<td>G. Hardware 1. Mainframe a. Bus concept b. Bus system categories 2. Microcomputer 3. Microprocessor 4. Storage devices a. cassette b. soft disc c. hard disc d. tape e. card reader 5. Input/output devices a. Types of CRT-video monitors (1) black and white (2) green phosphorous (3) color b. keyboard c. printer d. (1) dot matrix (2) daisy wheel (3) continuous band/metal band e. joystick f. voice synthesizer</td>
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</table>

If computers are present in school, take a look inside one. Discuss and show students how information is processed using a block diagram and possibly a microcomputer. Show picture of microprocessor.

- Show student diskettes, punched cards, etc.
- Discuss and relate how all devices work and interrelate.

#15, pp. 23-67

(#11), pp. 27-37

(#15), pp. 16-22
### INTRODUCTION

(Concluded)

### Topics

1. Programming Languages
   - a. BASIC
   - b. Pascal
   - c. FORTRAN
   - d. COBOL
   - e. Assembler

2. Program Logic

3. Software Sources
   - a. Commercial
   - b. User Groups
   - c. Self-generated
UNIT XIV: ROBOTICS: AN INTRODUCTION FOR YOUR CLASSROOM

**INTRODUCTION**
(PURPOSE/RATIONALE/INTENTION)

The purpose of this unit is to make the student aware of the changes being brought about by automation in industry.

Since robotics is in its infancy, there is to date no known textbook covering robotics. Therefore, resources for this unit are made from manufacturers and industrial robotics books.

**UNIT GOAL(S)**

The student should become aware of cybernetics as it relates to industry and be familiar with the concepts involved in robotics.

**GENERAL UNIT OBJECTIVES**

The learner will be able to identify the components of a robot, define this robot's work envelope, know different types of robots and their applications, and understand the socio-economic impact of robots upon society. A score of at least 70 percent on the unit exam is necessary to pass.
### UNIT XIV: ROBOTICS: AN INTRODUCTION FOR YOUR CLASSROOM - 3 hours

**OBJECTIVES**

The learner should be able to define what constitutes a robot and its components.

**TOPICS**

<table>
<thead>
<tr>
<th>A. What is Robotics</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is a robot</td>
<td>Read selected material.</td>
<td>If possible have robotic demonstration in class by a distributor.</td>
<td>(94), p. 1</td>
</tr>
<tr>
<td>2. Components of a robot</td>
<td>Take notes.</td>
<td>Discuss and point out components of a robot using either a robot in class, textbook, visual aids or handouts.</td>
<td>(94), pp. 19-38</td>
</tr>
<tr>
<td>a. manipulator/mechanical unit - mechanical linkages and joints</td>
<td>If possible take field trip to a local industry to see robots in action.</td>
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<td>(1) pneumatic cylinders</td>
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<td>(2) hydraulic cylinders</td>
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<td>(3) electric motors</td>
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<td>b. controller/brain of robot</td>
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<td>(1) control the motion of the manipulator</td>
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<td>(2) store program data in memory</td>
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<td>(3) interface with the equipment with which the robot interacts</td>
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<tr>
<td>c. power source to provide energy for the manipulator's actuators</td>
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<tr>
<td>3. Work envelope</td>
<td>Read selected information.</td>
<td>If possible, use robot visual aid or handout.</td>
<td>(94), p. 42</td>
</tr>
<tr>
<td>a. what it was designed for</td>
<td>If lab is not equipped, do lab activities. If not list and discuss pros, cons, and limitations.</td>
<td>(92), pp. 3-9</td>
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</tr>
</tbody>
</table>
UNIT XIV: ROBOTICS: AN INTRODUCTION FOR YOUR CLASSROOM (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
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</thead>
<tbody>
<tr>
<td>The learner should be able to list and define the types of robots.</td>
<td>Types of Robots</td>
<td>Take notes.</td>
<td>Discuss the different types of robots and where they may be used.</td>
<td>(19), p. 33</td>
</tr>
<tr>
<td></td>
<td>1. Non-servo controlled</td>
<td>Define use of each.</td>
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<td>a. simplest/least expensive</td>
<td>Discuss limitations and applications of each.</td>
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<td>b. responds to a predetermined sequence</td>
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<td>c. has the capacity to respond to changes in manufacturing environment</td>
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<td>2. Servo-controlled</td>
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<td>a. environmentally adaptive</td>
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<td>b. sense devices</td>
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<td>(1) position</td>
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<td>(2) speed</td>
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<td>(3) load</td>
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<td>(4) force</td>
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<td>3. Remote controlled</td>
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<td>a. types</td>
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<td>(1) master-slave unit</td>
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<td>(2) telemetry control</td>
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<td>(3) wire control</td>
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<td>b. application</td>
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<td>(1) environment where human cannot function</td>
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<td>(2) where robot travels great distances</td>
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</table>

The learner should be able to list and compare robotic applications in industry relating it to lab activities within the classroom.

C. Robotic Application

1. Industrial
   a. spot welding
   b. arc welding
   c. material handling
   d. assembly
   e. spray painting

Read, list and discuss robotics in industrial situations.

Introduce industrial applications.

(134), pp. 3-5
UNIT XIV: ROBOTICS: AN INTRODUCTION FOR YOUR CLASSROOM (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
</table>
| 2. Industrial Arts classroom | a. spot welding  
   b. arc welding  
   c. electronic component assembly  
   d. machine loading and unloading  
   e. line production  
   (1) material handling  
   (2) assembly control  
   (3) finishing process  
   (4) quality control  
   (5) research and development  
   (6) metal casting  
   a. pouring  
   b. shake-out  
   c. mold venting  
   (7) other imaginative applications. | Student can become more creative and imaginative if lab is equipped with a robot. Learner can simulate industrial robotic processes. | If possible tie-in the industrial processes with automated application to the classroom. | |
| D. Social Economic Impact | 1. What cybernetics means to industry  
2. Productivity levels | Discuss future implications. | Encourage students to take a serious look into the past, present and future. | |

The learner should be able to list and discuss the implications of robotics to the work place.
**UNIT XVI: INDUSTRIAL ELECTRICITY/ELECTRONICS**

**INTRODUCTION**
(PURPOSE/RATIONALE/INTENTION)

This unit is designed to present to the student information on the industrial applications of electricity and electronics. The unit includes a study of motors and generators, heating devices and methods, lighting and producing chemical reactions. That portion of the unit on producing chemical reaction may be particularly important to students in the petro-chemical corridor of Louisiana.

**UNIT GOAL(S)**

The goal of this unit is to familiarize the students with industrial applications of electricity and electronics.

**GENERAL UNIT OBJECTIVES**

As indicated by a minimum score of 70 percent, upon completion of this unit the student will be able to:

- Name four types of generators and explain how they operate.
- Name several types of motors, their uses and starting methods.
- Read a motor nameplate and gather specific information and apply that information to a specific need.
- Name several methods of producing heat from electricity, and briefly explain each.
- Explain how different lighting systems operate.
- Explain the importance of electrochemical reactions in industry and name several important electrochemical processes used.
<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
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</thead>
<tbody>
<tr>
<td>Student will be able to explain the operating theory of AC generators.</td>
<td>A. Generators</td>
<td>Assemble and test generator demonstrator.</td>
<td>Demonstrate generator effect using magnet or wire coil or</td>
<td>(12).p. 153</td>
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<tr>
<td></td>
<td>2. Inducing voltage and currents</td>
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<td>3. Generating the AC cycle—single loop</td>
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<td>4. Output voltages</td>
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<td>5. Moving field alternators</td>
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<td>6. DC generator</td>
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<td>a. brushes, poles, field coils</td>
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<td>b. commutator action</td>
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<td>c. pulsing DC</td>
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<td>d. lowering ripple</td>
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<td>e. generator construction</td>
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<td>f. split rings and commutator</td>
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<td>7. Types of generators</td>
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<td></td>
<td>a. series generator</td>
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<td>b. shunt generator</td>
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<td>c. compound generator</td>
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<td>d. independently excited generator</td>
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<td>e. generator applications</td>
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<td></td>
<td>B. Motors</td>
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<td></td>
<td>1. DC motors</td>
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<tr>
<td></td>
<td>a. motor action</td>
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<td></td>
<td>b. commutation</td>
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<td>c. counter EMF</td>
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<td>d. current draw</td>
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<td></td>
<td>e. speed</td>
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<td>f. motor starting</td>
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<td></td>
<td>Explain the operating theory of DC generators.</td>
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<td></td>
<td>Name the four different types of generators and normal application of</td>
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<td>each.</td>
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<td>Students will be able to explain the operating theory of DC motors.</td>
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<td>D. Motors</td>
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<td>1. DC motors</td>
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<td>a. motor action</td>
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<td>f. motor starting</td>
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### UNIT XV: INDUSTRIAL ELECTRICITY/ELECTRONICS (Continued)

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
</table>
| Students will be able to explain the operating principles of AC motors. | 2. A.C. motors  
   a. rotating the magnetic field  
   b. inducing rotor voltages  
   c. starting the rotation  
   d. motor force  
   e. centrifugal switches | Operate motor demonstrator on A.C. | | (#10), p. 150 |
| Name several types of motor and an example of their normal applications. | 3. Types of motors  
   a. series DC motor  
   b. compound DC motor  
   c. brushless DC  
   d. split phase AC  
   e. polyphase AC  
   f. synchronous motors  
   g. shaded pole motors  
   h. repulsion inductions  
   i. dual voltage  
   j. linear induction motors | Discuss uses of motors and try to determine type from use. | Give normal or common application for each type named | (#10), p. 150  
  (#6), p. 292  
  (#23), p. 176 |
| Student will be able to identify major parts of the motor. | 4. Motor construction  
   a. poles (stator)  
   b. housing  
   c. bells  
   d. armature (rotor)  
   e. commutators  
   f. centrifugal switch  
   g. bearings  
   h. fan | | Disassemble motor and show parts and how they interact. | |
| Student will be able to read motor plate or information sheets and interpret information. | 5. Motor ratings  
   a. voltage  
   b. current  
   c. horse power  
   d. phase  
   e. cycle  
   f. speed  
   g. temperature rise | Read motor plates and report information. | Discuss motor plates and information found on them. | |
**UNIT XV. INDUSTRIAL ELECTRICITY/ELECTRONICS (Continued)**

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
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</thead>
<tbody>
<tr>
<td><strong>Student will be able to name several types of motor starting systems and examples of their applications.</strong></td>
<td>6. Motor starting systems  a. potentiometers  b. stepped resistors  c. magnetic starters  7. Care and maintenance of motors  a. lubrication  b. cleaning</td>
<td>Wire magnetic starter, to motor or lamp, to indicate hook-up.</td>
<td>Student committee to service motor in lab.</td>
<td>Use high voltage transformer to indicate heat and light aspects of electric arcs.</td>
</tr>
<tr>
<td><strong>Student will be able to explain resistance heating and name several applications.</strong></td>
<td>C. Resistance Heating  1. Resistance heaters  a. radiant  b. infrared  2. Welding  a. arc welding  b. spot welding  3. carbon arc  a. furnaces  b. lamps  c. welding</td>
<td>Wind heating coil of nichrome wire and test.</td>
<td>Discuss greasing, cleaning, oiling parts, and thermal overload protection.</td>
<td>Use microwave oven as example of high frequency heating.</td>
</tr>
<tr>
<td><strong>Student will be able to explain several uses of electricity to produce chemical reactions.</strong></td>
<td>D. Electrochemical Production by Electrolysis  1. Oxygen  2. Hydrogen  3. Chlorine</td>
<td>Produce oxygen and hydrogen by electrolysis of water. Caution: Hydrogen is flammable. Students metal plate small objects.</td>
<td>Discuss importance of these processes to industry and society.</td>
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</tr>
<tr>
<td><strong>Students will be able to explain the different aspects of high frequency heating and give examples of their uses.</strong></td>
<td>E. High Frequency Heating  1. Induction heating  2. Microwave heating  3. Dielectric heating</td>
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</table>
### Objectives

Students will be able to explain the methods used to produce light.

### Topics

<table>
<thead>
<tr>
<th></th>
<th>Electric lighting</th>
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</thead>
<tbody>
<tr>
<td>F.</td>
<td>1. Incandescent lamps</td>
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<td>2. Ionized noble gases</td>
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<td>a. neon</td>
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<td>b. argon</td>
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<td>c. xenon</td>
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<td>3. Ionized metal vapor</td>
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<td>a. fluorescent</td>
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<td>b. black light</td>
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<td>4. Metal vapor-arc lamps</td>
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</tbody>
</table>

### Student Activities

- Student use neon bulb to construct relaxation oscillator.
- Demonstrate turn-on voltage and current response of glow lamps using neon bulb.

### Resources

- (+1), p. 260
- (+1), p. 62
<table>
<thead>
<tr>
<th>UNIT XVI: CARRERS</th>
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</thead>
<tbody>
<tr>
<td><strong>INTRODUCTION</strong></td>
</tr>
<tr>
<td>(PURPOSE/RATIONALE/INTENTION)</td>
</tr>
<tr>
<td>As industrial arts is to aid in vocational selection by the student it is important that the student be provided career information. This unit is designed to provide such information. The teachers should feel free to incorporate this unit at any point in the course that is practical.</td>
</tr>
<tr>
<td>OBJECTIVES</td>
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<tr>
<td>Student will be able to name several occupations related to the Electricity/Electronics and state sources of further information on these occupations.</td>
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</tbody>
</table>
### OBJECTIVES

<table>
<thead>
<tr>
<th>TOPICS</th>
<th>STUDENT ACTIVITIES</th>
<th>TEACHER ACTIVITIES</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. Construction Electrician</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1. Industrial</td>
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<td>2. Commercial</td>
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<tr>
<td>3. Residential</td>
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<td></td>
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<tr>
<td>G. Maintenance Electricians</td>
<td></td>
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<td></td>
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<tr>
<td>H. Broadcasting</td>
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<td>2. Technical school</td>
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<tr>
<td>3. University</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>J. Sources of Information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Government agencies</td>
<td></td>
<td></td>
<td></td>
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<td>2. Companies</td>
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<tr>
<td>3. Unions</td>
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Demonstrate use of occupational outlook handbook and other sources.
APPENDIX 1
SAMPLE TESTS
Unit I—Electricity/Electronic Safety
Sample Test (Review)

I. Multiple Choice: For each item below, select the one best answer. Then write the letter that represents your choice on the line to the left of each item.

