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ABSTRACT

The second in a series of three curriculum packages on wiring, these materials for a five-unit course were developed to prepare postsecondary students for entry-level employment in the residential wiring trade. The five units are: (1) blueprint reading and load calculations; (2) rough-in; (3) service; (4) trim out and troubleshooting; and (5) load center changes. The first section is designed to show teachers how to use the materials and includes an explanation of instructional elements; an instructional and task analysis for each unit; a list of tools, equipment, and materials; a glossary; and a list of 14 references. The instructional elements for the units include objectives, suggested activities, handouts, information sheets, transparency masters, assignment sheets, job sheets, tests, and test answers. Some elements, such as the information sheets, include diagrams and line drawings. (CML)

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# RESIDENTIAL WIRING

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Edited by

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The Mid-America Vocational Curriculum Consortium, Inc.

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CN100772 Teacher

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# RESIDENTIAL WIRING

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## FOREWORD

*Residential Wiring* is a revision of MAVCC's 1983 wiring publication of the same name. This manual is the second in a series of three wiring publications and picks up where the basic manual ends and prepares the student for entry-level employment in the residential wiring trade.

*Basic Wiring* is the first publication in the wiring series and serves as the foundation for students enrolled in a wiring program. It is a prerequisite to either *Residential Wiring* or *Commercial and Industrial Wiring*. This series of publications should provide the flexibility that instructors need to meet the individual needs of their students and the community.

*Commercial and Industrial Wiring*, the third publication in the wiring series, includes the additional technical knowledge and applications required for job entry in the commercial and industrial wiring trade.

These publications were developed with the assistance of many individuals who have expertise in various areas of the wiring trade. Some of these individuals represent professional associations and industry. Their assistance and devotion to this project is greatly appreciated. It should be emphasized that the student needs to be aware of professional trade associations and take an active part in them as much as possible. The professional trade associations, as well as vocational education, are an excellent avenue for continuing education within the electrical trade.

Every effort has been made to make these publications basic, readable, and by all means, usable. Three vital parts of instruction have been intentionally omitted from these publications: motivation, personalization, and localization. Those areas are left to the individual instructors and the instructors should capitalize on them. As these publications are used, it is hoped that students performance will improve and that students will be better able to assume a role in electrical wiring.

Harley Schlichting, Chairman  
Board of Directors  
Mid-America Vocational  
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Greg Pierce  
Executive Director  
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Appreciation is extended to those individuals who contributed their time and talent to the development of *Residential Wiring*.

The contents of this publication were planned and reviewed by:

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**Daniel Frohberg**  
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## USE OF THIS PUBLICATION

### Instructional Units

*Residential Wiring* contains five units of instruction. Each instructional unit includes some or all of the basic components of a unit of instruction; performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the tests. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

- A. The amount of material that can be covered in each class period
- B. The skills which must be demonstrated
  - 1. Supplies needed
  - 2. Equipment needed
  - 3. Amount of practice needed
  - 4. Amount of class time needed for demonstrations
- C. Supplementary materials such as pamphlets or filmstrips that must be ordered
- D. Resource people who must be contacted

### Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

## **Suggested Activities for the Instructor**

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

### **Information Sheets**

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

### **Transparency Masters**

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

### **Assignment Sheets**

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledge which is a necessary prerequisite to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

### **Job Sheets**

Job sheets are an important segment of each unit. The instructor should be able to demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

## Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

## Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

# RESIDENTIAL WIRING

## INSTRUCTIONAL TASK ANALYSIS

**JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)**

**RELATED INFORMATION: What the Worker Should Know (Cognitive)**

### UNIT I: BLUEPRINT READING AND LOAD CALCULATIONS

1. Terms and definitions
2. Blueprint symbols
3. Electrical symbols
4. Types of lines
5. Information commonly found in blueprint specifications
6. Minimum requirements for residential outlets
7. Calculating circuit loads and voltage drop
  
8. Draw receptacle and lighting outlets of a floor plan
9. Determine general lighting loads
10. Determine small appliance and laundry loads
11. Determine total connected load plus total demand load of a dwelling
12. Locate required receptacle and lighting outlets on a house plan

**JOB TRAINING: What the  
Worker Should Be Able to Do  
(Psychomotor)**

**RELATED INFORMATION: What  
the Worker Should Know  
(Cognitive)**

**UNIT II: ROUGH-IN**

1. Terms and definitions
  2. Locations where at least one receptacle outlet is required
  3. Planning techniques when placing boxes on plans
  4. Accepted heights for boxes
  5. Procedure for installing boxes in exterior walls
  6. Box extensions for noncombustible and combustible wall surfaces
  7. Common methods of finding room centers
  8. Required outlets
  9. Rules for electrical installations
- 
10. Locate receptacle, switch, and lighting outlets along a floor line and the ceiling on a blueprint
  11. Locate receptacle outlets along kitchen cabinets
  12. Install a device box when given cabinet height and wall covering
  13. Install a lighting outlet box when given ceiling covering thickness
  14. Wire a switch controlled split-wired receptacle
  15. Wire a receptacle fed from a lighting outlet through a single pole switch
  16. Wire a receptacle fed from a lighting outlet through a three-way switch
  17. Wire a four-way switching situation with the supply entering the lighting outlet box

**JOB TRAINING: What the  
Worker Should Be Able to Do  
(Psychomotor)**

**RELATED INFORMATION: What  
the Worker Should Know  
(Cognitive)**

**UNIT III: SERVICE**

1. Terms and definitions
2. Clearances for service drop conductors
3. Service disconnects
4. Facts that should be known before service installation is started
5. Parts of a service entrance
6. Types of grounding electrodes
7. Grounding electrode conductor installations and sizes
8. Short circuit protection at service equipment
9. Surge protection
  
10. Calculate service size and minimum number of circuits
11. Install an overhead raceway with service entrance conductors to a meter base
12. Connect meter base assembly to load center or panel
13. Install an underground service (lateral) raceway with conductors to a meter base

**JOB TRAINING: What the  
Worker Should Be Able to Do  
(Psychomotor)**

**RELATED INFORMATION: What  
the Worker Should Know  
(Cognitive)**

**UNIT IV: TRIM OUT AND TROUBLESHOOTING**

1. Terms and definitions
2. Common residential receptacle types and cover plates
3. Common residential switch types and cover plates
4. Common residential fixture locations
5. Appliance classifications
6. Requirements for appliance disconnect means
7. Grounding requirements for appliances
8. Parts of a duplex grounding type receptacle
9. Parts of an equipment grounding system
10. Steps for panel trim out
11. Troubleshooting procedures
12. Install a duplex grounding type receptacle
13. Install a range or dryer receptacle
14. Install a multi-circuit split-wired duplex grounding type receptacle
15. Wire a receptacle fed from a lighting outlet through a single pole switch
16. Connect a supply cord to a free standing range
17. Install a fixed appliance equipped with a pigtail to a branch circuit
18. Install a fusible safety switch for an air-conditioning condenser
19. Troubleshoot an electrical system problem

**JOB TRAINING: What the  
Worker Should Be Able to Do  
(Psychomotor)**

**RELATED INFORMATION: What  
the Worker Should Know  
(Cognitive)**

**UNIT V: LOAD CENTER CHANGES**

1. Terms and definitions
  2. Types of load centers
  3. Reasons for load center changes
  4. Ways to increase service size on an existing dwelling
  5. Procedures for changing existing service
- 
6. Replace an existing interior flush mount load center
  7. Install a rainproof load center to supplement an existing interior load center

## RESIDENTIAL WIRING

### TOOLS, EQUIPMENT, AND MATERIALS LIST

Auxiliary lighting	Mock up wall
Awl	Nut driver set
Bar hanger	Octagon box
Bulb, 120 volt	Pencil
Bushings	16 penny nails
Cable	Plasterboard nails
Cable clamp, 3/8"	Pocket knife
Cable connector	Portable GFI
Circuit tester	Pouch tools
Copper	PVC coupling
Device box	PVC 90° elbow
Drill motor	PVC male adapter
Drop cloth	Raceway
Duplex grounding type receptacle	Raintight fusible, rigid metal conduit
Electrical supply	Rigid nonmetallic tubing
Extension cord	Rule
Fasteners	Safety glasses
Feeder wire	Safety switch
Fixed appliance with pigtail	Service entrance cap
Folding rule	Single pole switch
Free standing range	Staples
GFI	Stud wall
Hacksaw blade	Switch, three-way
Incandescent bulb, 120 volt	Switch, four-way
Keyhole saw	Tapping screws, metal
Knockout cutter set	Voltmeter
Leather gloves	Volt-ohm-ammeter
Light socket	Wire connectors
Load center	Wire strippers
Locknuts	Wood bit
Meter base	

## RESIDENTIAL WIRING

### GLOSSARY

**Air-conditioning condenser** — Refrigeration equipment that sits outside a residential dwelling and is used to remove heat from refrigerant; usually contains a hermetically sealed compressor

**Appliance** — Utilization equipment, generally other than industrial, normally built in standardized sizes of types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, or deep frying

**Appliance branch circuit** — A branch circuit supplying energy to one or more outlets to which appliances are to be connected

**Backsplash** — That portion of a wall behind the kitchen cabinet, starting at the counter top and ending at the bottom of the wall hung cabinets

**Blueprint** — Copy of the original detailed drawings of a structure

**Blueprint lines** — A set of conventional symbols to depict an object

**Box center** — Midpoint on a box's vertical dimension

**Box set out** — Distance that the box extends past the stud

**Branch circuit** — The circuit that extends from the last overcurrent protection device to the outlets

**Cable clamp** — Piece of equipment used to secure cables

**Circuit breaker** — Automatic overcurrent device that trips on overloads or shorts and is resettable

**Cutout box** — An enclosure designed for surface mounting and having swinging door or covers secured directly to and telescoping with the walls of the box proper

**Device** — Unit of an electrical system which is intended to carry but not utilize electrical energy

**Disconnecting means** — A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply

**Duplex grounding receptacle** — A single device with two grounding type receptacles

**Dwelling** — One or more rooms used for eating, living, and sleeping with permanent provisions for cooking and sanitation

**Feeder circuit** — All circuit conductors between the service equipment or the source of a separately derived system and final branch circuit overcurrent device

**Feed through** — The use of a box for splicing or rerouting conductors to get to another location

**Flush** — Even with the surface

**Full load amps (F.L.A.)** — Amperage at which equipment is designed to operate

**Grounding electrode conductor** — Conductor used to connect the grounding electrode to the equipment grounding conductor and/or the grounded conductor of the circuit at the service