1. You should wear suitable eye protection
   A. to improve your vision
   B. to avoid myopia
   C. when engaged in any activity where hazards may exist
   D. to improve your appearance

2. Jewelry
   A. should never be worn in the electrical/electronics shop
   B. should all be removed when working in the shop except rings
   C. should be worn to improve your appearance
   D. can be worn if the student wishes

3. What factors determine how much current will flow through the human body?
   A. The amount of volts in the line
   B. The length of time you are connected
   C. The resistance of the body and whether the skin is moist or dry
   D. The strength of the person and his/her age

4. Some typical electrical shock hazards are
   A. wearing rubber sole shoes
   B. using the wrong extension cord
   C. working in low voltage area
   D. working around worn insulation

5. A safe distance for operating around live circuits 3,501 to 11,000 volts is
   A. three feet
   B. two feet
   C. one foot
   D. one-half foot

6. To control fires associated with electrical equipment and facilities, the extinguishing agent must be a nonconductor of electricity and provide a smothering effect. How is this type of fire classified?
   A. C
   B. D
   C. A
   D. B

7. In marking physical hazards, "caution" identification of high voltages at machinery is done by which of the OSHA color codes.
   A. Purple
   B. Red
   C. Green
   D. Yellow
Unit 1 Sample Test (Continued)

8. What work is done with side-cutting pliers?
   A. Use for cutting very soft wire
   B. Use for cutting heavier wire
   C. Use for forming loops at the end of wires
   D. Bending wire lugs

9. The path to ground is permanent and continuous so that the path has ample
current-carrying capacity. This is
   A. a live circuit
   B. a poor ground
   C. a good ground
   D. none of these

10. The ohmmeter should
    A. never be connected to a source with power
    B. always connected in parallel
    C. always connected in series
    D. any of the above
Unit I -- Electricity/Electronic Safety
Test Key

C 1.
A 2.
C 3.
D 4.
B 5.
A 6.
D 7.
B 8.
C 9.
A 10.
Unit II--Math Review
Sample Test

1. \( \frac{1}{10} + \frac{1}{8} + \frac{1}{40} = \)

2. \( \frac{2}{3} + \frac{6}{7} - \frac{4}{21} = \)

3. \( \frac{4}{9} + \frac{2}{3} = \)

4. \( \frac{3}{2} - \frac{1}{4} - \frac{2}{6} = \)

5. \( 2 \cdot \frac{5}{8} \div \frac{1}{4} = \)

6. \( \frac{6}{13} \div \frac{8}{39} = \)

7. \( \frac{836}{x79} \)

8. \( \frac{6.95}{x086} \)

9. \( \frac{5.26}{x3.5} \)

10. \( 2.5 \sqrt{53.25} \)

11. \( 16 \sqrt{228} \)

Express in scientific notation:

12. \( 186,000 = \)

13. \( 3,462,000,000 = \)

14. \( .0000056 = \)

15. \( .00102 = \)

Express as decimal numbers:

16. \( 3.26 \times 10^8 = \)

17. \( 4.71 \times 10^{-8} = \)

18. \( 1.346 \times 10^6 = \)

Make the following conversions as indicated.

19. \( 34600 = \)

20. \( 3.64 \text{ uni} = \)

21. \( 11.6 \text{ K} = \)

22. \( 1.43 \text{ M} = \)

23. \( 150,000,000 = \)
Unit II—Sample Test (Continued)

Solve the following equations for E.

24. \(3E = 16\) \(\Rightarrow E = \frac{16}{3}\)

25. \(\frac{E}{5} = 56\) \(\Rightarrow E = 280\)

26. \(2E = 36 + E\) \(\Rightarrow E = 36\)

27. \(V = \frac{ER}{R + S}\)

28. \(1.26 \times 10^3 + 1.4 \times 10^4 = \ldots\)

29. \(\sqrt{625} = \ldots\)

30. \(\sqrt{144 \times 10^{-3}} = \ldots\)
Unit II--Math Review
Test Key

1. \( \frac{1}{4} \)
2. \( \frac{4}{3} \)
3. \( \frac{10}{9} \)
4. \( \frac{1}{8} \)
5. \( \frac{5}{3} \)
6. \( \frac{9}{4} \)
7. 66044
8. 597.70
9. 18.41
10. 21.3
11. 14.25
12. \( 1.86 \times 10^5 \)
13. \( 3.462 \times 10^9 \)
14. \( 5.5 \times 10^{-6} \)
15. \( 1.02 \times 10^{-3} \)
16. 326,000,000
17. 0.0000000471
18. 1,346,000
19. 24.6 K
20. 0.00000364 N
21. 11,600 \( \Omega \)
22. 1,430 K \( \Omega \)
23. 150,000 K V
24. \( \# = 5.333 \)
25. \( \# = 280 \)
26. \( E = 36 \)
27. \( E = \frac{V R + VS}{R} \)
28. \( 15.26 \times 10^3 = 1.526 \times 10^4 \)
29. 25
30. \( 3.88 \times 10^{-2} \)
Unit III--Nature of Electricity
Sample Test (Review)

Name: ____________________________________________
Class: ____________________________________________
Date: _____________________________________________

I. Multiple Choice: "For each item below select the one best answer. Then write the letter that represents your choice on the line to the left of each item. Fill in the blank for 16 through 20.

   1. The basic material that makes up all matter is the
      A. atom
      B. element
      C. electron
      D. proton

   2. The smallest unit of matter that still retains the structure of the element is
      A. proton
      B. element
      C. neutron
      D. atom

   3. An atom that has lost an electron is called
      A. positive ion
      B. negative ion
      C. neutral atom
      D. no of these

   4. Particles with like charges will repel each other, particles with unlike charges will attract each other. What law of principle is this?
      A. Ohm's Law
      B. Electrostatic field
      C. Law of electrical charges
      D. EMF

   5. The outer part of the nucleus with a negative charge is
      A. electron
      B. neutron
      C. proton
      D. atom

   6. Material that has a large number of free electrons is called
      A. insulators
      B. terminals
      C. conductors
      D. atoms
Unit III—Sample Test (Continued)

7. Which is the best conductor for electricity?
   A. Copper
   B. Aluminum
   C. Glass
   D. Silver

8. A material with few free electrons is called a/an
   A. insulator
   B. terminal
   C. conductor
   D. proton

9. Which is not an insulating material?
   A. Dry wood
   B. Rubber
   C. Wire
   D. Glass

10. Capacitors make it possible to store electric energy. Electrons held in store are also known as
    A. insulating
    B. electrical potential
    C. semi-conducting

11. Holding back or impeding the movement of electrons along a conductor is known as
    A. temperature
    B. material
    C. resistance
    D. semi-conductor

12. The relationship of voltage, current, and resistance to each other is covered by a set of basic electrical principles known as
    A. Ohm's Law
    B. Kirchoff's Law
    C. EMF
    D. Law of charges

13. The equation for voltage (emf) is:
    A. \( I = \frac{E}{R} \)
    B. \( R = \frac{E}{I} \)
    C. \( E = I \times R \)
Unit III--Sample Test (Continued)

14. The equation for current is:
   A. \( E = I \times R \)
   B. \( R = \frac{E}{I} \)
   C. \( I = \frac{E}{R} \)

15. The equation for resistance is:
   A. \( E = I \times R \)
   B. \( R = \frac{E}{I} \)
   C. \( I = \frac{E}{R} \)

16. The rate of doing work is called ________________________

17. The rate in which weight is moved is ________________________

18. Electric power is measured in ____________________________

19. The basic formula for determining power in watts is ____________________________

20. There are how many watts in a kilowatt? ____________________________
Unit III—Nature of Electricity
Test Key

1. B - Element
2. D - Atom
3. A - Positive ion
4. C - Law of electrical charges
5. A - Electron
6. C - Conductors
7. D - Silver
8. A - Insulator
9. C - Wire
10. B - Electrical Potential
11. C - Resistance
12. A - Ohm's Law
13. C - \( E = I \times R \)
14. C - \( I = \frac{E}{R} \)
15. B - \( R = \frac{E}{I} \)

16. Power
17. Horsepower
18. Watts
19. \( P = E \times I \)
20. 1000 W
Unit IV---Meters and Measuring
Sample Test

Read and record the resistance on the ohmmeter scale above.

1. Function switch in the R X 1 position. Needle is pointing to "B" on the scale.

2. Function switch in the R X 10,000 position. Needle is pointing to "C" on the scale.

3. Function switch in the R X 100 position. Needle is pointing to "B" on the scale.

4. Function switch in the R X 10,000 position. Needle is pointing to "E" on the scale.

5. Function switch is in the R X 100 position. Needle is pointing to "E" on the scale.
Read and record the voltage of voltmeter.

6. Range switch in the 1000V position. Needle is pointing to "F" on the scale.
7. Range switch in the 50V position. Needle is pointing to "F" on scale.
8. Range switch in the 250V position. Needle is pointing to "D" on the scale.
9. Range switch in the 2.5V position. Needle is pointing to "D" on the scale.
10. Range switch in the 2.5V position. Needle is pointing to "F" on the scale.
Unit IV--Meters and Measuring
Test Key

1. 3 ohms
2. 70,000 ohms
3. 300 ohms
4. 130,000 ohms
5. 130 ohms
6. 4.5V x 100 = 450V
7. 22.5V
8. 225V
9. 2.25V
10. 1.125V
Multiple Choice: Select the one best answer and write the letter that represents it on the line to the left of each item.

1. What is the AC voltage produced at a generating station?
   A. 186,000V
   B. 4,000V
   C. 132,000V
   D. 13,200V

2. What is the voltage at which electricity is delivered to the home?
   A. 186,000V
   B. 2,300V
   C. 240V
   D. 13,200V

3. Once electricity passes the meter, it is hooked up to a
   A. branch circuit
   B. distribution panel
   C. service drop
   D. service head

4. Most laws or regulations covering the wiring of houses are based on
   A. Underwriters Laboratories, Inc.
   B. Canadian Standards
   C. New York Board
   D. National Electrical Code

Matching: Match the tools to their common uses by selecting the letter of the tool to match your choice on the line to the left of each item.

A. Lineman's pliers
B. Long nose pliers
C. Adjustable wire strippers
D. Multi-purpose tool
E. Soldering gun (pencil)
F. Ammeter
G. EMT bonder
H. Volt ohmmeter
I. Drill motor
J. Fish tape

5. (a) Forming small conductors (b) holding and pulling on conductors (c) cutting conductors
6. (a) Stripping insulation from conductors (b) cutting conductors (c) forming conductors
7. Boring holes for cables or conduits when electricity is available
8. (a) Checking circuit amperage (b) checking individual load amperage (c) checking motor starting and running current
Unit V - Sample Test (Continued)

9. (a) Stripping insulation (b) use to crimp terminals (c) cutting small bolts

10. Bending EMT

11. (a) Pulling wires or cables through EMT or pipe (b) pull cables up insulated walls

12. (a) Cutting cables and conductors (b) cutting screws (c) forming large conductors (d) pulling and holding conductors

13. (a) Splicing conductors (b) splicing soldered conductors

14. (a) Measuring circuit voltages (b) measuring circuit resistance (c) checking for circuit voltage

True-False: If you believe the statement is true, circle "T". If you believe it is false, circle "F".

T F 15. Single pole switches are used to turn lights on and off in one place.

T F 16. Three-way switches are used to turn lights on and off in two places.

T F 17. Romex cables are available with two or three wires and a bare ground wire.

T F 18. Flexible conduit and rigid conduit is bent with a tool called a conduit bender.

T F 19. Only two large appliances should be on one circuit. Example: range, dryer a dishwasher.

T F 20. Most electrical boxes are nailed to the stud to hold them in place.
Unit V--Residential Electricity

Test Key

1. D - 13,200V
2. C - 240V
3. B - Distribution panel
4. D - National Electrical Code
5. B - Long nose pliers
6. C - Adjustable
7. I - Drill motor
8. F - Ammeter
9. D - Multi-purpose tool
10. G - EMT bender
11. J - Fish tape
12. A - Lineman’s pliers
13. E - Soldering gun (pencil)
14. H - Volt ohmmeter
15. True
16. True
17. True
18. False
19. False
20. True
1. State Kirchoff's Current Law

2. State Kirchoff's Voltage Law

3. Define dielectric material

4. Name 4 types of capacitors

5. \( 0.005 \text{uf} = \) \( \text{pf} \)

6. Define working voltage

7. Calculate the time constant of an R.C. circuit with a 1.2 \( \text{uf} \) capacitor and 100k\( \Omega \) resistor.

8. Define series circuit

9. Calculate the total capacitance:

\[
\begin{array}{c}
\text{10 uF} \\
\text{30 uF}
\end{array}
\]

10. Give the formula for equivalent resistance in parallel.

Solve for each of the indicated quantities.

11.

\[
\begin{array}{c}
\text{9.2 k\( \Omega \)}} \quad \text{1.8 k\( \Omega \)} \\
\text{E}_{R_1} \\
\text{10 V.}
\end{array}
\]

\[
E_{R_1} = \quad \text{\( R_{\text{eq}} \) =}
\]

12.

\[
\begin{array}{c}
\text{20 V} \\
\text{100\( \Omega \)} \\
\text{470\( \Omega \)} \\
\text{220\( \Omega \)}
\end{array}
\]

\[
R_{\text{eq}} = \quad I = \quad P_{470\( \Omega \)} =
\]

106
13. \[ R_{\text{eq}} = \frac{60\Omega}{120\Omega + 600\Omega + 280\Omega} \]

14. \[ R_{\text{eq}} = \frac{10\Omega}{10\Omega + 10\Omega + 10\Omega} \]

15. \[ R_x \text{ (in parallel with 5000\Omega)} \]

To what is \( R_x \) equal if the voltmeter reads 0V?