**Habitable** — Suitable for people to occupy or live in

**Individual branch circuit** — Branch circuit that supplies only one piece of utilization equipment

**Life sustaining medical equipment** — Equipment necessary to keep patients alive

**Lighting outlet** — An outlet intended for the direct connection of a lampholder or light fixture

**Line leg** — Conductor that supplies electrical energy to a switch

**Load center** — A factory assembled metal cabinet consisting of fuses or circuit breakers for overcurrent protection of electrical wiring

**Multiple receptacle** — Single device with two or more receptacles

**Outage** — Period during which no current is available to circuits in a residential dwelling

**Overcurrent protection** — Weak link in the circuit that limits the amperage to a specified amount

**Pigtail** — Splicing technique that leaves an accessible conductor for termination at a device, load, or grounding terminal

**Poles** — Current carrying conductors, both grounded and ungrounded, on a receptacle

**Premises wiring** — The interior and exterior wiring including power, lighting, control and signal circuits together with associated hardware, fittings, and wiring devices

**Receptacle connecting fin** — Detachable design feature that makes terminals common connections

**Receptacle outlets** — An outlet where one or more receptacles are installed

**Roof flashing** — Protective equipment used where the mast emerges from the roof or eave to seal around the raceway and protect against water damage

**Room center** — Point in a room that is equal distance from parallel walls

**Service** — Where power is metered or is first attached to the structure

**Service cable** — Service conductors made up in the form of a cable

**Service conductors** — Supply conductors that extend from the street main or from transformers to the service equipment of the premises to be supplied

**Service drop** — Power conductors coming into building from power company

**Service entrance** — The conductors and equipment for delivering electricity from the supply system to the wiring system of the premises served

**Service entrance conductors, underground system** — Service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop

**Service equipment** — Necessary equipment, usually consisting of a circuit breaker or fuses and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply

**Service lateral** — Underground service conductors between the street main, including any risers at a pole or other structure or from transformers and the first point of connection to the service entrance conductors in a terminal box or meter or other enclosure with adequate space inside or outside the building wall

**Service mast** — That portion of a service raceway that extends through a roof or eave

**Service raceway** — Raceway that encloses the service entrance conductors

**Short circuit** — Unintentional contact of a conductor

**Single receptacle** — A single contact device with no other contact device on the same yoke

**Specifications** — A detailed set of written instructions which explain the drawing and become part of the contract

**Split-wired receptacle** — Receptacle that has had a connecting fin removed for remote control or separate circuit connections

**Strap or yoke** — Metal strip containing one or more devices

**Switch** — Device used to open or transfer circuit direction

**Switch leg** — Conductor that carries electrical energy from the switch to the load

**Switch loop** — Conductors between light and switch when supply enters the light

**Symbol** — An arbitrary sign that has been standardized and is used to represent an object, quantity, or method

**Terminal** — Point of attachment for conductors

**Tile cap** — Final tile in a ceramic backsplash when the tile is terminated at some point up the wall

Traveler — Transfer conductors in a switching situation; they are used between 3-ways and 4-ways

Trim out — Final stage in a residential wiring project; involves devices and plates, connecting and securing equipment, hanging fixtures, and testing the system

Troubleshooting — The systematic diagnosis of a malfunction

Voltage drop — A reduction in available voltage at the end of a circuit

Volt ampere — Voltage multiplied times amperage

Wires — Current carrying conductors and grounding conductors

## RESIDENTIAL WIRING

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*The National Electrical Code Handbook*. Fourth Edition. Quincy, MA: National Fire Protection Association, 1986.

# BLUEPRINT READING AND LOAD CALCULATIONS

## UNIT I

### UNIT OBJECTIVE

After completion of this unit, the student should be able to interpret blueprint drawings, identify symbols, and perform load calculations from the information provided in blueprint drawings and specifications. Competencies will be demonstrated by completing the assignment sheets and the unit test with a minimum score of 85 percent.

### SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to blueprint reading and load calculations with their correct definitions.
2. Identify blueprint symbols used in residential drawings.
3. Match electrical symbols with their correct descriptions.
4. Match types of lines with their pictures and descriptions.
5. List kinds of information commonly found in blueprint specifications.
6. Complete statements concerning minimum requirements for residential outlets.
7. Calculate circuit loads and voltage drop of a dwelling.
8. Draw receptacle and lighting outlets on a floor plan. (Assignment Sheet #1)
9. Determine general lighting loads. (Assignment Sheet #2)
10. Determine small appliance and laundry loads. (Assignment Sheet #3)
11. Determine total connected load plus total demand load of a dwelling. (Assignment Sheet #4)
12. Locate required receptacle and lighting outlets on a house plan. (Assignment Sheet #5)

# BLUEPRINT READING AND LOAD CALCULATIONS UNIT I

## SUGGESTED ACTIVITIES

- A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

- B. Provide students with objective sheet.
- C. Discuss unit and specific objectives.
- D. Provide students with information and assignment sheets.
- E. Discuss information and assignment sheets.
- F. Integrate the following activities throughout the teaching of this unit:
1. Collect and distribute to the class a number of blueprint and specification plans from local contractors.
  2. Plan for and invite a local contractor to visit the classroom and discuss the reading of blueprints and their importance in the job.
  3. Plan for and invite a local representative of the electrical inspection authority to visit the classroom to discuss the local code restrictions and how they affect the load calculations derived from blueprint and specification plans.
  4. Have the students organize into separate groups and have each group design and draw, to scale, a room or section of a house plan.

**EXAMPLE:** Group #1 will design and draw the kitchen; dining room area of the house plan complete with symbols and dimensions. Group #2 will design and draw the master bedroom and master bath area. Group #3 will design and draw the guest bedroom and hall bathroom area. Group #4 will design and draw the living room and garage area. All groups should draw their areas to scale and provide necessary symbols and specifications. A completed drawing may then be assembled and load calculations made from the composite drawing and specifications.

5. Obtain slides and films or video presentations related to blueprint reading and load calculation to show to the class.
6. Make copies of Handout #1 to distribute to class. Handout #1 will also serve as the answer sheet to Assignment Sheet #5.
7. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

## SUGGESTED ACTIVITIES

- G. Give test.
- H. Evaluate test.
- I. Reteach if necessary.

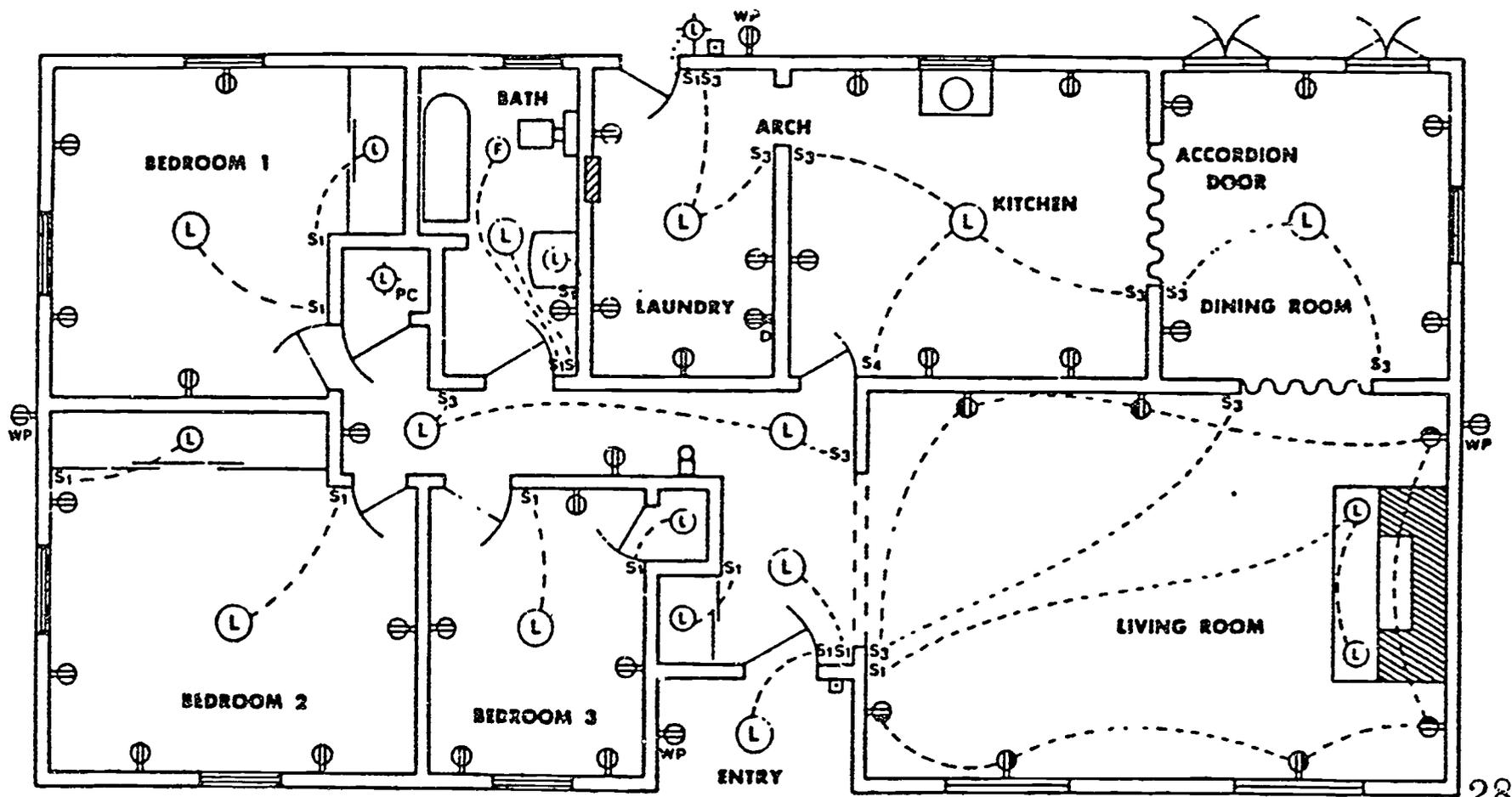
## REFERENCES USED IN WRITING THIS UNIT

- A. Gebert, Kenneth L. *Blueprint Reading*. Ninth Edition. Alsip, IL: American Technical Publications, Inc., 1983.
- B. Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- C. *The National Electrical Code Handbook*. Fourth Edition. Quincy, MA: National Fire Protection Association, 1986.

**BLUEPRINT READING AND LOAD CALCULATIONS  
UNIT I**

**HANDOUT #1 — ELECTRICAL FLOOR PLAN**

(NOTE: Floor plan appears on back of this page.)



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ELECTRICAL FLOOR PLAN

SCALE 1/8" = 1'

# BLUEPRINT READING AND LOAD CALCULATIONS

## UNIT I

### INFORMATION SHEET

#### I. Terms and definitions

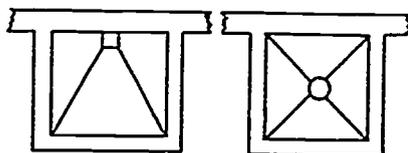
- A. Blueprint — Copy of the original detailed drawings of a structure
- B. Blueprint lines — A set of conventional symbols to depict an object
- C. Branch circuit — The circuit that extends from the last overcurrent protection device to the outlets
- D. Dwelling — One or more rooms used for eating, living, and sleeping with permanent provisions for cooking and sanitation
- E. Feeder circuit — All circuit conductors between the service equipment or the source of a separately derived system and final branch circuit overcurrent device

(NOTE: This circuit originates at the service equipment and extends to the subpanel.)

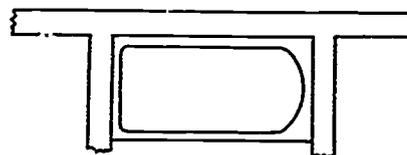
- F. Lighting outlet — An outlet intended for the direct connection of a lamp-holder or light fixture
- G. Receptacle outlets — An outlet where one or more receptacles are installed
- H. Service entrance — The conductors and equipment for delivering electricity from the supply system to the wiring system of the premises served
- I. Specifications — A detailed set of written instructions which explain the drawing and become part of the contract
- J. Symbol — An arbitrary sign that has been standardized and is used to represent an object, quantity, or method
- K. Voltage drop — A reduction in available voltage at the end of a circuit

#### II. Blueprint symbols used in residential drawings

- A. Plumbing

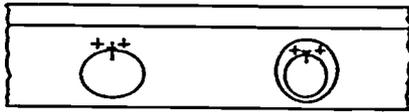


1. Showers

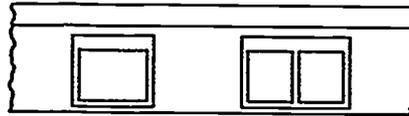


2. Built-in bathtub

### INFORMATION SHEET

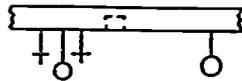


3. Built-in lavatories

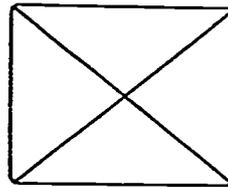


4. Single bowl sink

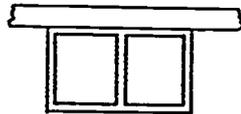
5. Double bowl sink



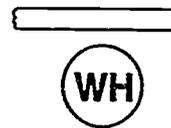
6. Shower heads



7. Furnace  
(designate fuel  
and capacity)



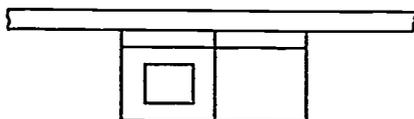
8. Laundry tubs



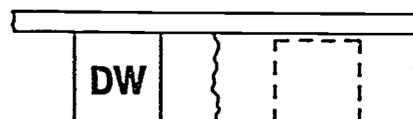
9. Water heater  
(designate capacity  
and fuel)

## INFORMATION SHEET

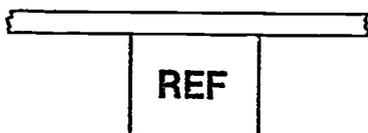
### B. Appliances



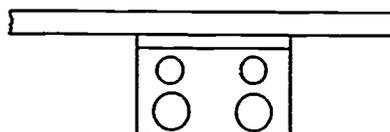
1. Washer and dryer



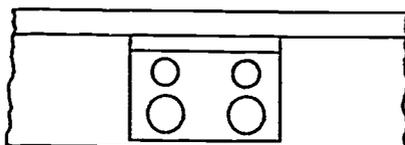
2. Freestanding and built-in dishwashers



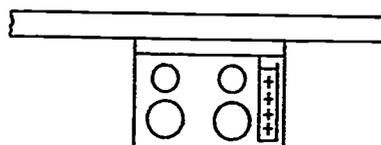
3. Refrigerator



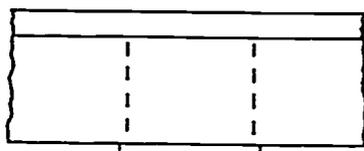
4. Freestanding range



5. Drop-in range



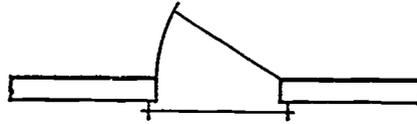
6. Surface cook top



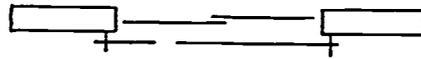
7. Built-in oven

## INFORMATION SHEET

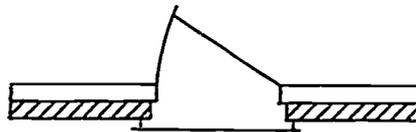
### C. Structural symbols



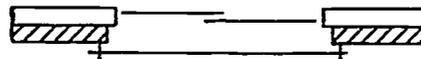
1. Plan view of exterior door in wood frame wall



2. Plan view of exterior sliding door in wood frame wall



3. Plan view of exterior door in masonry veneer wall



4. Plan view of exterior sliding door in masonry veneer wall



5. Plan view of interior hinged door



6. Plan view of interior pocket door

**INFORMATION SHEET**



7. Single window in frame wall



8. Multiple windows in frame wall



9. Plan view of double hung window in frame wall

**III. Electrical symbols**

**A. Convenience outlets**



Ceiling outlet



Fluorescent fixture



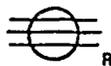
Junction box



Convenience outlet other than duplex  
1=single, 3=triplex, etc.



Weatherproof convenience outlet



Range outlet



Switch and convenience outlet



Duplex receptacle



Duplex receptacle split wired

## INFORMATION SHEET

 120/240, 1 $\phi$  combination receptacle

 Floor outlet (attach additional symbol for recept. tel., etc.)

 Special outlet—as noted

 240V, 4W, 3P receptacle—amps as noted

 240V, 3W, 2P receptacle—amps as noted

 Ground

 Fuse

 Circuit breaker

### B. Switch outlets

S Single pole switch

S<sub>2</sub> Double pole switch

S<sub>3</sub> Three-way switch

S<sub>4</sub> Four-way switch

S<sub>D</sub> Dimmer switch

S<sub>K</sub> Key operated switch

S<sub>P</sub> Switch and pilot light

S<sub>MC</sub> Momentary contact switch

## INFORMATION SHEET

Ⓣ Thermostat

Ⓜ Humidistat

### C. Panels, circuits, and miscellaneous

 Lighting panel

 Power panel

— Branch circuit; concealed in ceiling or wall

--- Branch circuit; concealed in floor

----- Branch circuit; exposed

→→ Home run to panel board; indicate number of circuits by number of arrows.

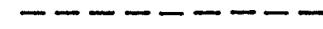
— Feeders

### IV. Types of lines

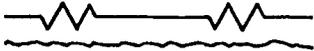
A. Object lines — (  ) — Show the main outline of the building including exterior walls, interior partitions, porches, patios, driveways, and interior walls; these lines should be the outstanding lines on a drawing

B. Dimension lines — (  ) — Thin unbroken lines which building dimensions are placed upon

C. Extension lines — (  ) — Extend, but do not touch the object lines and permit dimension lines to be drawn between them

D. Hidden lines — (  ) — Short dashes used to show lines that are not visible from that view

E. Center lines — (  ) — A series of short and long dashes used to designate the center of doors, windows, and circles and to provide a reference point for dimensioning

F. Break lines — (  ) — Used when an area cannot or should not be drawn entirely

G. Leaders — (  ) — Used to connect a note or dimension to a part of the building

## INFORMATION SHEET

### V. Information commonly found in blueprint specifications

- A. Sizes
- B. Types and quality of building materials
- C. Methods of construction
- D. Material lists

(NOTE: This can include electrical lists as supplied by the electrical contractor in bids to the general contractor)

- E. Owner's name and address
- F. Contractor's name and address
- G. Location of new structure
- H. Completion date
- I. Contractor's bid
- J. Guarantees
- K. Blueprint number

### VI. Minimum requirements for residential outlets

- A. Receptacles — Installed so that no point along the floor line in any wall space is more than 6 feet from an outlet

(NOTE: This is one minimum requirement. For other requirements see NEC Art: 210-52.)

- B. Switches — Located so that they may be operated from a readily accessible place

(NOTE: Install opposite hinge side of door. Other minimum requirements for switches are covered in NEC Art: 380.)

- C. Lighting — At least one wall switch controlled lighting outlet shall be installed in every habitable room, halls, stairways, attached garages, bathrooms, and outdoor entrances to residences

(NOTE: Other lighting outlet requirements covered in NEC Art: 210-70.)

## INFORMATION SHEET

### VII. Calculating circuit loads and voltage drop of a dwelling

A. Branch circuits — All branch circuit loads of a dwelling may be grouped into one of three categories: (1) general lighting load, (2) small appliance and laundry load, and (3) special appliance load.

1. General lighting load — To determine the general lighting load, multiply 3 volt amps (watts) times the total square foot area of the dwelling unit.

(NOTE: NEC Art: 220-3[b] Table list the unit load required per square foot.)

2. Small appliance and laundry load — The small appliance and laundry loads are figured at 1,500 volt-amps (watts) for each two wire circuit.

(NOTE: NEC Art: 220-16 lists requirements for small appliance and laundry circuits.)

3. Special appliance load — The special appliance loads are determined by the kilowatt rating listed on the nameplate.

(NOTE: NEC Art: 220-3 and 220-10[a] list requirements for special appliance loads.)

B. Feeder circuits (subpanels) — The computed load for the feeders shall not be less than the sum of the loads on the branch circuits supplied.

(NOTE: NEC Art: 220-10 covers feeder calculations.)

C. Total load (service) — All loads in a dwelling are not used simultaneously or for extended periods of time. The application of demand factors will produce lower total demand loads. Lower demand loads require small service entrance conductors, resulting in less material cost for the job.

(NOTE: Demand factors for dwelling loads are listed in NEC Art's: 220-11 [general lighting and receptacle load], 220-17 [fixed appliance load], 220-18 [dryer load], and 220-19 [range load].)