16. Determine the current through the 10\Omega resistor.

17. What is the current in the circuit after 10 seconds?
Unit VI—Direct Current Circuits
Test Key

1. The Algebraic sum of the currents entering a node is zero.
2. The Algebraic sum of the voltages around a loop equals zero.
3. Insulating material
4. Electrolytic, disc, polyester film, wax paper, mica, etc.
5. 5000 pf
6. The maximum safe voltage a capacitor may be charged to.
7. 12 seconds
8. Circuit with only one path
9. 7.5 uf
10. \( \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \)
11. 364V, 11K
12. 790Ω, 25.3 mA, 0.031 W
13. 2400Ω, 10W
14. 1733Ω
15. 1000Ω
16. 0.368A
17. 0 A
Fill in the blanks:

1. Lodestone is an example of a natural
2. Man-made magnets are referred to as
3. The property that determines a material's magnetic characteristic is called
4. Permeability is defined as the ease with which a substance will accept
5. Small groups of these atoms tend to form tiny permanent magnets called
6. When current flows through a wire; a magnetic
7. Horseshoe shapes have an advantage over the bar shapes because the

Answer the following questions:

8. What determines the polarity of an electromagnet?
9. What two factors determines the strength of a coiled conductor?
10. What kind of magnet results when low-carbon steel is used?
Unit VII—Magnetism
Test Key

1. Magnet
2. Artificial
3. Permeability
4. Flux
5. Magnetic domains
6. Field
7. Polos
8. The direction of current flow
9. The amount of current flowing in the coil and the number of turns of wire
10. Temporary magnet
Unit VIII--Electronic Test Equipment
Sample Test

1. The permanent magnet moving coil meter is the type used in most general-purpose meters. This type of movement is often called __________________________ movement.
   A. taut-hand
   B. iron wire
   C. d/Arsanva
   D. Electrodynamometer

2. All voltage measurements are made with the meter in __________________________ with the circuit.

3. The purpose of the zero-adjustment on the ohmmeter is to compensate for changes in __________________________

4. Before a circuit may be tested with an ohmmeter, the ________

5. When the voltmeter, ammeter, and ohmmeter are combined into a single unit, the unit is called a __________________________ or a __________________________.

6. A motor which converts heat to electricity to drive a d'Arsanval movement is called a __________________________

7. When converting analog to digital, the single-step method has better resolution and accuracy than the dual-slope method. True or False

8. To measure larger current values with a digital meter, the resistance in the meter is increased/decreased.

9. What is the most popular type of display used in a digital meter?
   A. d'Arsanval
   B. Liquid crystal display
   C. Electrostatic
   D. Light emitting diode

10. A display which is brighter than the LED but not as bright as the incandescent is the __________________________

11. The liquid crystal display uses more/less power than any other display.

12. A 3-digit meter has a maximum range of
   A. 99V
   B. 999V
   C. 9999V
   D. 99999V
Unit VIII--Sample Test (Continued)

13. The heart of any oscilloscope is the ____________________________

14. What are the two methods for electron beam deflection in the CRT? ____________________________

15. Why should the beam keep moving across the CRT screen? ____________________________

16. The triggering in the oscilloscope helps to ____________________________

17. Oscilloscope voltage measurements are:

A. peak-to-peak
B. RMS
C. average
D. AC only.

18. Which of the following statements is true concerning transistor testers?

A. Leakage can be measured in the circuit, while beta must be measured out of the circuit.
B. Beta can be measured in the circuit, while leakage must be measured out of the circuit.
C. Leakage and beta can be measured in the circuit.
D. Neither leakage nor beta can be measured in the circuit.

19. A power supply in an oscilloscope must

A. only produce a number of voltages
B. be able to produce a variety of voltages
C. be well regulated
D. all of the above.

20. A delayed sweep:

A. is used in place of a magnifier
B. is the normal sweep
C. has a separate time base
D. all of the above.
Unit VIII--Electronic Test Equipment

Test Key

1. C
2. parallel
3. battery voltage
4. power; removed
5. VOM; multimeter
6. thermocouple
7. false
8. decreased
9. LCD
10. gas discharge
11. less
12. B
13. cathode ray tube
14. electromagnetic, electrostatic
15. because the phosphor will burn
16. stabilize
17. A
18. B
19. D
20. D
Unit IX--AC Circuits
Sample Test

Identify each of the following waveforms:

1. 
2. 
3. 

4. If a sine wave has a peak voltage of 12V, what is its RMS value?

5. What is the period of a 150 KHz signal?

6. Why do large motors and heating units use three-phase alternating current?

7. Opposition to alternating current produced by ideal capacitors or inductors is called

8. Impedance is the combined opposition of __________ and __________ of a circuit.

9. Impedance is measured in __________

10. Three losses of power in a transformer are __________ and __________.

11. A connection to the secondary of a transformer is called a __________.

12. Define electrical isolation.

13. Power factor is the ratio of __________ to __________ in an ac circuit.

14. Calculate the resonant frequency of a circuit that contains 1.6 mH of inductance and 6.25 pf of capacitance?

Solve for the indicated quantities:

Primary = 100 turns
Secondary = 1250 turns

Power into Primary + __________
Unit IX--Sample Test (Continued)

16. Identify the circuit diagram below.

\[ \begin{align*}
\text{Find: } Z &= \\
\text{Phase angle} &= \\
\end{align*} \]

17. Identify the circuit diagrams below.

\[ \begin{align*}
L &= 0.1 \text{h} \\
C &= 100 \mu \text{f} \\
R &= 100 \Omega
\end{align*} \]

18. \[ \text{Diagram} \]

19. \[ \text{Diagram} \]

20. \[ \text{Diagram} \]
1. Sine wave
2. sawtooth or ramp wave
3. square wave
4. 8.484
5. 6.67 u seconds
6. constant power
7. reactance
8. resistance, reactance
9. ohms
10. hysteresis, eddy currents, resistance
11. tap
12. physical separation of two circuits.
13. true power, apparent power
14. 1.59 MHz
15. 187.6 A, 281, 250 W
16. 250/37°
17. 656 Ω
18. High pass
19. Low pass
20. Band reject
1. Atoms held together within a pure semiconductor are held together
   A. by positive and negative charges
   B. in random manner
   C. by covalent bonds
   D. like the atoms within a conductor

2. Current flow in a semiconductor consists of
   A. holes only.
   B. ions
   C. electrons only
   D. electrons and holes

3. Which of the following is not a benefit of semiconductor devices?
   A. Higher reliability
   B. Lower cost
   C. Smaller size, less weight
   D. Higher operating voltages
   E. Less power consumption

4. What type of semiconductor material utilizes electrons as majority carriers?
   A. P-type
   B. N-type
   C. Trivalent
   D. Intrinsic

5. Both germanium and silicon materials are made up of atoms that have four electrons in their outer shell. These electrons are referred to as ________ electrons.

6. The basic function of a semiconductor device in an electronic circuit is to
   A. control current or voltage
   B. replace vacuum tubes
   C. simplify design

7. When an electron breaks away from a covalent bond, a hole is created. True or False

8. The resistance of a semiconductor ________ as the temperature decreases.

9. A semiconductor at high temperatures will function as a ________

10. The two most used materials in making semiconductor electronic components are ________ and ________.
Unit X—Semiconductor Fundamentals
Test Key

1. C
2. D
3. D
4. B
5. Valance
6. A
7. True
8. Increases
9. Conductor
10. Silicon and germanium
Unit XI-Electronic Devices
Sample Test

1. If a positive voltage is applied to the anode of a diode it is said to be in the _____ condition.

2. The white band marks the ____ of the diode.

3. The three basic bi-polar transistor circuits are _______.

4. Define cutoff.

5. A thyristor used to control alternating current is called the _____.

6. Name three case styles for integrated circuits. ________

7. A diode that has a controlled avalanche breakdown voltage that can be used as a regulator is the ____ diode.

8. Light emitting diodes produce light in the _____ bias condition.

9. The terminals of a field effect transistor are the ____ and ______.

10. A device whose resistance decreases with light intensity is called a ________

11. A device used to increase voltage without a transformer is called a ________

12. An increase in the amplitude of a signal is ________

True-False:

T F 13. Light emitting diodes produce light by getting hot.

T F 14. Integrated circuits are used for digital and analog signals.

T F 15. The bias on a transistor is its operating point.

T F 16. Transistors can be used to operate a relay from a small input signal.

T F 17. The silicon controlled rectifier is a bi-directional device.

T F 18. A full wave bridge rectifier can be packaged as a single unit.

T F 19. Some op-amps require both positive and negative voltage supplies.

T F 20. Capacitor coupling is used to block excessive currents from the previous stage.
1. Forward bias
2. cathode
3. common base, common collector, common emitter
4. the bias point at which a transistor no longer conducts
5. TRIAC
6. Can, DIP, flatpack
7. Zener
8. Forward
9. gate, source, drain
10. photoconductive cell
11. voltage multiplier
12. gain
13. false
14. true
15. true
16. true
17. false
18. true
19. true
20. true
Unit XII--Circuit Fabrication,
Sample Test

1. What type of pc board material is used where dimensional stability is not a concern?
   A. Epoxy glass
   B. Polyester glass
   C. Epoxy paper
   D. Phenolic paper

2. Copper foil is designated by the weight of the copper on the surface; the term "ounce" indicates
   A. ounces per square inch
   B. ounces per square foot
   C. ounces per square meter
   D. ounces per square centimeter

3. If you are using a one ounce copper clad board what would be the copper surface thickness?
   A. .001
   B. .002
   C. .003
   D. .004

4. Epoxy glass boards have approximately times the flexural strength of phenolic-paper boards.
   A. 2
   B. 4
   C. 8
   D. 16

5. Which of the following PC boards would be the most expensive to purchase?
   A. Phenolic paper, one ounce single-sided board
   B. Epoxy glass, one-ounce single-sided board
   C. Phenolic paper, one ounce single-sided, sensitized
   D. Epoxy glass, one ounce double-sided board, sensitized.

6. The chemical process used to remove unwanted copper from a PC board during the subtractive process is called:
   A. laminating
   B. etching
   C. plating
   D. routing

7. Component leads usually require relatively small mounting holes, however on oversized holes, especially those ½ inch and larger, you should
   A. increase the drill rpm
   B. exert greater feed pressure
   C. use a countersink
   D. drill a smaller pilot hole first
8. The entire process of printed circuit board design starts with a basic document which is the
   A. master pattern
   B. schematic diagram
   C. block diagram
   D. photo mask

9. What would be the most accurate aid for use in positioning full-size IC pad?
   A. Reset ink pen
   B. Rub-on transfer pads
   C. Layout dolls
   D. Crepe art tape

10. Before direct pattern artwork can be prepared on a circuit board, the board must be
    A. etched
    B. resist-coated
    C. free of grease, dirt and fingerprints
    D. exposed to light

11. When exposing a positive type photo-sensitized circuit board, light must be used.
    A. subdued incandescent
    B. incandescent
    C. infrared
    D. ultraviolet

12. Major circuit defects after etching, such as edge definition, pitting, and voids, can be caused by
    A. poor adhesion of artwork
    B. dirty board surface
    C. improper board preparation
    D. all of the above

13. What is the safest etchant to make a printed circuit board?
    A. ammonium persulfate
    B. ferric chloride
    C. cupric chloride
    D. hydrochloric acid

14. What are the two methods of image transfer suitable for producing several identical circuit board patterns from a single piece of artwork?
    A. screen printing and direct pattern
    B. screen printing and photoresist
    C. direct etch and direct pattern
    D. direct pattern and photoresist
15. When working with etchant chemicals in the shop, which of the following should you do for safety's sake?
   A. stir etchants with kitchen utensils
   B. pour etchants in aluminum trays for mixing
   C. dispose of the contents after use
   D. dispose of etchants in the sink

16. Name three tools which can be used for cutting PC boards.
   1.
   2.
   3.

17. A cutting tool used to chip off the excess length of component leads is called ______ cutters.

18. Of the four common drill bit sizes listed below, which one has the smallest diameter?
   A. 1/16 inch
   B. No. 55
   C. No. 60
   D. No. 65

19. Of the following, which composition of solder for electronic work would work best?
   A. Lead, nickel, and resin flux
   B. Nickel, tin, and resin flux
   C. Tin, lead, and resin flux
   D. Tin, lead and acid flux

20. A good solder joint will appear
   A. dull
   B. rough
   C. shiny
   D. white
Unit XIII—Introduction to Computer Literacy
Sample Test

1. What is the difference between a microprocessor and a microcomputer?

2. VLSI chips contain at least _______ transistors.
   A. 50
   B. 500
   C. 5,000
   D. 50,000

3. With what invention could mathematical manipulations be done electronically rather than mechanically by DeForet in 1906?

4. Memory that can be read or written by any selected random address is called
   A. ROM
   B. RAM
   C. PROM
   D. EPROM

5. A term used in referring to groups of binary digits is called
   A. nibble
   B. CPU
   C. Byte
   D. bit

6. What is the smallest unit of information in a digital computer?
   A. Bit
   B. Byte
   C. Nibble
   D. RAM

7. Scientists were first to develop what programming language?
   A. COBOL
   B. Basic
   C. Fortran
   D. Assembler

8. A program which is normally prepared in typed form on paper and not designed into the circuitry is logically called

9. Prior to magnetic disks what type of magnetic memory was available?
   A. Punch card
   B. Magnetic tape
   C. Paper tape
   D. All of the above
Unit XIII--Sample Test (Continued)

10. A device which contains arithmetic logic and control units in a single package is called a

A. microprocessor  
B. programmable ROM  
C. main frame  
D. power supply
Unit XII—Introduction to Computer Literacy
Test Key

1. A microcomputer is a system containing a microprocessor.
2. D
3. Triode vacuum tube
4. B
5. C
6. A
7. Fortran
8. Software
9. B
10. A
Unit XIV--Robotics: An Introduction for Your Classroom Sample Test

1. The word robot was first used by Czech novelist, essayist, and dramatist in 1921.

2. In what operation in manufacturing assembly do robots play the biggest part?

3. What industry uses the most industrial robots?

4. What are at least two classes or types of robots?

5. The hand or gripping device is usually attached to the end of the robot's

6. The majority of the industrial robots are stationary? True or False

7. All robots consist of two major component systems. They are the control system and the
   A. programmable memory
   B. stepper motors
   C. X & Y limit switches
   D. manipulators

8. List at least three ways a robot can grasp or otherwise handle a job.
   1.
   2.
   3.

9. The shape of the work envelope for a robot is determined almost entirely by what three major axes?
   1.
   2.
   3.

10. Name at least five possible robotic applications for the industrial arts classroom.
    1.
    2.
    3.
    4.
    5.
Unit XIV--Robotics: An Introduction for Your Classroom
Test Key

1. Karl Capek
2. welding
3. automobile
4. non-servo controlled, servo controlled and remote controlled
5. manipulator
6. true
7. D
8. Mechanical grippers, hooking on to a part, scooping or ladling, electromagnets, vacuum cups, quick disconnect bayonet sockets
9. 1. jointed arm
    2. spherical coordinate
    3. cylindrical coordinate configurations.
10. spot welding, arc welding, electronic component assembly, machine loading and unloading, material handling, assembly and quality control, research and development, metal casting, using wax instead of molten metal.
Unit XV--Industrial Electricity/Electronics
Sample Test

1. Explain how electricity is produced in an AC generator.

2. Define counter EMF and explain its importance to the operation of electric motors.

3. Name four pieces of information found on motor name plates.

4. Name four types of AC motors.

5. Explain how heat is generated in spot welding.

6. List three uses (besides welding) for resistance heating.

True-False:

T F 7. Electricity can produce chemical reactions.

T F 8. Aluminum is refined by an electrolysis reaction.

T F 9. Oxygen can be separated from water by electricity.

T F 10. High frequency radio waves (microwaves) can be used to produce heat.

T F 11. Incandescent lights produce light by producing an arc in a gas.

T F 12. The speed of an AC motor is related to the voltage.

T F 13. Generators lose power.

T F 14. Copper can be electrically plated to other metals.

T F 15. Chlorine gas is produced by electrolysis of salt.
Unit XV—Industrial Electricity?Electronics
Test Key

1. As the armature revolves through the magnetic field, current is induced in the wire. The polarity and amplitude are dependent on speed, and angle of armature.

2. Counter EMF is a voltage produced by a motor that opposes the applied voltage. Counter EMF limits the current in the motor to safe levels.

3. Brand; speed, horsepower, voltage, current, cycle, phase, et al

4. Hysteresis, split phase, three phase, repulsion induction, shaded pole

5. As current passes through the weld the resistance of the junction of the dissimilar metals produces heat.

6. Incandescent lamps, arc lamps, radiant heating, infrared heating

7. True

8. True

9. True

10. True

11. False

12. False

13. True

14. True

15. True
APPENDIX 2

TOOL LIST
Hand Tools

Alignment Tool (set)
Apron—Rubber/Solvent Resistant
Benders, EMT
Benders, Hickey
Bit, Auger (set)
Bit, Screwdriver (set)
Bit, Speed (set)
Brace, Ratchet
Brake, Box and pan
Breadboards
Brush, Drafting
Brush, Wire
Capacitor, Substitution Box
Chisel, Cold (set)
Coil Winder
Countersink, High Speed
Crimping Tool
Curve Tracer
Desoldering Tool
Die, Letter (set)
Die, Number (set)
Divider, Wing
Drafting Board
Drafting Equipment (set)
Drill, Electric, Portable (1/4")
Drill, Hand (1/4")
Drill Stand, Fractional
Drill, Twist, (letter set)
Drill, Twist (number set)
Drill, Twist, Straight shank (fractional set)
Extension cord
Files (see specifications for listing)
File Card and Brush
File, Jeweler's (set)
File, Needle (set)
Fish Tape
Function/Signal Generator
Gauge, Screw pitch
Gauge, Thickness (feeler)
Gauge, Wire and sheet metal (American)
Gauge, Wire and sheet metal (U.S.S.)
Goggles (spectacles), Clean observation
Grinder, Pedestal
Hammer, Ball peen (12 oz. and 16 oz.)
Hammer, Claw (16 oz.)
I.C. Insertion/Extraction tool
Knife, Electrician's
Level
Light, Extension
Hand Tools (Continued)

Logic probe
Magnet, Bar
Magnet, Horseshoe
Meter, Ammeter
Meter, Galvanometer
Meter, Inductance
Meter, Volt-ohm (multi-range)
Meter, VTVM or Electronic
Neon Test Light
Nibbler, Hand operated
Oilerc, Bench
Oilstone, Combination, India
Oilstone, Combination, Silicon carbide
Oscilloscope-15MHZ, Single trace
Oscilloscope-50MHZ, Dual trace
Pipe Cutter
Pipe Reamer
Pliers, Combination (6")
Pliers, Duckbill
Pliers, Diagonal cutting
Pliers, Needle nose
Pliers, Side-cutting
Pliers, Locking jaw
Power supply
Press, Drill
Punch, Center (set)
Punch, Chassis (round set)
Punch, Chassis (square set)
Punch, Pin (set)
Punch, Whitney hand
Reamer, Electrician's hand
Resistor, Substitution Box
Rule, Steel (12")
Rule, Folding
Saw, Coping
Saw, Hack (hand)
Saw, Hand, Crosscut
Saw, Reciprocal
Scissors
Screwdriver, Insulated (set)
Screwdriver, Phillips (set)
Screwdriver, Retaining type
Shear, Squaring foot
Shield, Face
Signal Tracer
Snip, Aviation (left)
Snip, Aviation (right)
Snips, Tinner's, Straight (#8)
Soldering Copper, Electric pencil
Soldering Pencil -- controlled heat, ground tip
Hand Tools (Continued)

Soldering Gun, Electric
Square, Combination
Square, Steel Framing
Square, Try (6"
Strip Heater--Plastic
Tap and Die, NC (U.S. standard) (set)
Tap and Die, NF (S.A.E.) (set)
Tap and Die, Pipe (set)
Tester, Transistor
Tester, Tube
Tray--Plastic--Acid Resistant
Welder, Spot
Wire Wrapping tools--Hand
Wrench, Adjustable end (6"
Wrench, Allen key (hex) (set)
Wrench, Nutdriver (set)
Wrench, Open end (set)
Wrench, Socket (3/8"
Vise, Circuit Board


APPENDIX 3

FIRE EXTINGUISHERS
Fire Extinguisher

Each fire extinguisher bears a letter (which usually has a metallic or green background) which indicates what class of fire the extinguisher will successfully put out. Water types of extinguishers, which are effective for Class A fires, can be of several kinds: stored pressure, cartridge operated, water pump tank, and soda acid.

Foam extinguishers are successful for Class A and B fires, while carbon dioxide and sodium and potassium bicarbonate dry chemical extinguishers are effective for only Class B and C fires. Multipurpose ABC dry chemical extinguishers, in either stored pressure or cartridge operated types, work for A, B, or C classes of fires. Class D fires should only be fought with special extinguishing agents approved by recognized testing laboratories (see chart on the following page).

If clothing should catch on fire, avoid panic. The flames should be smothered by wrapping in a blanket or coat, or by rolling on the floor or ground.

Fire Prevention

1. Do not overload electrical circuits.
2. Do not use frayed or defective electrical cords.
3. Do not allow any electrical repairs to be made by the students unless they are supervised by the instructor.
4. Do not use gasoline for anything except to run an engine.
5. Do not prime the engine with gasoline while it is running.
6. Do not weld near gas tanks, fuel lines, or any combustible materials.
7. Retain gasoline and store it in a safety can only.
8. If a fire should occur, use the proper extinguishers (see chart on the following page).
   A. Carbon dioxide: all electrical equipment
   B. Foam: oils, gasoline, grease, or paint
   C. Soda-acid: wood, cloth, paper or rubbish
   D. Vaporizing liquids: general purpose
9. If a fire cannot be readily extinguished, keep calm, evacuate the shop immediately, and turn in an alarm.
## KNOW YOUR FIRE EXTINGUISHERS

<table>
<thead>
<tr>
<th>WATER TYPE</th>
<th>FOAM</th>
<th>CARBON DIOXIDE</th>
<th>SODIUM OR POTASSIUM BICARBONATE</th>
<th>DRY CHEMICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>STORED PRESSURE</td>
<td></td>
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<tr>
<td>CARTRIDGE OPERATED</td>
<td></td>
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<tr>
<td>WATER PUMP TANK</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SODA ACID</td>
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</tr>
<tr>
<td>FOAM</td>
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<td></td>
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<tr>
<td>CO₂</td>
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<td></td>
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<tr>
<td>CARTRIDGE OPERATED</td>
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<td>STORED PRESSURE</td>
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<td>STORED PRESSURE</td>
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<tr>
<td>CARTRIDGE OPERATED</td>
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</tbody>
</table>

### CLASS A FIRES
- WOOD PAPER: TRASH HAVING GLowing EMBERS
- WATER Type: FOAM
- METHOD OF OPERATION: PULL PIN-SQUEEZE HANDLE
- RANGE: 30'-40'
- MAINTENANCE: CHECK AIR PRESSURE GAUGE MONTHLY
- NOTES: YES

### CLASS B FIRES
- FLAMMABLE LIQUIDS, GASOLINE, OIL, PAINTS, GREASE, ETC.
- WATER Type: FOAM
- METHOD OF OPERATION: PUMP HANDLE
- RANGE: 30'-40'
- MAINTENANCE: DISCHARGE AND FILL WITH WATER ANNUALLY
- NOTES: UPDATE YOUR FIRE EXTINGUISHING CAPABILITY - ASK FOR "TRADE-IN" PRICE

### CLASS C FIRES
- ELECTRICAL EQUIPMENT
- WATER Type: WATER
- METHOD OF OPERATION: PULL PIN-HANDLE
- RANGE: 30'-40'
- MAINTENANCE: CHECK AIR PRESSURE GAUGE MONTHLY
- NOTES: OBSOLETE

### CLASS D FIRES
- COMBUSTIBLE METALS
- WATER Type: WATER
- METHOD OF OPERATION: PULL PIN-HANDLE
- RANGE: 30'-40'
- MAINTENANCE: WEIGH CARTRIDGE DRY CHEMICAL ANNUALLY
- NOTES: OBSOLETE

### SPECIAL EXTINGUISHING AGENTS APPROVED BY RECOGNIZED TESTING LABORATORIES

- Class D fires - In hot metal areas which may use magnesium, titanium, zirconium, and sodium, one must provide Type D extinguishers or D rated dry chemical available for use on metal fires.
- It is important to use the correct extinguisher on the proper class of fire.
APPENDIX 4

SAFETY RECORDKEEPING
Safety Recordkeeping

One of the primary reasons for keeping health and safety records is to focus attention on problem areas so that corrective measures can be taken. The evaluation of accidents that have occurred, using a specific form like the one presented in this section, requires that the instructor look for causes and make plans to correct any problems which may be present. Good safety recordkeeping in this area also provides a basis for evaluating the safety program in use and initiating needed changes in procedures or facilities.

Safety records may also help to protect the instructor and the institution in the event of lawsuits. Although parental permission forms, safety tests, and safety instruction records do not provide a complete defense against such actions, they do tend to show the instructor was acting in "good faith" and may be construed as a partial defense in some courts.

Sample record forms, both a school's records and an instructor's records, are presented at the end of this unit. They may be reproduced or modified to fit the needs of a particular teacher or institution. The purpose or use of these forms is outlined below. Also included are copies of OSHA forms #100, #101, and #102, required of businesses and institutions that are under OSHA provisions.

School Records

1. Accident forms

A. Accident reports should be made out as soon as possible after an accident has occurred. Copies of the reports should be retained in the instructor's file. Additional copies should be filed in the appropriate administrative offices.

B. A variety of accident report forms are available; however, they should all contain the following information when completed.

1. What was the nature of the accident? What were the circumstances leading up to the accident? What was the nature of the injuries or damage? What were the persons involved doing? What unsafe acts or acts were committed? What were the direct or indirect causes? What machine, tool, substance, or object was most closely connected with the accident? What corrective action is indicated?

2. Who was injured or nearly injured? Who were the participants in the accident? Who committed the unsafe act? Who were the witnesses? Who administered first aid to the injured? Who completed the accident report?

3. Where did the accident occur? Where was the instructor at the time of the accident? Where was the injured person with respect to the machine, tool, substance, object, or person most closely associated with the accident?
4. When did the accident occur? When was the accident investigation made? When was the accident report completed?

5. Why was the unsafe act or hazardous condition permitted? Why did the person act unsafely? Why did the accident occur?

6. How did the accident happen? How did the physical environment contribute to the accident? How can similar future accidents be prevented?

II. Records of Safety Committee Meetings

Each institution’s safety committee should meet periodically to discuss the safety program being used and to review recommendations for improving the program.

III. Safety Inspection Records

Records of every inspection conducted in the vocational education and industrial arts laboratory should be filed by the institution.

IV. School-Wide Safety Efforts and Programs

Information detailing the program in use in the school should be on file in the main office.

Teacher Records

1. Safety Instruction Records

Records of safety inspections, schedules of safety talks, and signed sheets acknowledging safety instruction should be kept by the instructor.

II. Parental Permission/Consent Forms

Written parental permission should be obtained before minor students are permitted to use tools and operate equipment in industrial education laboratories. The purpose of this permission is to emphasize that safety is a cooperative effort, and to impress upon both students and parents that there is a certain degree of danger involved in the use of tools and equipment. It also offers the parent the option to prohibit the student's use of tools or equipment, if so desired.

III. Safety Tests

Instructors should administer appropriate safety tests to students before allowing them to use tools or equipment which could cause injury. The completed tests should be filed for reference. In addition to the test, a "statement of acknowledgment" should be filed with the safety test.
IV. Hazardous Conditions Reports

Any potential health or safety hazard should be reported in writing. Reports should be kept on file, noting the action that has been taken to alleviate the hazardous condition.

OSHA Records

Records required by the Federal Occupational Safety and Health Act are included here to provide administrators and instructors a guide for some other types of records.

I. Form #100 - Log of Occupational Injuries and Illnesses
II. Form #101 - Supplementary Record of Occupational Injuries and Illnesses
III. Form #102 - Summary of Occupational Injuries and Illnesses for Calendar Year.
**STANDARD STUDENT ACCIDENT REPORT FORM**

**Part A. Information on ALL Accidents**

1. **Name:**
   - Home Address:

2. **School:**
   - Sex: M ☐ F ☐ Age ☐ Grade or classification:

3. **Time accident occurred:** Hour A.M. P.M. Date:

4. **Place of Accident:** School/Building ☐ School Grounds ☐ To or from School ☐
   - Home ☐ Elsewhere ☐

5. **DESCRIPTION OF THE ACCIDENT**
   - How did accident happen? What was student doing? Where was student? List specifically unsafe acts and unsafe conditions existing. Specify any tool, machine or equipment involved.