D. Voltage drop — The formula for calculating voltage drop is,

$$VD = \frac{2 \times L \times R \times I}{1000}$$

VD = Voltage Drop

L = One way length of circuit in feet

R = Conductor resistance in ohms per 1000 feet

(NOTE: See Chapter 9, Table 8 of the NEC.)

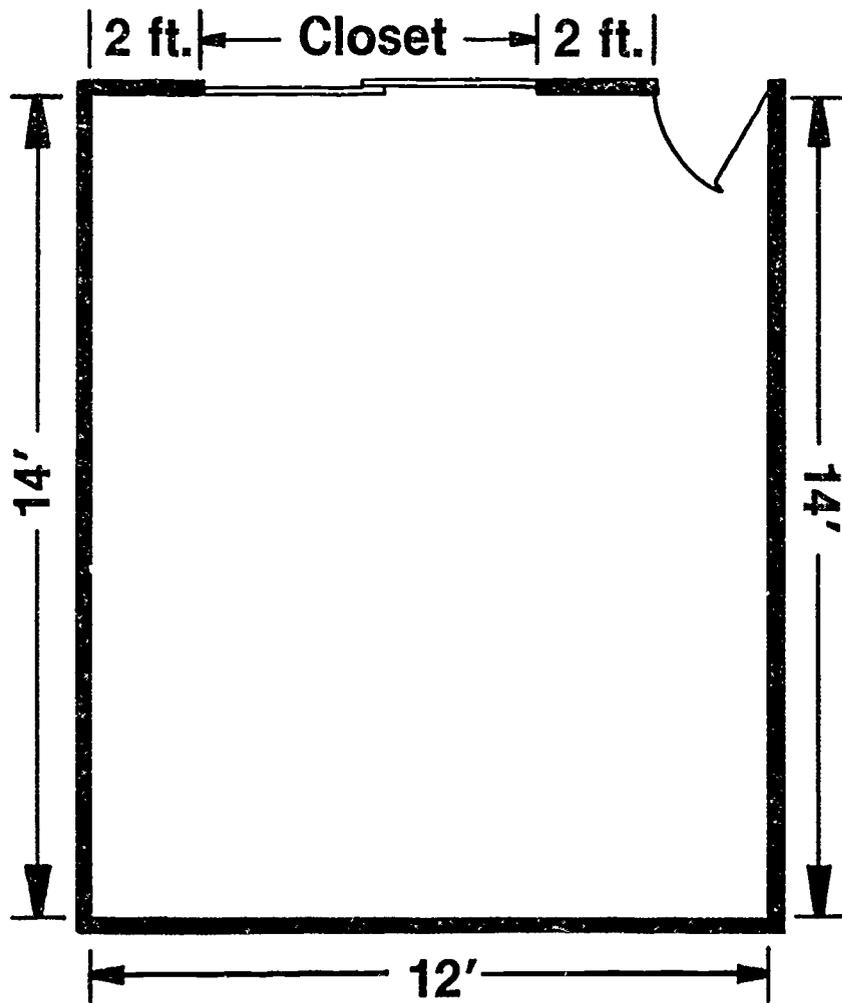
I = Load current (amperes)

# BLUEPRINT READING AND LOAD CALCULATIONS UNIT I

## ASSIGNMENT SHEET #1 — DRAW RECEPTACLE AND LIGHTING OUTLETS ON A FLOOR PLAN

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

Directions: Using electrical symbols, draw locations of receptacle outlets and lighting outlets for the floor plan below. Refer to NEC Art: 210-52 for minimum spacing and location.



# BLUEPRINT READING AND LOAD CALCULATIONS UNIT I

## ASSIGNMENT SHEET #2 — DETERMINE GENERAL LIGHTING LOADS

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

Directions: List the general lighting loads for the following dwellings. Use NEC Art: 220-3(b) to determine general lighting load minimum requirements. Show all computations in space provided.

1. 3200 sq. ft. with no garage. \_\_\_\_\_

2. 2750 sq. ft. with no garage. \_\_\_\_\_

3. 4100 sq. ft. including a 20 ft. x 24 ft. garage. \_\_\_\_\_



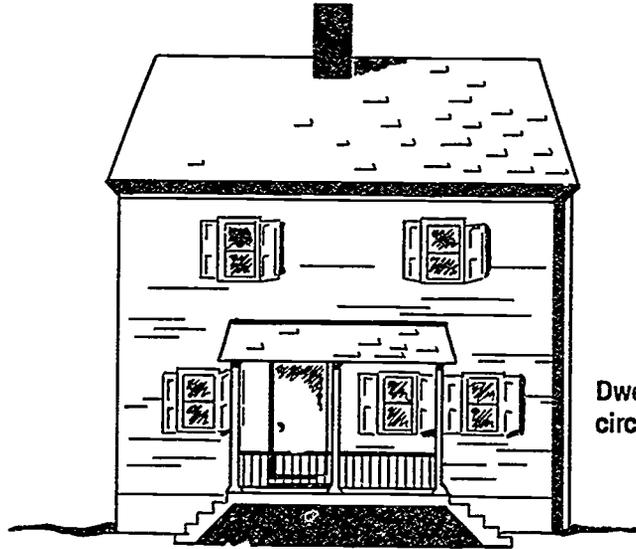
# BLUEPRINT READING AND LOAD CALCULATIONS UNIT I

## ASSIGNMENT SHEET #4 — DETERMINE TOTAL CONNECTED LOAD PLUS TOTAL DEMAND LOAD OF A DWELLING

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

Directions: Calculate the total connected load for the dwelling described below. Next apply appropriate demand factors to determine the total demand load.

(NOTE: NEC Art: 220-11 and accompanying Table will provide proper demand percentage information.)



2400 Sq. Ft. Dwelling

Dwelling has two small appliance circuits and one laundry circuit.

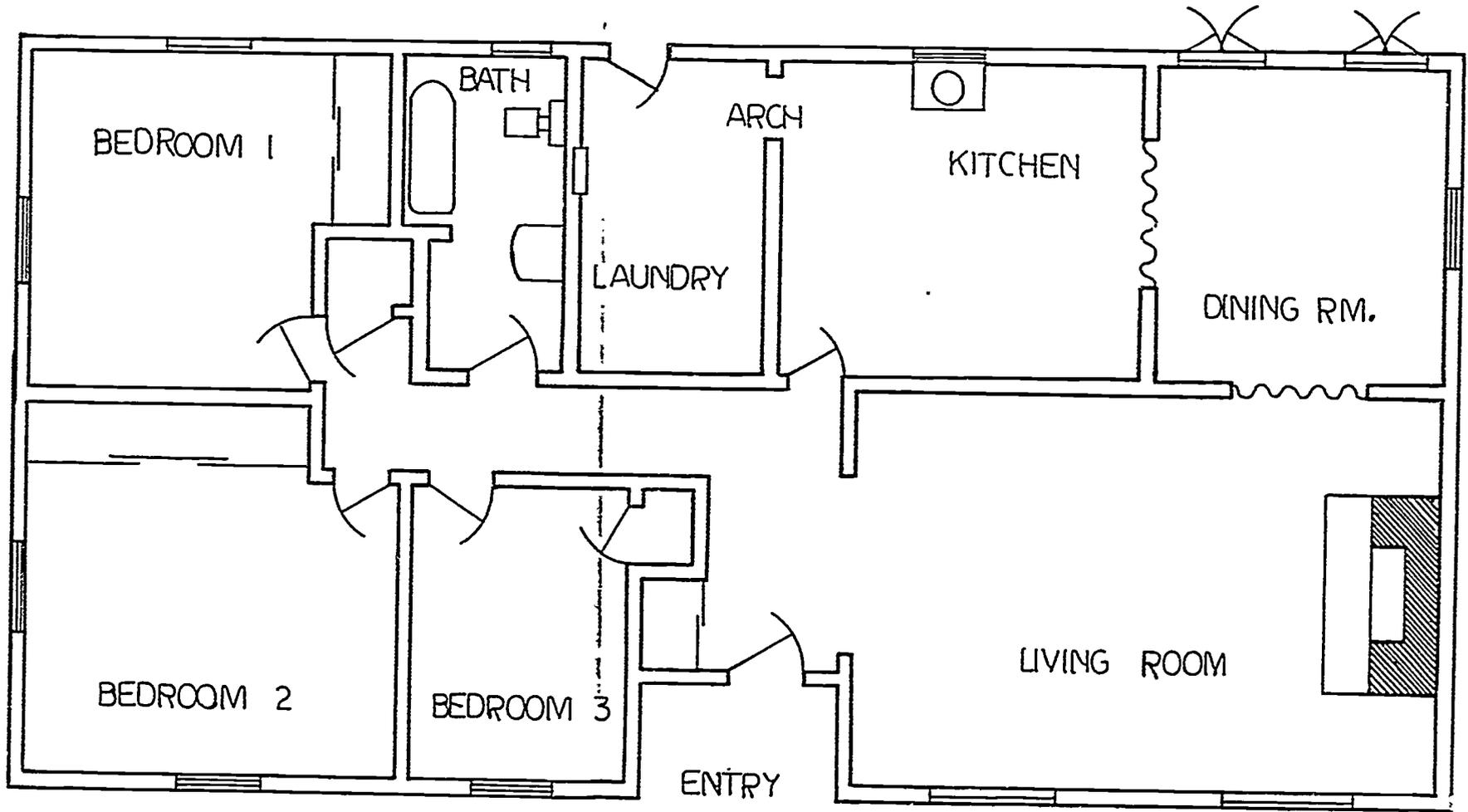
Step #1	2400 sq. ft.	_____	VA
Step #2	2 small appliance circuits	_____	VA
Step #3	1 laundry circuit	_____	VA
	Total connected load	_____	VA
Step #4	(NEC Table 220-11)		
	x %	_____	VA
	x %	_____	VA
	Total demand load	_____	VA

# BLUEPRINT READING AND LOAD CALCULATIONS UNIT I

## ASSIGNMENT SHEET #5 — LOCATE REQUIRED RECEPTACLE AND LIGHTING OUTLETS ON A HOUSE PLAN

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

Directions: Using the information provided in this unit and the NEC requirements, draw in the electrical symbols for the receptacle and lighting outlets to meet minimum requirements on the accompanying house plan.

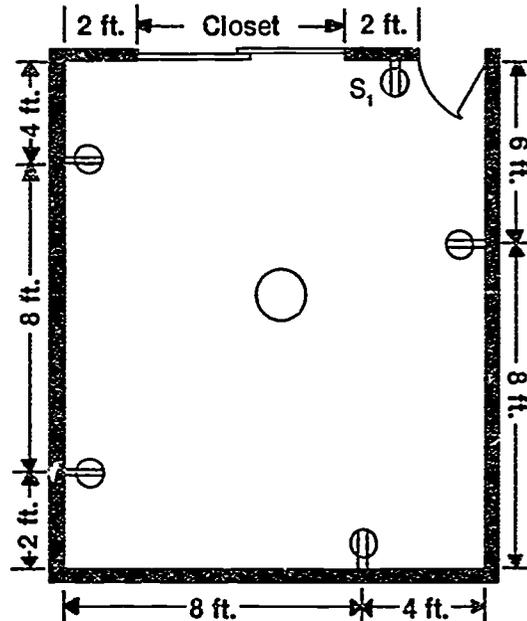


ELECTRICAL FLOOR PLAN

# BLUEPRINT READING AND LOAD CALCULATIONS UNIT I

## ANSWERS TO ASSIGNMENT SHEETS

### Assignment Sheet #1



(NOTE. This answer represents one possible solution. Instructor may evaluate to own satisfaction.)

### Assignment Sheet #2

- |    |                             |                    |
|----|-----------------------------|--------------------|
| 1. | 3200 sq. ft. × 3VA =        | 9600 VA            |
| 2. | 2750 sq. ft. × 3VA =        | 8250 VA            |
| 3. | 4100 sq. ft.                | 24 ft.             |
|    | <u>- 480 sq. ft. garage</u> | <u>× 20 ft.</u>    |
|    | 3620 sq. ft.                | 480 sq. ft. garage |

$$3620 \text{ sq. ft.} \times 3VA = 10,860 \text{ VA}$$

### Assignment Sheet #3

- |    |                                         |                                     |
|----|-----------------------------------------|-------------------------------------|
| 1. | Small appliance circuits                | 2 circuits × 1500VA = 3000 VA       |
|    | Laundry circuits                        | 1 circuit × 1500VA = <u>1500 VA</u> |
|    | Total small appliance and laundry loads | 3 circuits × 1500VA = 4500 VA       |
| 2. | Small appliance circuits                | 4 circuits × 1500VA = 6000 VA       |
|    | Laundry circuits                        | 1 circuit × 1500VA = <u>1500 VA</u> |
|    | Total small appliance and laundry loads | 5 circuits × 1500VA = 7500 VA       |

## ANSWERS TO ASSIGNMENT SHEETS

### Assignment Sheet #4

Step #1	2400 sq. ft. x 3VA	=	7200 VA
Step #2	2 small appliance circuits x 1500VA	=	3000 VA
Step #3	1 laundry circuit x 1500VA	=	1500 VA
	Total connected load	=	11,700 VA
Step #4			
	1st 3000 x 100%		3000 VA
	Remaining 8700 x 35%		3045 VA
	Total demand load	=	11,700 VA

Assignment Sheet #5 — Evaluated to the satisfaction of the instructor.

(NOTE: See Handout #1 for detailed outlet layout.)

# BLUEPRINT READING AND LOAD CALCULATIONS UNIT I

## TEST

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

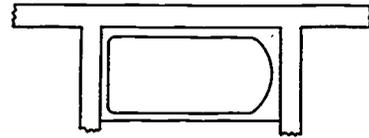
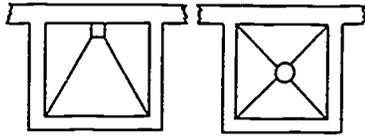
1. Match the terms on the right with their correct definitions.

- |         |                                                                                                                                                |                      |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| _____a. | A set of conventional symbols to depict an object                                                                                              | 1. Blueprint         |
| _____b. | One or more rooms used for eating, living, and sleeping with permanent provisions for cooking and sanitation                                   | 2. Blueprint lines   |
| _____c. | An outlet intended for the direct connection of a lampholder or light fixture                                                                  | 3. Branch circuit    |
| _____d. | A detailed set of written instructions which explain the drawing and become part of the contract                                               | 4. Dwelling          |
| _____e. | A reduction in available voltage at the end of a circuit                                                                                       | 5. Feeder circuit    |
| _____f. | Copy of the original detailed drawings of a structure                                                                                          | 6. Lighting outlet   |
| _____g. | An outlet where one or more receptacles are installed                                                                                          | 7. Receptacle outlet |
| _____h. | All circuit conductors between the service equipment or the source of a separately derived system and final branch circuit over-current device | 8. Service entrance  |
| _____i. | An arbitrary sign that has been standardized and is used to represent an object, quantity, or method                                           | 9. Specification     |
| _____j. | The circuit that extends from the last over-current protection device to the outlets                                                           | 10. Symbols          |
| _____k. | The conductors and equipment for delivering electricity from the supply system to the wiring system of the premises served                     | 11. Voltage drop     |

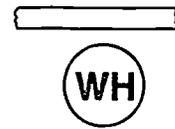
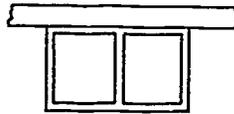
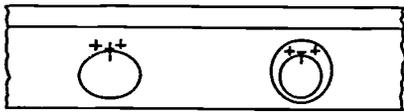
TEST

2. Identify blueprint symbols used in residential drawings.

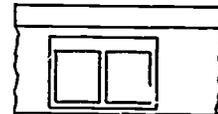
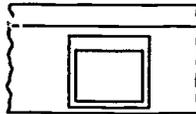
a. Plumbing



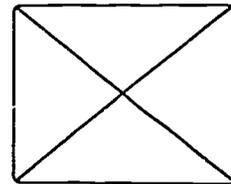
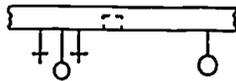
1) \_\_\_\_\_ 2) \_\_\_\_\_



3) \_\_\_\_\_ 4) \_\_\_\_\_ 5) \_\_\_\_\_



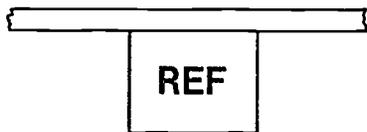
6) \_\_\_\_\_ 7) \_\_\_\_\_



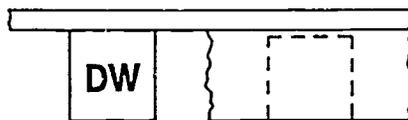
8) \_\_\_\_\_ 9) \_\_\_\_\_

TEST

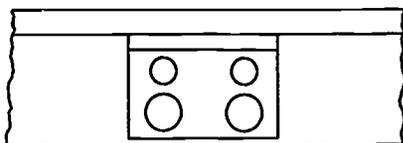
b. Appliances



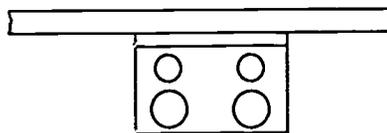
1) \_\_\_\_\_



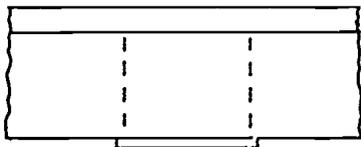
2) \_\_\_\_\_



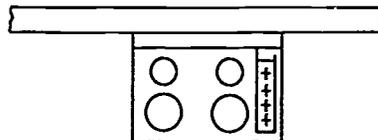
3) \_\_\_\_\_



4) \_\_\_\_\_



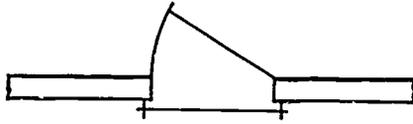
5) \_\_\_\_\_



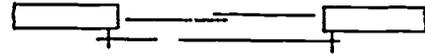
6) \_\_\_\_\_

TEST

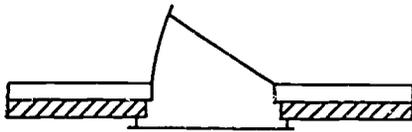
c. Structural symbols



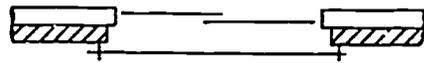
1) \_\_\_\_\_



2) \_\_\_\_\_



3) \_\_\_\_\_



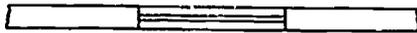
4) \_\_\_\_\_



5) \_\_\_\_\_



6) \_\_\_\_\_



7) \_\_\_\_\_



8) \_\_\_\_\_



9) \_\_\_\_\_

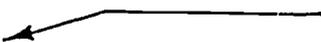
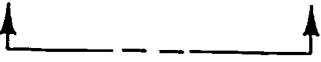
TEST

3. Match the electrical symbols on the right with their correct descriptions.

- |       |                                              |     |                                                                                       |
|-------|----------------------------------------------|-----|---------------------------------------------------------------------------------------|
| ___a. | Ceiling outlet                               | 1.  |    |
| ___b. | Range outlet                                 | 2.  | S <sub>2</sub>                                                                        |
| ___c. | Double pole switch                           | 3.  |    |
| ___d. | Fluorescent fixture                          | 4.  | S <sub>4</sub>                                                                        |
| ___e. | Lighting panel                               | 5.  | S <sub>D</sub>                                                                        |
| ___f. | Branch circuit; exposed                      | 6.  |    |
| ___g. | Duplex receptacle                            | 7.  | S <sub>p</sub>                                                                        |
| ___h. | Ground                                       | 8.  | S <sub>mc</sub>                                                                       |
| ___i. | Floor outlet                                 | 9.  |    |
| ___j. | Momentary contact switch                     | 10. |    |
| ___k. | Power panel                                  | 11. |   |
| ___l. | Four-way switch                              | 12. | -----                                                                                 |
| ___m. | Dimmer switch                                | 13. |  |
| ___n. | 240V, 3w, 2p receptacle                      | 14. |  |
| ___o. | Switch and convenience outlet                | 15. |  |
| ___p. | Branch circuit; concealed in ceiling or wall | 16. |  |
| ___q. | Fuse                                         | 17. |  |
| ___r. | Junction box                                 | 18. |  |
| ___s. | Switch and pilot light                       | 19. |  |
| ___t. | Feeders                                      | 20. |  |
| ___u. | Circuit breaker                              | 21. |  |
| ___v. | Home run to panel board                      | 22. |  |
| ___w. | 120/240, 1φ combination receptacle           | 23. |  |
| ___x. | Thermostat                                   | 24. |  |

TEST

4. Match the types of lines on the right with their pictures and descriptions.

- |                                                                                                                                                                                                                                                                                                          |                                                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| <p>_____ a. </p> <p>Used to connect a note or dimension to a part of the building</p>                                                                                                                                   | <p>1. Object lines</p>                           |
| <p>_____ b. </p> <p>Short dashes used to show lines that are not visible from that view</p>                                                                                                                             | <p>2. Center lines</p>                           |
| <p>_____ c. </p> <p>Heavy lines consisting of a series of one long and two short dashes with arrows at each end pointing away from the area that is cut away for the purpose of sectioning</p>                          | <p>3. Leaders</p> <p>4. Cutting-plane lines</p>  |
| <p>_____ d. </p> <p>Thin unbroken lines which building dimensions are placed upon</p>                                                                                                                                   | <p>5. Hidden lines</p> <p>6. Dimension lines</p> |
| <p>_____ e. </p> <p>Used when an area cannot or should not be drawn entirely</p>                                                                                                                                        | <p>7. Break lines</p>                            |
| <p>_____ f. </p> <p>A series of short and long dashes used to designate the center of doors, windows, and circles and to provide a reference point for dimensioning</p>                                               |                                                  |
| <p>_____ g. </p> <p>Show the main outline of the building including exterior walls, interior partitions, porches, patios, driveways, and interior walls; these lines should be the outstanding lines on a drawing</p> |                                                  |

5. List five kinds of information commonly found in blueprint specifications.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_
- e. \_\_\_\_\_

TEST

6. Complete the following statements concerning minimum requirements for residential outlets by inserting the words which best complete each statement.