<table>
<thead>
<tr>
<th>Nature of Injury</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion</td>
<td>Fracture</td>
</tr>
<tr>
<td>Amputation</td>
<td>Laceration</td>
</tr>
<tr>
<td>Asphyxiation</td>
<td>Poisoning</td>
</tr>
<tr>
<td>Bite</td>
<td>Puncture</td>
</tr>
<tr>
<td>Bruise</td>
<td>Scalds</td>
</tr>
<tr>
<td>Burn</td>
<td>Scratches</td>
</tr>
<tr>
<td>Concussion</td>
<td>Shock (él.)</td>
</tr>
<tr>
<td>Cut</td>
<td>Sprain</td>
</tr>
<tr>
<td>Dislocation</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part of Body Injured</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdomen</td>
<td>Foot</td>
</tr>
<tr>
<td>Ankle</td>
<td>Hand</td>
</tr>
<tr>
<td>Arm</td>
<td>Head</td>
</tr>
<tr>
<td>Back</td>
<td>Knee</td>
</tr>
<tr>
<td>Chest</td>
<td>Leg</td>
</tr>
<tr>
<td>Ear</td>
<td>Mouth</td>
</tr>
<tr>
<td>Elbow</td>
<td>Nose</td>
</tr>
<tr>
<td>Eye</td>
<td>Scalp</td>
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<tr>
<td>Face</td>
<td>Tooth</td>
</tr>
<tr>
<td>Finger</td>
<td>Wrist</td>
</tr>
<tr>
<td>Other (specify)</td>
<td></td>
</tr>
</tbody>
</table>

6. **Degree of Injury:**
   - Death ☐ Permanent Impairment ☐ Temporary Disability ☐ Nondisabling ☐

7. **Total number of days lost from school:** (To be filled in when student returns to school)

8. **Teacher in charge when accident occurred (enter name)**
   - Present at scene of accident: No ☐ Yes ☐

9. **First-aid treatment:** By (name):
   - Sent to school nurse: By (name):
   - Sent home: By (name):
   - Sent to physician: By (name):
   - Sent to hospital: By (name):
   - Physician's Name:
   - Name of Hospital:

10. **Was a parent or other individual notified?**
    - Yes ☐ No ☐
    - When: 
    - How: 

11. **Name of parent notified**
    - By whom? (enter name)

12. **Witnesses:**
    - 1. Name: Address:
    - 2. Name: Address
### Specify Activity
- Athletic field
- Auditorium
- Cafeteria
- Classroom
- Corridor
- Dressing room
- Gymnasium
- Home Econ.
- Laboratories

### Specify Activity
- Locker
- Pool
- Sch. grounds
- Showers
- Stairs
- Toilets & washrooms
- Other (specify)

### Remarks
- What recommendations do you have for preventing other accidents of this type?

### Signed:
- Principal
- Teacher

### CAUSE: Unsafe Acts (mark basic cause)
1. Operating without authority
2. Operating at unsafe speed
3. Making safety device inoperative
4. Using unsafe equipment or equipment unsafely
5. Unsafe loading, placing, mixing
6. Taking unsafe position
7. Working on moving or dangerous equipment
8. Distraction, teasing, horseplay
9. Failure to use personal protective devices

### Why was the unsafe act committed?

### CAUSE: Unsafe Conditions (mark contributing cause, if any)
10. Inadequately guarded
11. Defective tools, equipment or substance
12. Hazardous arrangement
13. Unsafe illumination
14. Unsafe ventilation
15. Unsafe clothing
16. Unguarded
17. Unsafe design or construction

### Why did the unsafe condition exist?

### GUIDES TO CORRECTIVE ACTION:

<table>
<thead>
<tr>
<th>Unsafe Act</th>
<th>Unsafe Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stop</td>
<td>1. Remove</td>
</tr>
<tr>
<td>2. Study</td>
<td>2. Guard</td>
</tr>
<tr>
<td>3. Instruct (tell-show-try-check)</td>
<td>3. Warn</td>
</tr>
<tr>
<td>4. Train</td>
<td>If supervisor can't handle, then</td>
</tr>
<tr>
<td>5. Maintain discipline</td>
<td>4. Recommend for</td>
</tr>
<tr>
<td></td>
<td>(a) own supervisor, or</td>
</tr>
<tr>
<td></td>
<td>(b) other supervisors, or</td>
</tr>
<tr>
<td></td>
<td>(c) safety committee, or</td>
</tr>
<tr>
<td></td>
<td>(d) maintenance dept., or</td>
</tr>
<tr>
<td></td>
<td>(e)</td>
</tr>
<tr>
<td></td>
<td>5. Follow up</td>
</tr>
</tbody>
</table>

Based on the cause checked above, indicate below the corrective action you are taking.

What have you done to prevent similar injuries?
MINUTES OF SAFETY COMMITTEE MEETING

School ____________________________ Date ____________________________
Address ____________________________ Time Meeting Opened

Members Present: ____________________________ Absent: ____________________________

Minutes of previous meeting dated ____________________________ were read.

Comments:

UNFINISHED BUSINESS AND OLD RECOMMENDATIONS, BY NUMBER ONLY, NOT DISPOSED OF:

RECOMMENDATIONS COMPLETED SINCE LAST MEETING: (Record by recommendation number only)

NEW BUSINESS:

Inspection reports were reviewed and discussed.

NEW RECOMMENDATIONS: (Number consecutively from previous recommendations and describe.)

REMARKS: The following accidents which occurred since the last meeting were discussed:

<table>
<thead>
<tr>
<th>Date of Injury</th>
<th>Employee</th>
<th>Cause</th>
<th>Recommendations</th>
</tr>
</thead>
</table>

OTHER COMMITTEE REMARKS:

Are Safety Posters being regularly received and posted?

Put additional remarks on the reverse side

Meeting adjourned

Next meeting to be held

Signed

Secretary of Committee
ACKNOWLEDGEMENT OF SAFETY INSTRUCTION AND PLEDGE

I have received the SAFETY INSTRUCTIONS regarding the operation of the following power driven machines. I fully understand the importance of these rules and regulations, and I am fully aware that the violation of any one of them may endanger myself and others.

My instructor has demonstrated to me the proper methods of using each machine listed below and has pointed out the safety precautions necessary to avoid injury.

I have demonstrated my ability to use each machine listed below in the presence of my teacher. I understand the safety precautions involved and I understand how to ensure my safety through the proper use of the machines. I am confident that I can operate these machines safely. When in doubt about the operation of any machine or other equipment, I will consult the teacher before proceeding.

(Name of each machine to be written in by the pupil after he/she has passed the safety test and demonstrated the ability to use it.)

<table>
<thead>
<tr>
<th>NAME OF MACHINE</th>
<th>DATE</th>
<th>STUDENT'S SIGNATURE</th>
<th>TEACHER'S INITIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<td>3</td>
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<td>4</td>
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<td>5</td>
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<td>6</td>
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<td>7</td>
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<td>8</td>
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<tr>
<td>9</td>
<td></td>
<td></td>
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<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I have passed the tests covering safety in the shop and the use of the above-listed machines.

I promise to observe the SAFETY INSTRUCTIONS and to follow the instructions given in the demonstration. I may use the machines only after I have been properly instructed in their safe use, and I have received the approval of the teacher.

School __________________________ Signed __________________________ pupil

Date ___________________________ Instructor __________________________
SAMPLE PERMISSION FORM

_________ (student's name) has our/my permission to operate the equipment in the ___________ laboratory at ____________ School. It is understood that instruction in its safe operation will be given before he/she is allowed to use any piece of equipment and that he/she will be properly supervised at all times.

In the case of an accident, it is preferred that he/she be given treatment by:

Dr: __________________________

or Dr: ________________________

Our home phone number is: __________________________

Our work phone number is: __________________________

If neither parent/guardian can be reached at the above numbers, please notify:

_________________________ at _______________________

(responsible person) (telephone number)

Date: _______________________

Signed: _______________________

(father/guardian)

_________________________

(mother/guardian)

_________________________

(other—specify relationship)
HAZARDOUS CONDITIONS REPORT

TO
(Building Administrator) (Position) (School)

Description and Location of Health or Safety Hazard


Suggested Solution


Teacher's signature

Distribution: Original - Building Administrator
1st Copy - Department Chairperson
2nd Copy - Teacher Reporting Hazard
3rd Copy - Parish Safety Officer

Action Taken


By Whom
(Signature)
Supplementary Record of Occupational Injuries and Illnesses

EMPLOYER
1. Name
2. Mail address (No. and street) (City or town) (State)
3. Location, if different from mail address

INJURED OR ILL EMPLOYEE
4. Name (First name) (Middle name) (Last name) Social Security No.
5. Home address (No. and street) (City or town) (State)
6. Age
7. Sex: Male. Female. (Check one)
8. Occupation (Enter regular job title, not the specific activity he was performing at time of injury.)
9. Department (Enter name of department or division in which the injured person is regularly employed, even though he may have been temporarily working in another department at the time of injury.)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS
10. Place of accident or exposure (No. and street) (City or town) (State)
   If accident or exposure occurred on employer's premises, give address of plant or establishment in which it occurred. Do not indicate department or division within the plant or establishment. If accident occurred outside employer's premises at an identifiable address, give that address. If it occurred on a public highway or at any other place which cannot be identified by number and street, please provide place references locating the place of injury as accurately as possible.
11. Was place of accident or exposure on employer's premises? (Yes or No)
12. What was the employee doing when injured? (Be specific. If he was using tools or equipment or handling materials, name them and tell what he was doing with them.)
13. How did the accident occur? (Describe fully the events which resulted in the injury or occupational illness. Tell what happened and how it happened. Name any objects or substances involved and tell how they were involved. Give full details on all factors which led or contributed to the accident. Use separate sheet for additional space.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS
14. Describe the injury or illness in detail and indicate the part of body affected. (e.g., amputation of right index finger at second joint; fracture of rib; lead poisoning; dermatitis of left hand, etc.)
15. Name the object or substance which directly injured the employee. (For example, the machine or thing he struck against or which struck him; the vapor or poison he inhaled or swallowed; the chemical or radiation which irritated his skin; or in cases of straining, hernia, etc., the thing he was lifting, pulling, etc.)
16. Date of injury or initial diagnosis of occupational illness (Date)
17. Did employee die? (Yes or No)

OTHER
18. Name and address of physician
19. If hospitalized, name and address of hospital

Date of report Prepared by
Official position

OSHA No. 101 Form approved:
Case or File No. OMB No. 44X 1453

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Form opprovcl

Supplementary Record of Occupational Injuries and Illnesses
SUPPLEMENTARY RECORD OF
OCCUPATIONAL INJURIES
AND ILLNESSES

To supplement the Log of Occupational Injuries and Illnesses (OSHA No. 101), each establishment must maintain a record of each recordable occupational injury or illness. Workmen's compensation, insurance, or other reports are acceptable as records if they contain all facts listed below or are supplemented to do so. If no suitable report is made for other purposes, this form (OSHA No. 101) may be used or the necessary facts can be listed on a separate plain sheet of paper. These records must also be available in the establishment without delay and at reasonable times for examination by representatives of the Department of Labor and the Department of Health, Education and Welfare, and States accorded jurisdiction under the Act. The records must be maintained for a period of not less than five years following the end of the calendar year to which they relate.

Such records must contain at least the following facts:

1) About the employer—name, mail address, and location if different from mail address.

2) About the injured or ill employee—name, social security number, home address, age, sex, occupation, and department.

3) About the accident or exposure to occupational illness—place of accident or exposure, whether it was on employer's premises, what the employee was doing when injured, and how the accident occurred.

4) About the occupational injury or illness—description of the injury or illness, including part of body affected; name of the object or substance which directly injured the employee; and date of injury or diagnosis of illness.

5) Other—name and address of physician; if hospitalized, name and address of hospital; date of report; and name and position of person preparing the report.

SEE DEFINITIONS ON THE BACK OF OSHA FORM 100.
Summary of Occupational Injuries and Illnesses for Calendar Year 19__

Establishment:  
NAME:  
ADDRESS:  

<table>
<thead>
<tr>
<th>INJURY AND ILLNESS CATEGORY</th>
<th>TOTAL CASES</th>
<th>DEATHS</th>
<th>LOST WORKDAY CASES</th>
<th>NONFATAL CASES WITHOUT LOST WORKDAYS</th>
<th>TERMINATIONS OR PERMANENT TRANSFERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>CASES</td>
<td>DAYS AWAY FROM WORK</td>
<td>DAYS OF RESTRICTED WORK ACTIVITY</td>
</tr>
<tr>
<td></td>
<td>NUMBER</td>
<td></td>
<td>NUMBER</td>
<td></td>
<td>NUMBER</td>
</tr>
<tr>
<td></td>
<td>CODES</td>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>OCCUPATIONAL INJURIES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupational Skin Diseases</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>or Disorders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust Diseases of the Lungs</td>
<td></td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory Conditions Due</td>
<td></td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to Toxic Agents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poisoning (Systemic Effects</td>
<td></td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of Toxic Materials)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disorders Due to Physical</td>
<td></td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disorders Associated</td>
<td></td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Repeated Trauma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Other Occupational</td>
<td></td>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illnesses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL—OCCUPATIONAL</td>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ILLNESSES (Sum of codes 21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>through code 29)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL—OCCUPATIONAL</td>
<td></td>
<td>31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INJURIES AND ILLNESSES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sum of code 10 and code 30)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This is NOT a report form. Keep it in the establishment for 5 years.

I certify that this Summary of Occupational Injuries and Illnesses is true and complete, to the best of my knowledge.

Signature:  
Title:  
Date:  

OMB No 449-01-453  
Use previous edition of this form for summarizing your 1974 cases. This edition is for summarizing your cases for 1975 and subsequent years.
SUMMARY OF OCCUPATIONAL INJURIES AND ILLNESSES

Every employer who is subject to the recordkeeping requirements of the Occupational Safety and Health Act of 1970 must use this form to prepare an annual summary of the occupational injury and illness experience of the employees in each of his establishments within one month following the end of each year.

POSTING REQUIREMENTS: A copy or copies of the summary must be posted at each establishment in the place or places where notices to employees are customarily posted. This summary must be posted no later than February 1 and must remain in place until March 1.

INSTRUCTIONS for completing this form: All entries must be summarized from the log (OSHA No. 100) or its equivalent. Before preparing this summary, review the log to be sure that entries are correct and each case is included in one of the following classes: deaths (date in column B), lost workday cases (check in column 9), or nonfatal cases without lost workdays (check in column 10). If an employee's loss of workdays is continuing at the time the summary is being made, estimate the number of future workdays he will lose and add that estimate to the workdays he has already lost and include this total in the summary. No further entries are to be made with respect to such cases in the next year's summary.

Occupational injuries and the seven categories of occupational illnesses are to be summarized separately. Identify each case by the code in column 7 of the log of occupational injuries and illnesses.

The summary from the log is made as follows:

A. For occupational injuries (identified by a code 10 in column 7 of the log form) make entries on the line for code 10 of this form.

Column 1 - Total Cases. Count the number of entries which have a code 10 in column 7 of the log. Enter this total in column 1 of this form. This is the total of occupational injuries for the year.

Column 2 - Deaths. Count the number of entries (dates of death) for occupational injuries in column 8 of the log.

Column 3 - Total Lost Workday Cases. Count the number of checks for occupational injuries in column 9 of the log.

Column 4 - Cases Involving Days Away From Work. Count the number of checks for occupational injuries in column 9A of the log.