- a. Receptacles — Installed so that no point along the \_\_\_\_\_  
\_\_\_\_\_ in any wall space is more than \_\_\_\_\_ feet  
from an outlet
- b. Switches — Located so that they may be \_\_\_\_\_ from a readily  
accessible place
- c. Lighting — At least \_\_\_\_\_ wall switch controlled lighting outlet  
shall be installed in every \_\_\_\_\_ room, halls, stairways, attached  
garages, bathroom, and outdoor entrances to a residence

7. Calculate circuit loads and voltage drop for the example below.

Dwelling has a floor space of 2,100 square feet. It also has an 11 kw electric range.

General lighting load

a. \_\_\_\_\_ sq. ft.  $\times$  3 watts per sq. ft. = b. \_\_\_\_\_

Minimum number of branch circuits

General lighting load c. \_\_\_\_\_  $\div$  115 = d. \_\_\_\_\_  $\div$  20 = e. \_\_\_\_\_  
or number of general lighting circuits

(NOTE: This number always rounds to next whole number if a fraction appears.)

Small appliance load: Two 2-wire 20 ampere circuits

Laundry load: One 2-wire 20 ampere circuit.

Minimum size feeders required

Computed load

General lighting	f. _____ watts
Small appliance	+3,000 watts
Laundry	+1,500 watts
Total (without range)	g. _____ watts
3,000 watts at 100% =	3,000 watts
Total (without range) h. _____ - 3,000 =	
_____ watts $\times$ 35% =	i. _____ watts
Net computed load (without range)	j. _____ watts
Range load	8,000 watts
Net computed load (with range)	k. _____ watts

A branch circuit conductor with a resistance of 1.93 ohm per mft. is installed at a length of 110 ft. This circuit has a load current of 12 amps. Calculate the voltage drop for this circuit.

l. \_\_\_\_\_

**TEST**

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

8. Draw receptacle and lighting outlets on a floor plan. (Assignment Sheet #1)
9. Determine general lighting loads. (Assignment Sheet #2)
10. Determine small appliance and laundry loads (Assignment Sheet #3)
11. Determine total connected load plus total demand load of a dwelling. (Assignment Sheet #4)
12. Locate required receptacle and lighting outlets on a house plan. (Assignment Sheet #5)

# BLUEPRINT READING AND LOAD CALCULATIONS UNIT I

## ANSWERS TO TEST

1.   a.   2                   g.   7  
      b.   4                   h.   5  
      c.   6                   i.   10  
      d.   9                   j.   3  
      e.   11                  k.   8  
      f.   1
2.   a.   Plumbing  
      1) Showers  
      2) Built-in bathtub  
      3) Built-in lavatories  
      4) Laundry tubs  
      5) Water heater  
      6) Single bowl sink  
      7) Double bowl sink  
      8) Shower heads  
      9) Furnace
- b.   Appliances  
          1) Refrigerator  
          2) Dishwasher (freestanding or built-in)  
          3) Drop-in range  
          4) Free standing range  
          5) Built-in oven  
          6) Surface cook top
- c.   Structural symbols  
          1) Exterior door in wood frame wall  
          2) Exterior sliding door in wood frame wall  
          3) Exterior door in masonry veneer wall  
          4) Exterior sliding door in masonry veneer wall  
          5) Interior hinged door  
          6) Interior pocket door  
          7) Single window in frame wall  
          8) Multiple windows in frame wall  
          9) Double hung window in frame wall
3.   a.   3                   i.   20                   q.   13  
      b.   15                  j.   8                   r.   11  
      c.   2                   k.   1                  s.   7  
      d.   10                 l.   4                  t.   6  
      e.   21                 m.   5                 u.   24  
      f.   12                 n.   23                v.   14  
      g.   17                 o.   16                w.   19  
      h.   22                 p.   18                x.   9

## ANSWERS TO TEST

4. a. 3                    e. 7  
 b. 5                    f. 2  
 c. 4                    g. 1  
 d. 6

5. Answer five of the following:

- a. Sizes
- b. Types and quality of building materials
- c. Methods of construction
- d. Material lists
- e. Owner's name and address
- f. Contractor's name and address
- g. Location of new structure
- h. Completion date
- i. Contractor's bid
- j. Guarantees
- k. Blueprint number

6. a. Floor line, 6  
 b. Operated  
 c. One, habitable

7. a. 2,100                g. 10,800  
 b. 6,300                h. 10,800  
 c. 6,300                i. 2,730  
 d. 54.8                 j. 5,730  
 e. 3                     k. 13,730  
 f. 6,300                l. 5.095

8-12. Evaluated to the satisfaction of the instructor.

## **ROUGH-IN UNIT II**

### **UNIT OBJECTIVE**

After completion of this unit, the student should be able to locate and install receptacle, switch, and lighting outlets for a residential dwelling. Competencies will be demonstrated by completing the assignment sheets, job sheets, and the unit tests with a minimum score of 85 percent.

### **SPECIFIC OBJECTIVES**

After completion of this unit, the student should be able to:

1. Match terms related to rough-in with their correct definitions.
2. List five locations where at least one receptacle outlet is required.
3. Select true statements concerning planning techniques when placing boxes on plans.
4. Complete statements concerning accepted heights for boxes in various locations.
5. Select true statements concerning the procedure for installing boxes in exterior walls to be brick veneered.
6. Distinguish between box extensions for noncombustible and combustible wall surfaces.
7. List two common methods of finding room centers.
8. Select true statements concerning required outlets.
9. Complete statements concerning rules for electrical installations.
10. Locate receptacle, switch, and lighting outlets along a floor line and the ceiling on a blueprint. (Assignment Sheet #1)

**OBJECTIVE SHEET**

11. Locate receptacle outlets along kitchen cabinets. (Assignment Sheet #2)
12. Demonstrate the ability to:
  - a. Install a device box when given cabinet height and wall covering. (Job Sheet #1)
  - b. Install a lighting outlet box when given ceiling covering thickness. (Job Sheet #2)
  - c. Wire a switch controlled split-wired receptacle. (Job Sheet #3)
  - d. Wire a receptacle fed from a lighting outlet through a single pole switch. (Job Sheet #4)
  - e. Wire a receptacle fed from a lighting outlet through a three-way switch. (Job Sheet #5)
  - f. Wire a four way switching situation with the supply entering the lighting outlet box. (Job Sheet #6)

## ROUGH-IN UNIT II

### SUGGESTED ACTIVITIES

- A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

- B. Make transparencies from the transparency masters included with this unit.
- C. Provide students with objective sheet.
- D. Discuss unit and specific objectives.
- E. Provide students with information and assignment sheets.
- F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

- G. Provide students with job sheets.
- H. Discuss and demonstrate the procedures outlined in the job sheets.
- I. Integrate the following activities throughout the teaching of this unit:
1. Take a field trip to a residential construction site where electrical rough-in is exposed.
  2. Have local or state inspector talk to class about area building codes pertaining to the wiring of new dwellings.
  3. Reinforce safety precautions concerning electrical installations.
  4. Make extra project assignments to build student's proficiency.
  5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

- J. Give test.
- K. Evaluate test.
- L. Reteach if necessary.

## REFERENCES USED IN WRITING THIS UNIT

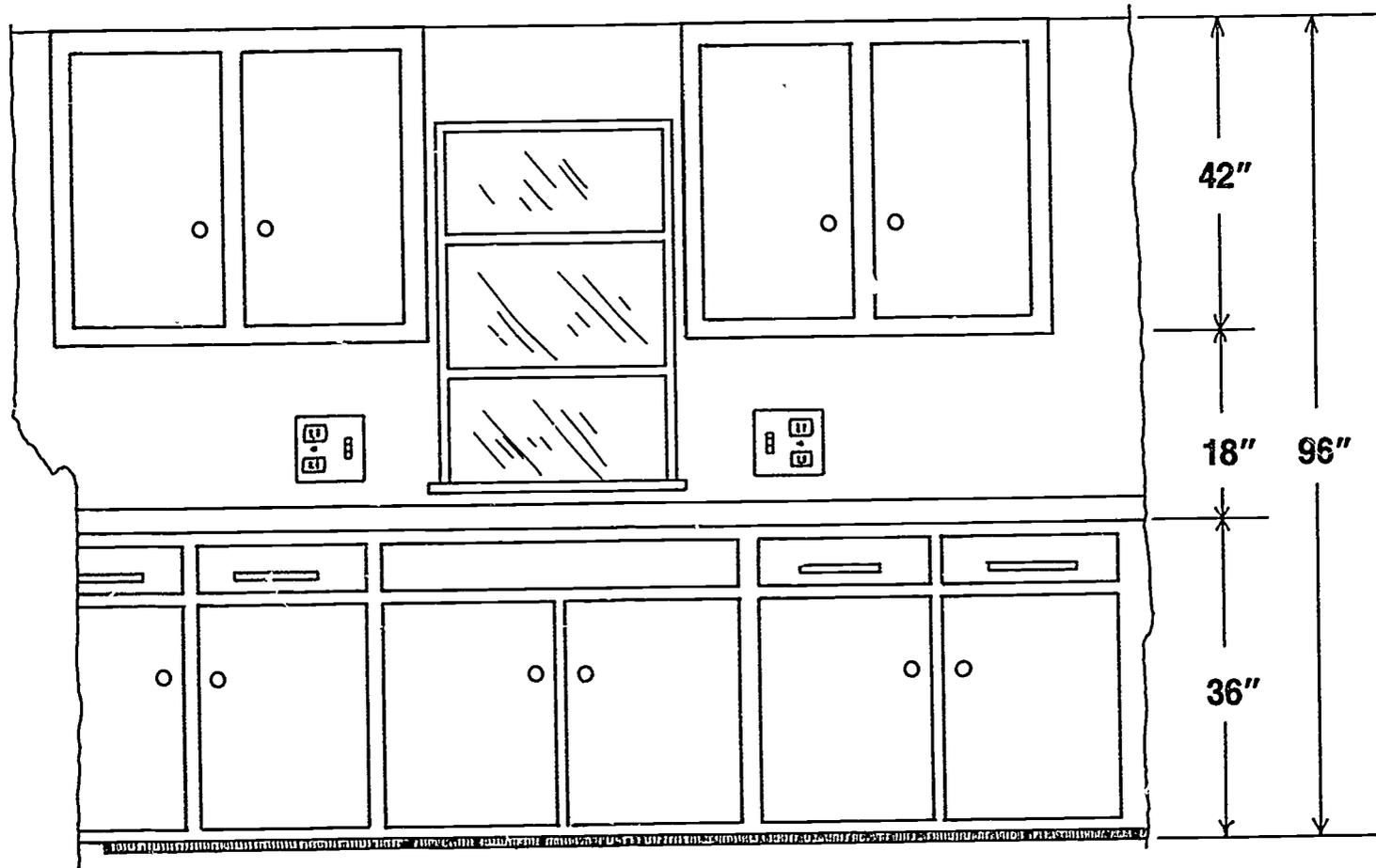
- A. *National Electrical Code, 1987*. Quincy, MA: National Fire Protection Association, 1986.
- B. Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

## SUGGESTED SUPPLEMENTAL MATERIAL

Texts...

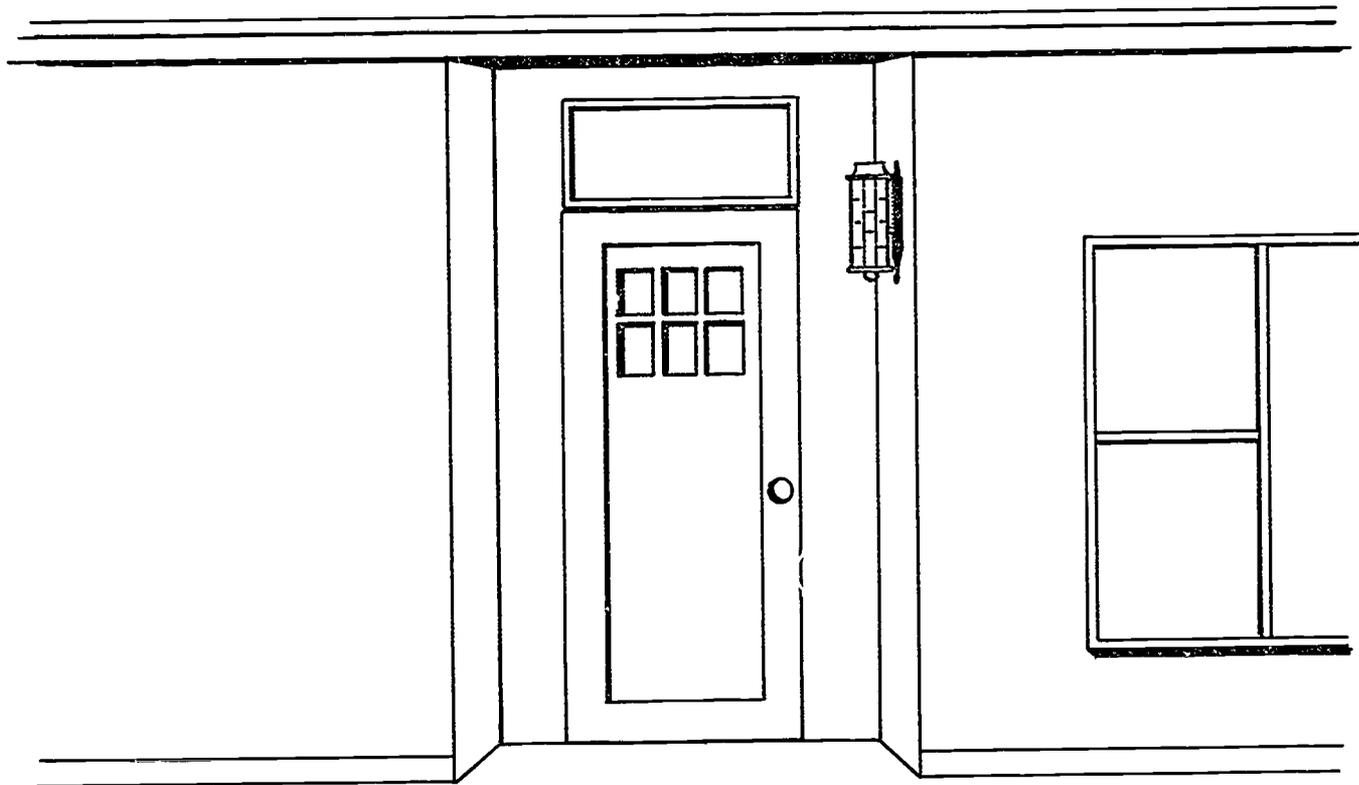
- A. *Designing Electrical Systems*. American Technical Publishers, Homewood, IL 60430.
- B. Holzman, Harvey N. *Modern Residential Wiring*. South Holland, IL: Goodheart-Willcox Company Inc., 1986.

# Placement of Electrical Outlets in the Kitchen



Putting Switches and Receptacles in Even Groups  
Makes the Job Look Planned

## Box Locations (Outside Entrance and Exit)

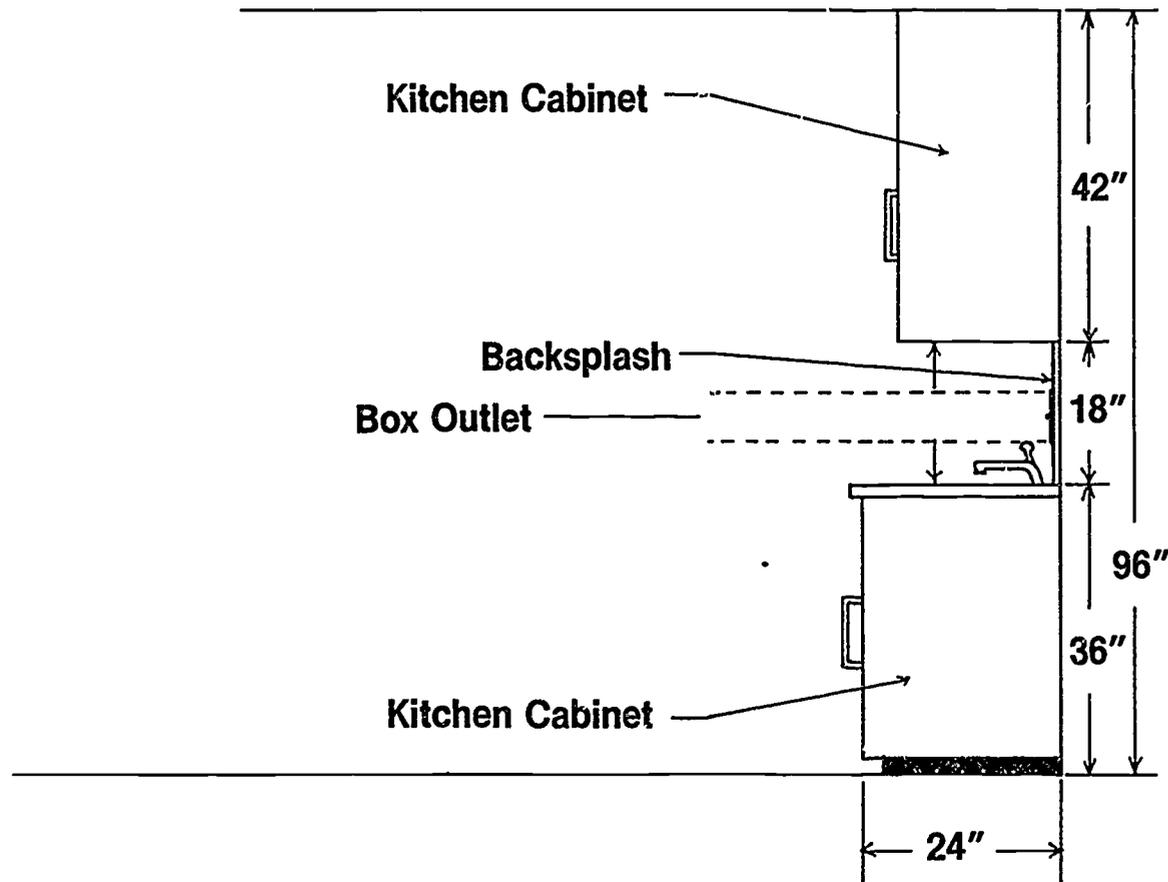


Keeping Boxes at Least Two Feet from the Top Plate  
Will Allow Full View of the Larger Fixtures