Column 5 - Days Away From Work. Add the entries (total days away) for occupational injuries in column 9A of the log.

Column 6 - Days of Restricted Work Activity. Add the entries (total of such days) for occupational injuries in column 9B of the log.

Column 7 - Cases Involving Days away From Work. Add the entries (total days away) for occupational injuries in column 9A of the log.

Column 8 - Nonfatal Cases Without Lost Workdays. Count the number of checks for occupational injuries in column 10 of the log.

Column 9 - Terminations or Permanent Transfers. Count the number of checks for occupational injuries in column 11 of the log.

CHECK: If the totals for code 10 have been entered correctly, the sum of columns 2, 3, and 7 will equal the number entered in column 1.

B. Follow the same procedure for each illness code, entering the totals on the appropriate line of this form.

C. Add the entries for codes 21 through 29 in each column for occupational illnesses and enter totals on the line for code 30.

D. Add the entries for codes 10 and 30 in each column and enter totals on the line for code 31.

CHECK: If the summary has been made correctly, the entry in column 1 of the total line (code 31) of this form will equal the total number of cases on the log.

The person responsible for the preparation of the summary shall certify that it is true and complete by signing the statement on the form.

Use previous edition of this form for summarizing your 1974 cases. This edition is for summarizing your cases for 1975 and subsequent years. Forms for the 1974 summary can be obtained from the appropriate State statistical grant agency (if there is one in your State) or from the appropriate Regional Office of the Bureau of Labor Statistics. Addresses are in the booklet entitled Recordkeeping Requirements under the Occupational Safety and Health Act of 1970.
APPENDIX 5

MATH REVIEW
MATH REVIEW

I. Rounding Numbers

1. What is 4386 rounded to the nearest ten?
   a) 4280  b) 4380  c) 4390  d) 4400

2. What is 643,849 rounded to the nearest thousand?
   a) 643,850  b) 643,800  c) 644,000  d) 640,000

3. What is 9,675,000 rounded to the nearest hundred thousand?
   a) 9,670,000  b) 9,675,000  c) 9,680,000  d) 9,700,000

II. Add and Subtract Integers

4. 4326
   a) 22,833  b) 21,832  c) 21,742  d) 21,732
   9857
   +5634

5. 3804 + 527 + 96 + 12,485 =
   a) 16,912  b) 15,902  c) 15,911  d) 124,912

6. 512,705
   a) 463,169  b) 473,177  c) 463,067  d) 463,077
   -49,638

III. Multiply and Divide Integers

7. 836
   a) 56,044  b) 65,044  c) 66,046  d) 66,044
   x79

8. 987 x 456
   a) 440,172  b) 450,072  c) 450,182  d) 451,072

9. 6300 ÷ 97 =
   a) 64 92/97  b) 65 95/97  c) 65 85/97  d) 66

10. 1498 ÷ 49 =
    a) 32 8/49  b) 31  c) 32 30/49  d) 30 4/7

IV. Add and Subtract Fractions

11. 7 5/6
    +2 3/6
    a) 9 2/6  b) 10 1/3  c) 10 1/2  d) 10 8/6

12. 5 1/2 + 2 5/8 =
    a) 9 1/8  b) 7 6/10  c) 8 9/3  d) 7 6/16

156 230
13. $17 \frac{3}{8} - 12 \frac{7}{8}$
   a) $4 \frac{6}{8}$  b) $5 \frac{3}{4}$  c) $4 \frac{1}{2}$  d) $5 \frac{1}{2}$

14. $9 \frac{2}{3} - 5 \frac{1}{4}$
   a) $4 \frac{1}{4}$  b) $4 \frac{11}{12}$  c) $3 \frac{5}{12}$  d) $4 \frac{5}{12}$

V. Multiply Fractions

15. $\frac{5}{6} \times 426 = \frac{210}{355}$
   a) $\frac{71}{210}$  b) $\frac{355}{356}$

16. $3 \frac{3}{5} \times 8 \frac{9}{9} = \frac{24}{15}$
   a) $24 \frac{15}{15}$  b) $3 \frac{24}{45}$  c) $3$  d) $3 \frac{1}{5}$

17. $12 \times 8 \frac{3}{4} = \frac{72}{100}$
   a) $96 \frac{3}{4}$  b) $105$  c) $72$  d) $100$

18. $8 \frac{2}{5} \times 6 \frac{2}{3} = \frac{48}{4}$
   a) $56$  b) $48 \frac{4}{15}$  c) $48 \frac{4}{8}$  d) $46$

VI. Divide Fractions

19. $15 \div 9 \frac{1}{10}$
   a) $9 \frac{10}{15}$  b) $10 \frac{9}{15}$  c) $13 \frac{1}{2}$  d) $16 \frac{2}{3}$

20. $6 \frac{2}{3} \div 4 = \frac{1}{1\frac{2}{3}}$
   a) $1 \frac{1}{2}$  b) $1 \frac{1}{2}$  c) $1 \frac{2}{3}$  d) $1 \frac{3}{4}$

21. $8 \frac{2}{3} \div 2 \frac{3}{3} = \frac{16}{23}$
   a) $8$  b) $13$  c) $16 \frac{2}{3}$  d) $17 \frac{1}{3}$

22. $3 \frac{3}{8} \div 2 \frac{1}{4} = \frac{2}{3}$
   a) $1 \frac{1}{2}$  b) $1 \frac{3}{4}$  c) $2 \frac{3}{8}$  d) $6 \frac{3}{32}$

VII. Convert Fractions and Decimals

23. Change $\frac{3}{4}$ to a decimal.
   a) 0.075  b) 0.75  c) 7.5  d) 75.0

24. Change $\frac{1}{2}$ to a decimal.
   a) 2.0  b) 0.02  c) 0.2  d) 0.5

25. Change $0.3$ to a fraction in lowest terms.
   a) $\frac{3}{100}$  b) $\frac{1}{3}$  c) $\frac{3}{10}$  d) $0.3$
26. Change 0.07 to a fraction in lowest terms.
   a) $\frac{7}{100}$  b) $\frac{7}{10}$  c) $\frac{1}{7}$  d) 0.7

VIII. Add and Subtract Decimals

27. $0.982 + 0.7 + 0.65 = $
   a) 1.054  b) 1.117  c) 2.332  d) 9.117

28. $53.869 + 42.75 = $
   a) 95.944  b) 96.619  c) 58.144  d) 95.619

29. $0.071 - 0.06 = $
   a) 0.065  b) 0.067  c) 0.076  d) 0.011

30. $0.607 - 0.438 = $
   a) 0.231  b) 0.169  c) 0.179  d) 0.279

IX. Multiply Decimals

31. $0.695 \times 0.86 = $
   a) 0.5977  b) 5.977  c) 59.77  d) 58.97

32. $0.67 \times 0.48 = $
   a) 0.3226  b) 0.3216  c) 3.216  d) 32.16

33. $0.609 \times 3.80 = $
   a) 2.3142  b) 0.23142  c) 2.31402  d) 0.2314

34. $5.26 \div 3.5 = $
   a) 1.741  b) 184.10  c) 17.410  d) 18.41

X. Divide Decimals

35. $25 \div 53.25 = $
   a) 0.23  b) 0.213  c) 2.013  d) 2.13

36. $8.001 \div 0.7 = $
   a) 1.143  b) 10.43  c) 11.43  d) 114.3

37. $62.5 \div 0.25 = $
   a) 25  b) 250  c) 205  d) 0.25

38. $2.193 \div 0.215 = $
   a) 1.20  b) 12  c) 10.2  d) 102
Using the Delta-Tee formulas to solve these problems:

1. \( 9.1 \Omega \)

2. \( 60 \Omega \)

3. \( 13.6 \)

4. \( 233 \)

5. \( 233 \)
NUMERATION

Rounding Numbers
Round numbers to any specific place value through one million.

<table>
<thead>
<tr>
<th>Ten Millions</th>
<th>Millions</th>
<th>Hundred Thousands</th>
<th>Ten Thousands</th>
<th>Thousands</th>
<th>Hundreds</th>
<th>Tens</th>
<th>Ones</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000,000</td>
<td>1,000,000</td>
<td>100,000</td>
<td>10,000</td>
<td>1,000</td>
<td>100</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

Answer These Questions:

1. What is 4386 rounded to the nearest ten?
   A. 4280
   B. 4380
   C. 4390
   D. 4400

2. What is 643,849 rounded to the nearest thousand?
   A. 643,850
   B. 643,800
   C. 644,000
   D. 640,000

3. What is 9,675,000 rounded to the nearest hundred thousand?
   A. 9,670,000
   B. 9,675,000
   C. 9,680,000
   D. 9,700,000

235
WHOLE NUMBER OPERATIONS

Add and subtract integers.

Solve These Problems:

4. \[ \begin{array}{c}
4326 \\
9857 \\
2015 \\
+5634
\end{array} \]

A. 22,833  
B. 21,832  
C. 21,742  
D. 21,732

5. \[ 3804 + 527 + 96 + 12,485 = \]

A. 16,912  
B. 15,902  
C. 15,911  
D. 124,912

6. \[ \begin{array}{c}
512,705 \\
-49,638
\end{array} \]

A. 463,169  
B. 473,177  
C. 463,067  
D. 463,077

Multiply and divide integers.

Solve These Problems:

7. \[ \begin{array}{c}
836 \\
x79
\end{array} \]

A. 56,044  
B. 65,044  
C. 66,046  
D. 66,044
8. \(987 \times 456 = \)

A. 440,172
B. 450,972
C. 450,182
D. 451,072

9. \(6300 \div 97 = \)

A. 64 92/97
B. 65 95/97
C. 65 85/97
D. 66

10. \(1498 \div 49 = \)

A. 328/49
B. 31
C. 32 30/49
D. 30 4/7

FRACTIONS AND OPERATIONS

Add and subtract fractions.
Add mixed numbers with unlike denominators.
Subtract mixed numbers with like denominators. (regrouping)
Subtract mixed numbers with unlike denominators. (no regrouping)

Solve These Problems:

11. \(7 \frac{5}{6} + 2 \frac{3}{6} = \)

A. 9 2/6
B. 10 1/3
C. 10 1/2
D. 10 8/6

12. \(5 \frac{1}{2} + 2 \frac{5}{8} = \)

A. 8 1/8
B. 7 6/10
C. 8 9/8
D. 7 6/16

237
13. \(17 \frac{3}{8} - 12 \frac{7}{8}\)

A. \(4 \frac{6}{8}\)
B. \(5 \frac{3}{4}\)
C. \(4 \frac{1}{2}\)
D. \(5 \frac{1}{2}\)

14. \(9 \frac{2}{3} - 5 \frac{1}{4}\) =

A. \(4 \frac{1}{4}\)
B. \(4 \frac{11}{12}\)
C. \(3 \frac{5}{12}\)
D. \(4 \frac{5}{12}\)

Multiply fractions.

Multiply a mixed number by a proper fraction.

Multiply a whole number by a mixed number.

Multiply two mixed numbers.

Solve These Problems:

15. \(\frac{5}{6} \times 426 =\) 

A. 71
B. 210
C. 355
D. 356

16. \(3 \frac{3}{5} \times \frac{8}{9} =\) 

A. \(\frac{24}{15}\)
B. \(3 \frac{24}{45}\)
C. 3
D. \(3 \frac{1}{5}\)

17. \(12 \times 8 \frac{3}{4} =\) 

A. 96 \(\frac{3}{4}\)
B. 105
C. 72
D. 100
18. $8 \frac{2}{5} \times 6 \frac{2}{3} =$ 

A. 56 
B. 48 $\frac{4}{15}$ 
C. 48 $\frac{4}{8}$ 
D. 46 

Divide Fractions.
Divide a whole number by a proper fraction.
Divide a mixed number by a proper fraction.
Divide a mixed number by a mixed number.

Solve These Problems:

19. $15 \div 9\frac{1}{10} =$ 

A. 9 $\frac{10}{15}$ 
B. 10 $\frac{9}{15}$ 
C. 13 $\frac{1}{2}$ 
D. 16 $\frac{2}{3}$ 

20. $6 \frac{2}{3} \div 4 =$ 

A. 1 $\frac{1}{12}$ 
B. 1 $\frac{1}{2}$ 
C. 1 $\frac{2}{3}$ 
D. 1 $\frac{3}{4}$ 

21. $8 \frac{2}{3} \div 2\frac{2}{3} =$ 

A. 8 
B. 13 
C. 16 $\frac{2}{3}$ 
D. 17 $\frac{1}{3}$ 

22. $3 \frac{3}{8} \div 2 \frac{1}{4} =$ 

A. 1 $\frac{1}{2}$ 
B. 1 $\frac{3}{4}$ 
C. 2 $\frac{3}{8}$ 
D. 6 $\frac{3}{32}$
DECIMALS AND DECIMAL OPERATIONS

Convert fractions and decimals.

Change a common fraction to an equivalent decimal fraction.

Change a decimal fraction to an equivalent common fraction.

Solve These Problems:

23. Change $\frac{3}{4}$ to a decimal.
   A. 0.075
   B. 0.75
   C. 7.5
   D. 75.0

24. Change $\frac{1}{2}$ to a decimal.
   A. 2
   B. 0.02
   C. 0.2
   D. 0.5

25. Change 0.3 to a fraction in lowest terms.
   A. $\frac{3}{100}$
   B. $\frac{1}{3}$
   C. $\frac{3}{10}$
   D. 3

26. Change 0.07 to a fraction in lowest terms.
   A. $\frac{7}{100}$
   B. $\frac{7}{10}$
   C. $\frac{1}{7}$
   D. 7
Add and subtract decimals.
Add decimals through thousandths.
Subtract decimals through thousandths.

Solve These Problems

27. \(0.982 + 0.7 + 0.65\) = \\
   A. 1.054  \\
   B. 1.117  \\
   C. 2.332  \\
   D. 9.117  \\

28. \(53.869 + 42.75\) = \\
   A. 95.944  \\
   B. 96.619  \\
   C. 58.144  \\
   D. 95.619  \\

29. \(0.071 - 0.06\) = \\
   A. 0.065  \\
   B. 0.067  \\
   C. 0.076  \\
   D. 0.011  \\

30. \(0.607 - 0.438\) = \\
   A. 0.231  \\
   B. 0.169  \\
   C. 0.179  \\
   D. 0.279
Multiply decimals.

Multiply a whole number (limit: 3 digits) by a decimal (limit: thousandths).

Multiply a decimal by a decimal. (limit: thousandths).

Solve These Problems:

31. $0.695 \times 86$

A. 0.5977
B. 5.977
C. 59.77
D. 58.97

32. $0.67 \times 0.48$

A. 0.3226
B. 0.3216
C. 3.216
D. 32.16

33. $0.609 \times 3.80$

A. 2.3142
B. 0.23142
C. 2.31402
D. 0.2314

34. $5.26 \times 3.5$

A. 174.1
B. 184.10
C. 17.410
D. 18.41
Divide decimals.

Divide decimals. (limit: 5-digit dividends, 3-digit divisors).

Solve These Problems:

35. \[ \frac{53.25}{25} \]

A. 0.23  
B. 0.213  
C. 2.013  
D. 2.13

36. \[ 8.001 - 0.7 = \]

A. 1.143  
B. 10.43  
C. 11.43  
D. 114.3

37. \[ 62.5 - 0.25 = \]

A. 25  
B. 250  
C. 205  
D. 0.25

38. \[ 2.193 - 0.215 = \]

A. 1.20  
B. 12  
C. 10.2  
D. 102

243

169
FORMULAS AND CONVERSION

Amplitude Conversion

\[ E_{p-p} = 2E_p \quad E_p = \frac{E_{p-p}}{2} \]

\[ E_p = 1.414 \quad E_{RMS} = \frac{E_p}{2} \]

\[ E_p = 1.57 \quad E_{AVE} = \frac{E_p}{2} \]

\[ E_{RMS} = 1.11 \quad E_{AVE} = \frac{E_{RMS}}{2} \]

These formulas may be used for current by substituting \( I \) for \( E \).

Bandwidth

\[ BW = \frac{fr}{Q} \]

Capacitance

\[ C = \frac{Q}{V} \]

In series \( C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} \)

In parallel \( C_T = C_1 + C_2 + C_3 \cdots \)

Capacitive Reactance

\[ X_C = \frac{1}{2\pi f C} \]

In series \( X_{CT} = X_{C_1} + X_{C_2} + X_{C_3} \cdots \)

In parallel \( X_{CT} = \frac{1}{\frac{1}{X_{C_1}} + \frac{1}{X_{C_2}} + \frac{1}{X_{C_3}}} \)

Conductance

\[ G = \frac{1}{R} \]

Current

\[ I = \frac{Q}{T} \]

In impedance circuits \( I = \frac{E_T}{Z} \quad I = \frac{1}{\sqrt{2R} + (I_C - I_L)^2} \)
Frequency-Period Conversions

\[ T = \frac{1}{f} \quad f = \frac{1}{T} \]

Impedance

\[ Z = \frac{E_T}{I_T} \]

Series circuit

\[ Z = \sqrt{R^2 + (X_L - X_C)^2} \quad Z = \sqrt{R^2 + X_C^2} \]

Parallel circuit

\[ Z = \frac{R X_L}{\sqrt{R^2 + X_L^2}} \quad Z = \frac{R X_C}{\sqrt{R^2 + X_C^2}} \]

\[ Z = \frac{R X_L X_C}{\sqrt{(RX_L - RX_C)^2 + (X_L^2 - X_C^2)}} \]

Inductance: Induced voltage \( E = L(\frac{\Delta i}{\Delta T}) \)

Quality \( Q = \frac{X_L}{R} \)

In series \( L_T = L_1 + L_2 + L_3 \ldots \)

In parallel \( L_T = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} \ldots \)

Inductive Reactance: \( X_L = 2 \pi f L \)

In series \( X_{LT} = X_{L1} + X_{L2} + X_{L3} \ldots \)

In parallel \( \frac{1}{X_{L1}} + \frac{1}{X_{L2}} + \frac{1}{X_{L3}} \ldots \)

Ohms Law

\[ E = IR \quad I = \frac{E}{R} \quad R = \frac{E}{I} \]
Parallel Circuits

\[ P_T = P_{R1} + P_{R2} + P_{R3} \cdots \]

\[ R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \cdots \]

\[ E_T = E_{R1} = E_{R2} = E_{R3} \cdots \]

\[ I_T = I_{R1} + I_{R2} + I_{R3} \cdots \]

**Power**

\[ P = IE \text{ (direct current)} \]

\[ P = I^2R \quad P = \frac{E^2}{R} \]

\[ P = \frac{W}{T} \]

\[ P_{app} = IE \text{ (Alternating Current)} \]

\[ P = IE \cos \Theta \]

**Power Factor**

\[ PF = \cos \Theta \]

\[ PF = \frac{P}{P_{app}} \]

**Quality (figure of merit)**

\[ Q = \frac{X}{R} \]

**Resistance**

\[ R = \text{resistivity} \cdot \text{length} \]

\[ \text{area} \]

**Resonant Frequency**

\[ f_r = \frac{1}{2\pi \sqrt{LC}} \]

**Series Circuit**

\[ P_T = P_1 + P_2 + P_3 \cdots \]

\[ R_T = R_1 + R_2 + R_3 \cdots \]

\[ E_T = E_{R1} + E_{R2} + E_{R3} \cdots \]

\[ I_T = I_1 = I_2 = I_3 \cdots \]
Time Constant

\[ T = RC \quad \text{and} \quad T = \frac{L}{R} \]

Transformers

\[ \frac{N_{pri}}{N_{sec}} = \frac{E_{pri}}{E_{sec}} = \frac{I_{sec}}{I_{pri}} \]

\[ \left( \frac{N_{pri}}{N_{sec'}} \right)^2 = \frac{Z_{pri}}{Z_{sec}} \]

AC Voltage

\[ E = \frac{W}{Q} \]

\[ E_T = I_T Z \]

Series circuit

\[ E = \sqrt{E_R^2 + E_C^2} \quad \text{and} \quad E = \sqrt{E_R^2 + E_L^2} \]

\[ B = \sqrt{E_R^2 + (\omega L - \omega C)^2} \]
OHM'S LAW

IN THE
MAGIC TRIANGLE

\[ E = \text{volts} \]
\[ I = \text{amps} \]
\[ R = \text{ohms} \]

**Three Formulas from Ohm's Law**

A. \( E = I \times R \) or \( E = \frac{\text{Volts}}{\text{Amps} \times \text{Ohms}} \)

B. \( I = \frac{E}{R} \) or \( I = \frac{\text{Volts}}{\text{Ohms}} \)

C. \( R = \frac{E}{I} \) or \( R = \frac{\text{Ohms}}{\text{Volts} \times \text{Amps}} \)
OHM'S LAW FOR POWER
IN THE
MAGIC TRIANGLE

\[ P = \text{Watts} \]
\[ I = \text{Amps} \]
\[ E = \text{Volts} \]

THREE FORMULAS FROM OHM'S LAW FOR POWER

A. \[ P = I \times E \]
   or \( P = \text{Watts} = \text{Amps} \times \text{Volts} \)

B. \[ I = \frac{P}{E} \]
   or \( I = \text{Amps} = \frac{\text{Watts}}{\text{Volts}} \)

C. \[ E = \frac{P}{I} \]
   or \( E = \text{Volts} = \frac{\text{Watts}}{\text{Amps}} \)

250
APPENDIX 7

OHM'S LAW AND POWER LAW WORKSHEETS
# Ohms Law Worksheet I

Given two of the circuit parameters find the third.

**Formula:** \( E = I \times R \)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E=10V</td>
<td>I=0.015</td>
</tr>
<tr>
<td>2</td>
<td>E=50V</td>
<td>R=5000 ( \Omega )</td>
</tr>
<tr>
<td>3</td>
<td>I=1.5A</td>
<td>R=1.5K ( \Omega )</td>
</tr>
<tr>
<td>4</td>
<td>I=10A</td>
<td>E=50V</td>
</tr>
<tr>
<td>5</td>
<td>E=6V</td>
<td>R=50 ( \Omega )</td>
</tr>
<tr>
<td>6</td>
<td>E=120</td>
<td>I=14A</td>
</tr>
<tr>
<td>7</td>
<td>R=100K ( \Omega )</td>
<td>I=5mA</td>
</tr>
<tr>
<td>8</td>
<td>R=2.2M ( \Omega )</td>
<td>E=22KV</td>
</tr>
<tr>
<td>9</td>
<td>I=5.5A</td>
<td>E=11KV</td>
</tr>
<tr>
<td>10</td>
<td>R=47K ( \Omega )</td>
<td>I=10mA</td>
</tr>
<tr>
<td>11</td>
<td>I=16.6A</td>
<td>R=.6 ( \Omega )</td>
</tr>
<tr>
<td>12</td>
<td>E=440</td>
<td>I=3A</td>
</tr>
<tr>
<td>13</td>
<td>E=37KV</td>
<td>R=740K ( \Omega )</td>
</tr>
<tr>
<td>14</td>
<td>E=96V</td>
<td>I=400mA</td>
</tr>
<tr>
<td>15</td>
<td>I=75mA</td>
<td>R=47K ( \Omega )</td>
</tr>
<tr>
<td>16</td>
<td>R=100 ( \Omega )</td>
<td>I=5A</td>
</tr>
<tr>
<td>17</td>
<td>R=390 ( \Omega )</td>
<td>E=26V</td>
</tr>
<tr>
<td>18</td>
<td>I=.003A</td>
<td>E=54V</td>
</tr>
<tr>
<td>19</td>
<td>I=45uA</td>
<td>R=20M ( \Omega )</td>
</tr>
<tr>
<td>20</td>
<td>E=167V</td>
<td>I=16.7A</td>
</tr>
</tbody>
</table>
POWER LAW WORKSHEET

Solve the following problems using the power law formulas.

1. \( E = 120 \text{V} \) \( I = 3 \text{A} \)
2. \( E = 45 \text{V} \) \( I = 4 \text{A} \)
3. \( I = 5 \text{A} \) \( E = 1.6 \text{KV} \)
4. \( E = 34 \text{V} \) \( I = 50 \text{mA} \)
5. \( E = 60 \text{V} \) \( I = 35 \text{A} \)
6. \( E = 100 \text{V} \) \( R = 500 \Omega \)
7. \( E = 120 \text{V} \) \( R = 47 \text{K}\Omega \)
8. \( E = 120 \text{V} \) \( R = 47 \Omega \)
9. \( E = 1200 \text{V} \) \( R = 2 \Omega \)
10. \( I = 2 \text{A} \) \( R = 8 \Omega \)
11. \( I = 16 \text{A} \) \( R = 2 \Omega \)
12. \( I = 35 \text{mA} \) \( R = 39 \text{K}\Omega \)
13. \( I = 10 \) \( R = 480 \Omega \)
14. \( I = 35 \text{ma} \) \( R = 12 \text{M}\Omega \)
15. \( I = 14 \text{ma} \) \( E = 45 \text{kV} \)

For the following problems solve for the indicated quantity.

16. \( I = 6 \text{A} \) \( P = 360 \text{W} \) \( E = \) 
17. \( E = 115 \text{V} \) \( P = 3450 \text{W} \) \( I = \) 
18. \( R = 35 \Omega \) \( E = 50 \text{V} \) \( I = \) 
19. \( E = 64 \text{V} \) \( P = 320 \text{W} \) \( I = \) 
20. \( R = 34 \text{M}\Omega \) \( I = 5 \text{uA} \) \( E = \) 
21. \( E = 120 \text{V} \) \( I = 300 \text{mA} \) \( P = \) 
22. \( P = 350 \text{W} \) \( E = 120 \text{V} \) \( I = \) 
23. \( I = 5 \text{A} \) \( E = 120 \text{V} \) \( R = \) 
24. \( P = 1250 \text{W} \) \( I = 10 \text{A} \) \( E = \) 
25. \( P = 64 \text{W} \) \( R = 4 \Omega \) \( I = \)
Ohm's Law

1. \( I = 10A \) \( R = 27 \Omega \) \( E = \) 

2. \( E = 110V \) \( I = 0.02A \) \( R = \) 

3. \( E = 20V \) \( I = 5A \) \( P = \) 

4. \( E = 110V \) \( R = 2000 \Omega \) \( I = \) 

5. \( P = 120W \) \( I = 2A \) \( E = \) 

6. 7.
\[ E = 32V \]
\[ R = 800 \Omega \]
\( I = \) 
\( P = \) 

8 - 9.
\[ I = 0.005A \]
\[ R = 40,000 \Omega \]
\( E = \) 
\( P = \) 

10. \( P = 72W \) 
\[ R = 8 \]
\( I = \)
APPENDIX 8

IDENTIFICATION OF TOOLS
Tools and Equipment

FILE (SINGLE & DOUBLE CUT)  CHISEL

POWER AUGER  REAMER

PIPE CUTTER

ADJUSTABLE WRENCH  ELECTRICIAN HAMMER

STUBBY SCREWDRIVER  LINEMAN PLIERS

PHILIPS SCREWDRIVER  GROOVE JOINT PLIERS
KNOCK OUT PUNCHES

FISH TAPE

257
VOLTMETER

CLAMP AMMETER

HICKEY

LEVER (TORPEDO)

PLUMB BOB

CONDUIT BENDER
- Neon Tester Light
- Adjustable Wire Stripper
- Pocket Knife
- Awl
- Tool Pouch
- Phillips Screwdriver
- Folding Rule
- Diagonal Pliers
- Tappling Tool
- Long Nose Pliers
- Multi-Purpose Tool
TAP TOOL

RETAPPING DAMAGED THREADS

TAP TOOL
STUBBY SCREWDRIVERS

STUBBY SCREWDRIVER TIGHTENING A LUG IN LIMITED WORKING SPACE

PIPE CUTTER

FIGURE 2
PIPE REAMER

FIGURE 3

SOLDERING GUN

SOLDERING TWO WIRES TOGETHER
APPENDIX 9

GRADUATIONS OF A RULE.
Graduations on a Rule

Halves

Quarters

Eighths

Sixteenths

Thirty-seconds

Gradsuations Applied to a Rule
READING THE EIGHTHS RULE

13/8" = 1 5/8"
8/8" = 1"
7/8"
6/8" = 3/4"
5/8"
4/8" = 1/2"
3/8"
2/8" = 1/4"
1/8"
READING THE SIXTEENTHS RULE

.37/16" = 2 5/16"
22/16" = 1 6/16"
16/16" = 1"
15/16"
14/16" = 7/8"
13/16"
12/16" = 3/4"
11/16"
10/16" = 5/8"
9/16"
8/16" = 1/2"
7/16"
6/16" = 3/8"
5/16"
4/16" = 1/4"
3/16"
Study Question:

1. Use the drawing below and read the rule to the nearest one-fourth inch.

A. O-A
B. O-B
C. O-C
D. O-D
E. O-E
F. O-F

2. Use the drawing below and read the rule to the nearest one-eighth inch.

A. O-A
B. O-B
C. O-C
D. O-D
E. O-E
F. O-F
3. Use the drawing below and read the rule to the nearest one-sixteenth inch.

A. 0-A
B. 0-B
C. 0-C
D. 0-D
E. 0-E
F. 0-F

Using a rule with one-sixteenth inch graduations, measure the following objects. Convert each of the measurements to the actual size of the object. (Have instructor explain scale.)

4. Scale 1/8" = 1'

A. Length
B. Height
Study Questions: Continued

5. A. Length  
B. Height

6. A. Width  
B. Length  
C. Height
APPENDIX 10

HOUSEWIRING MATERIALS
WALL PLATES

SINGLE TOGGLE

DUPLEX RECEPTACLE

TWO TOGGLE

SINGLE TOGGLE AND
DUPLEX RECEPTACLE

SINGLE TOGGLE AND
SINGLE RECEPTACLE

TWO TOGGLE AND
DUPLEX RECEPTACLE

WEATHERPROOF SINGLE RECEPTACLE

WEATHERPROOF DUPLEX RECEPTACLE (HORIZONTAL)

WEATHERPROOF DUPLEX RECEPTACLE WITH SCREW COVERS

WEATHERPROOF DUPLEX RECEPTACLE (VERTICAL)
COMMON RESIDENTIAL RECEPTACLES

- RANGE RECEPTACLE
  125/250v, 50 amp

- DRYER RECEPTACLE
  125/250v, 30 amp

- SWITCH AND RECEPTACLE

- DUPLEX GROUNDING RECEPTACLE
  125v, 15 amp

- DUAL VOLTAGE RECEPTACLE
  125/250v, 20 amp

- AIR CONDITIONER RECEPTACLE
  250v, 20 amps

- AIR CONDITIONING RECEPTACLE
  250 volt, 30 amp

272
BOX DESIGN FEATURES

CLAMPS

NONMETALLIC CABLE CLAMPS

METALLIC CABLE CLAMP

BRACKETS

SIDE MOUNT

FRONT MOUNT

SIDE AND FRONT MOUNT

Continued
OCTAGON AND SQUARE BOXES

OCTAGON BOXES

WITH CABLE CLAMPS AND NAIL HOLES

WITH BRACKET

EXTENSION

WITH CABLE CLAMPS AND GROUNDING PIGTAIL

WITH BAR HANGER AND CABLE CLAMPS

SQUARE BOXES

SQUARE BOX (ONE PIECE MOLDED CONSTRUCTION)

SQUARE BOX (ONE PIECE WELDED CONSTRUCTION)

WITH BRACKET

WITH BRACKET, CABLE CLAMPS AND GROUNDING PIGTAIL

Fig. 1 Continued

EXTENSION

274
DEVICE BOXES

HANDY BOXES

HANDY BOX (MOLDED CONSTRUCTION)

HANDY BOX (WELDED CONSTRUCTION)

EXTENSION

BRACKET BOX

SWITCH BOXES

BRACKET

NON-GANGABLE

WITH CABLE CLAMPS

GANGABLE

WITH NAIL HOLES

GANGABLE

WITH EARS AND CABLE CLAMPS

GANGABLE

BRACKET BOX

WITH CABLE CLAMPS

WITH DRYWALL GRIPS,

CABLE CLAMPS AND EARS

BEVELED CORNER

WITH CLAMPS

GANGABLE

WITH GROUNDING PIGTAIL

NAIL ON

SOLID

TWO GANG BRACKET
BOX COVERS

ROUND COVERS

- FLAT BLANK
- FLAT WITH KNOCKOUT
- RAISED WITH KNOCKOUT
- RAISED FOR SINGLE DEVICE
- RAISED OPEN
- FLAT TOGGLE
- FLAT DUPLEX RECEPTACLE
- FLAT SINGLE RECEPTACLE

SQUARE COVERS

- FLAT BLANK
- FLAT BLANK WITH KNOCKOUT
- RAISED OPEN
- FLAT SINGLE DEVICE
- RAISED SINGLE DEVICE
- FLAT TWO DEVICE
- RAISED TWO DEVICE
APPENDIX II

READING METERS
This voltmeter will read from left to right on the scale.

1. With the range switch at 250V, the needle on the meter is indicating 235V.
2. Range switch in the 250V position. Needle is pointing to "B" on the scale. The meter is indicating 125V.
3. Range switch in the 50V position. Needle is pointing to "B" on the scale. The meter is indicating 25V.
4. Range switch in the 1000V position. (NOTE: Use the 0-10 scale when in the 1000V position.) Since 1000 is 100 times greater than 10, multiply any reading taken from the 0-10 scale by 100. Needle is pointing to "E" on the scale. The meter is indicating 2.4V x 100 = 240V.
5. Range switch in the 250V position. Needle is pointing to "A" on the scale. The meter is indicating 25V. (The reading would be more accurate if the range switch were changed to 0-50V.)
6. Range switch in the 250V position. Needle is pointing to "C" on the scale. The meter is indicating 0V. (The range switch should be switched in the direction of the lowest range until the proper range is reached.)
Read the resistances on the ohmmeter scale below. This ohmmeter scale reads from right to left.

[Diagram of ohmmeter scale]

(NOTE: The letters on the scale are there for the purpose of working this exercise and they do not appear on actual ohmmeters.)

Example: With the function switch at R x 10,000 and the needle pointing at 2 on the scale

\[ \frac{10,000}{2} = 5,000 \text{ ohms} \]
Using the Ammeter in a Circuit

Ammeter should be connected in the circuit.

NEVER across the circuit.

Fig. 1

Fig. 2
APPENDIX 12

SAMPLE LAB EXERCISES
DIODE CHARACTERISTICS

1KΩ

MATERIALS
1 KΩ resistor
1 N4001 diode
0-10 mA Ammeter
0-50 uA Ammeter
Volt ohmmeter
VTVM or electronic voltmeter
Variable Power Supply

1. Construct the circuit shown in the schematic diagram. Begin by adjusting $E_s$ to 0.2V. Record $E_d$ and current in chart. Complete chart at values indicated.

<table>
<thead>
<tr>
<th>$E_s$</th>
<th>0.2</th>
<th>0.5</th>
<th>0.7</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_d$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Is diode forward biased or reverse biased?

2. Reduce voltage to zero. Reverse diode connections and replace the 0-10 mA ammeter with a 0-50 uA ammeter. Repeat the measurements from step 1.

<table>
<thead>
<tr>
<th>$E_s$</th>
<th>0.2</th>
<th>0.5</th>
<th>0.7</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
<th>5.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_d$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Is diode forward biased or reverse biased?

Using graph paper graph the volt-ampere characteristics of the diode ($I$ vs $E_d$). Remember that at $E_d = 0$, $I = 0$. 

209
ZENER DIODE CHARACTERISTICS

1. Construct the circuit shown in the schematic above. Be sure to check the polarity of the meters. Adjust $E_s$ to 0.2V. Record diode voltage $E_d$, and current $I$, in chart below. Continue for each value of $E_s$ indicated.

<table>
<thead>
<tr>
<th>$E_s$</th>
<th>0.5</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>5.0</th>
<th>6.0</th>
<th>7.0</th>
<th>8.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_d$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I$</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Compare your results with the forward bias results from the diode characteristics lab.

2. Reduce the voltage to zero. Reverse the diode connections. Replace the 0-10 mA ammeter with the 0-50 uA ammeter. Repeat the measurement taken in Step 1. NOTE: At some voltage level the 0-50 uA ammeter may need to be replaced by the 0-10 mA. At this point be sure and reduce power to zero before making changes in the circuit.

<table>
<thead>
<tr>
<th>$E_s$</th>
<th>0.5</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>5.0</th>
<th>6.0</th>
<th>7.0</th>
<th>8.0</th>
<th>10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_d$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Using graph paper graph the volt-ampere characteristics of the diode ($I$ vs $E_d$).
SCR CHARACTERISTICS

1. Construct the circuit shown in the schematic diagram. Adjust 10KΩ pot to the middle range. Apply 15 V DC in the polarity indicated. Did the LED light? Why?

2. Reduce voltage to zero. Reverse the connections of the power supply and the diode. Reapply the 15V. What happened? Did the LED light? Why?

3. Reduce voltage and return power supply and diode connections to normal (step 1). Connect VTVM from ground to potentiometer as shown. Adjust to zero volts with meter on the 1/10 volt scale. Connect jumper wire across S1 terminals. Slowly turn potentiometer until LED lights. Record VTVM reading. This voltage is referred to as turn on voltage. Readjust potentiometer to midpoint and reduce supply voltage to zero. Remove jumper from S1. Remove VTVM.


5. Reduce supply to zero. Connect oscilloscope as shown in schematic. Replace jumper on S1 terminals. Apply voltage. LED should be lighted. Adjust potentiometer for maximum brightness of LED. Using oscilloscope, measure peak voltage of waveform. Sketch the scope display.

1. Construct the circuit shown. Using oscilloscope, adjust output of the signal generator to 0.5V peak-to-peak at 1000 HZ. Adjust potentiometer for minimum resistance. Apply signal to input and power to chip.

2. Using oscilloscope measure the voltage at points A and B.

\[ E_A = \quad E_B = \]

Determine voltage gain \( \text{Gain} = \frac{E_B}{E_A} \) Is the signal at \( E_B \) in phase or inverted as compared to \( E_A \)?

3. Adjust potentiometer to mid-range. Repeat measurements from step 2.

\[ E_A = \quad E_B = \quad \text{Gain} = \]

4. Adjust potentiometer to maximum resistance. Repeat the measurements from step 2.

\[ E_A = \quad E_B = \quad \text{Gain} = \]

5. Remove power. Replace the 100KΩ potentiometer with the 1 MΩ potentiometer. Apply power. Adjust for maximum voltage output. \( E_B = \) Determine gain. \( \text{Gain} = \) Adjust potentiometer for minimum output. Determine gain. What can you conclude about the effects of the MΩ potentiometer on the gain of the circuit?

---

I.C. AMPLIFIER

Materials
- LM3900N Quad opamp I.C.
- 2 100 KΩ Resistor
- 100 KΩ potentiometer
- 1 MΩ Resistor
- 2 MΩ Resistor
- 0.01 uf capacitor
- 1 MΩ potentiometer
- Breadboard
- Signal generator
- Oscilloscope
- Power supply

---

286

BEST COPY AVAILABLE
L.E.D. FLASHER

1. Connect circuit as indicated in schematic diagram. Note that pins 3 and 7 are not connected. Upon applying power LED should flash at a rate of approximately 6 Hertz.

2. Connect oscilloscope as shown to display output waveform. Sketch the waveform.

3. Using the oscilloscope measure the peak voltage.

4. Disconnect the circuit from power. Remove the connection from pin 1 to Capacitor \(C_1\). Be sure pin 8 is still connected to Capacitor \(C_1\). Reconnect the power. Has the output changed? How?
SQUARE WAVE GENERATOR

Construct the circuit as shown in the schematic diagram. Note that Pin 5 is not connected and that pin 3 is the output. R3 is acting as a load.

Adjust R1 for maximum resistance using ohmmeter. Connect oscilloscope to R3 as shown. Apply power to the circuit.

Sketch the output waveform. What is the peak voltage? Decrease the resistance of R1. What effect does this have on the frequency? Why?
APPENDIX 13

PRINTED CIRCUIT BOARD CONSTRUCTIONS
Direct pattern etching process.

Methods of exposing photo-sensitized circuit board.
A CLAMPING THE PC BOARD

SURPLUS BOARD MATERIAL

CUTTING LINE

C-CLAMPS

B HAND SAWING THE PC BOARD

FOIL SIDE TOWARD BLADE

Handsawing PC boards.

A DRILL POINT ANGLE

70° TO 120°

B RPM GUIDE FOR DRILLING 1/16 INCH PC BOARD MATERIALS

<table>
<thead>
<tr>
<th>DRILL SIZE</th>
<th>SPEED (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 70</td>
<td>5000</td>
</tr>
<tr>
<td>No. 65</td>
<td>5000</td>
</tr>
<tr>
<td>No. 60</td>
<td>5000</td>
</tr>
<tr>
<td>1/16 inch</td>
<td>5000</td>
</tr>
<tr>
<td>1/8 inch</td>
<td>3000</td>
</tr>
<tr>
<td>3/16 inch</td>
<td>2500</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>1700</td>
</tr>
<tr>
<td>5/16 inch</td>
<td>1300</td>
</tr>
<tr>
<td>7/16 inch</td>
<td>800</td>
</tr>
</tbody>
</table>
Design aids for making circuit board conductors
(Courtesy of THE DATAK CORPORATION)

Dry transfer design aids
(Courtesy of THE DATAK CORPORATION)
A. Clean the Copper Foil

B. Apply the Artwork

C. Immerse and Agitate Board in Etchant Bath

D. Rinse in Tap Water

E. Inspect for Defects

Direct pattern etching process.
A  HEATING THE METALS

B  APPLYING THE SOLDER

C  SOLDERING THE JOINT

MOVEMENT CAUSE A POROUS SOLDER JOINT

SOLDER DOES NOT FLOW ONTO LEAD, A HARD ROSIN BEAD SURROUNDS AND INSULATES CONNECTION.

SOLDER APPEARS TO FLOW INWARD AND SIT ON TOP OF FOIL

SOLDERING IRON POSITIONED INCORRECTLY
**A**

Notice that this connection is smooth and shiny, and that the solder blends smoothly with the terminal.

**B**

Cold solder joints have a dull, grainy texture.
APPENDIX 14

ROBOTICS
Mechanical Configuration and Coordinate System

(Courtesy Cincinnati Milacron, Lebanon, Ohio)
(Courtesy Robot Systems, Inc., Norcross, GA)
SPHERICAL COORDINATE

(Courtesy Unimation Incorporated, Danbury, CT)

CYLINDRICAL COORDINATE

(Courtesy Prab Robots, Inc., Kalamazoo, Michigan)
APPENDIX 15

BODY EFFECTS OF CURRENT

301
Body Effects on Current

Current and its effects on the human body at 120V, 60 hertz (cycle):

.0005 or less amperes -- no sensation
.0005 to .002 amperes -- threshold of perception
.002 to .010 amperes -- muscular contraction (mild to strong)
.005 to .025 amperes -- painful shock, inability to let go
.025 to .050 amperes -- violent muscular contraction
.050 to .200 amperes -- ventricular fibrillation (convulsive movement of the heart - fatal)

over .100 amperes -- paralysis of breathing (apply artificial respiration immediately)
BIBLIOGRAPHY