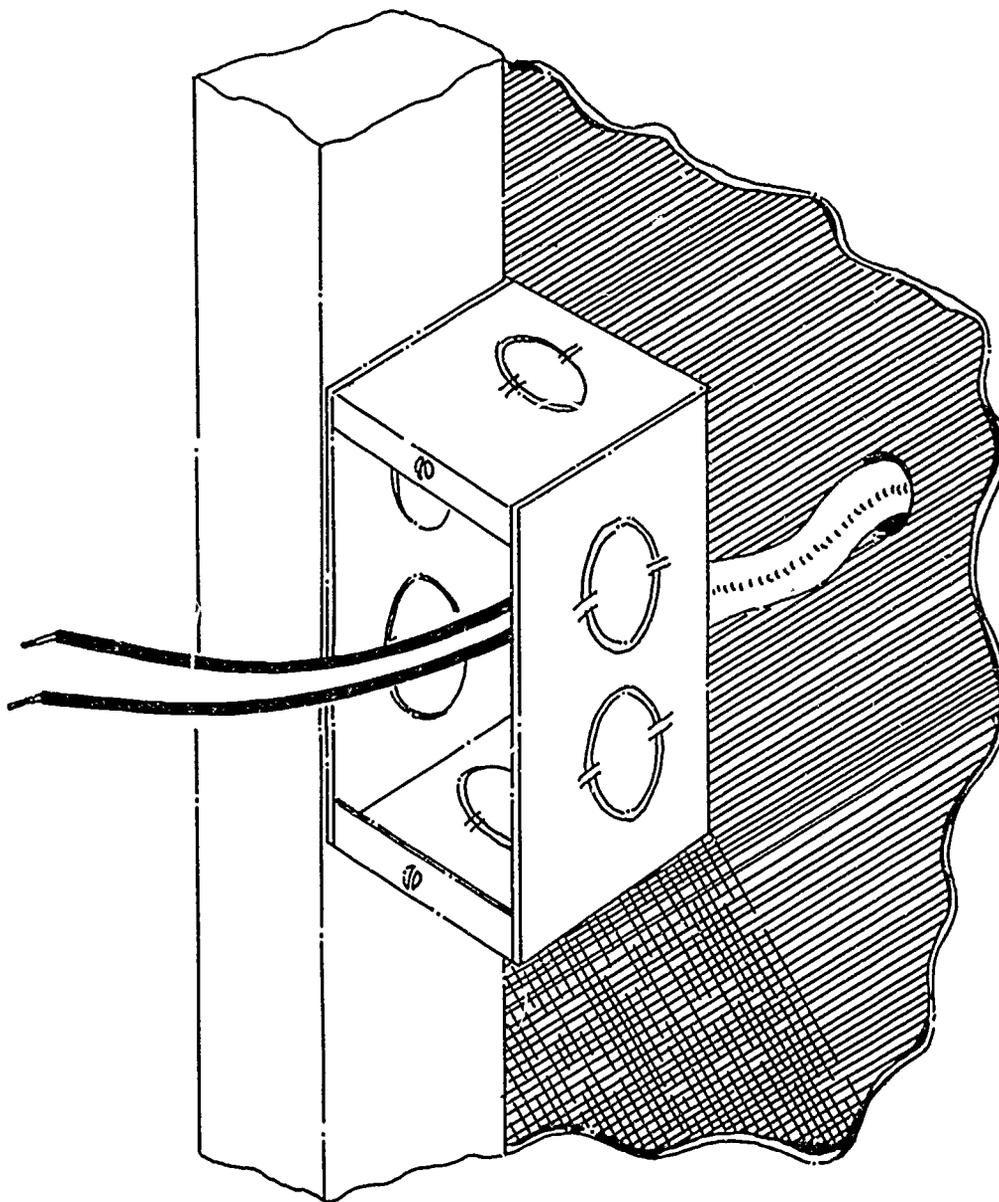
63

64

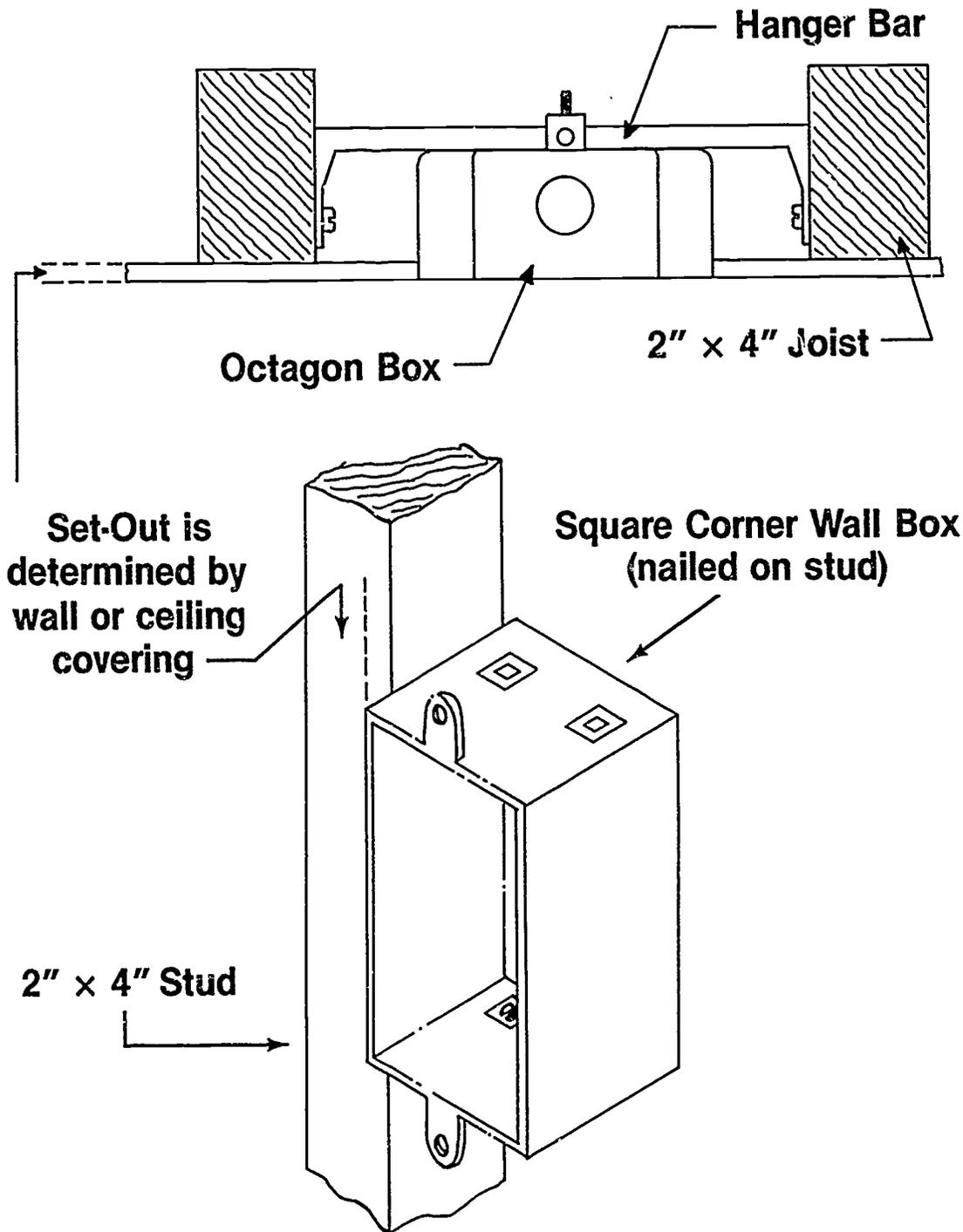
# Examples of Kitchen Dimensions (For Placement of Boxes)



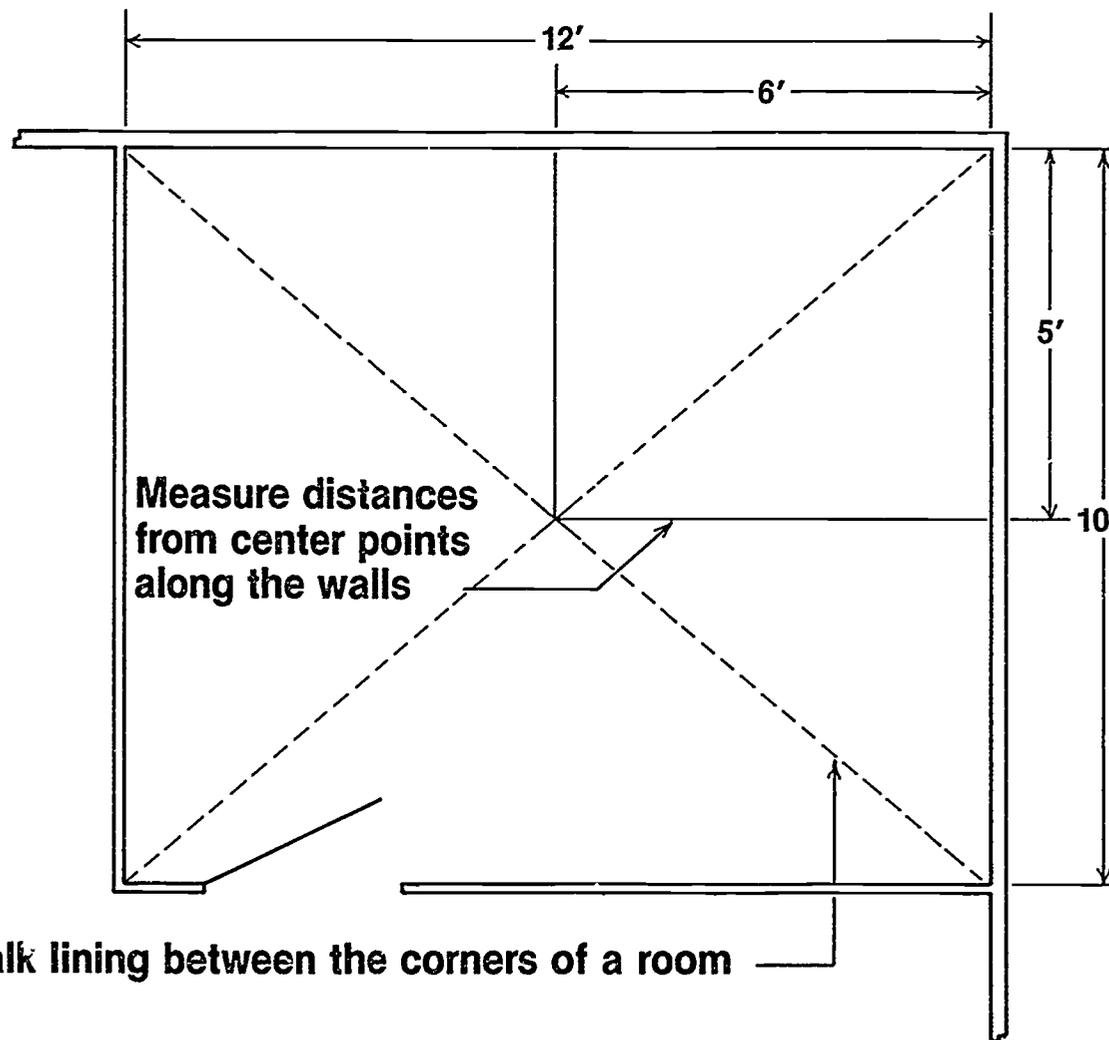
# Flush Box Installation in Brick Veneer



# Installing Boxes (Flush Mount)



## Locating Center Points for Ceiling Outlet Boxes



## ROUGH-IN UNIT II

### INFORMATION SHEET

#### I. Terms and definitions

- A. Backsplash — That portion of a wall behind the kitchen cabinet, starting at the counter top and ending at the bottom of the wall hung cabinets
- B. Box center — Midpoint on a box's vertical dimension
- C. Box set out — Distance that the box extends past the stud
- D. Flush — Even with the surface
- E. Habitable -- Suitable for people to occupy or live in
- F. Room center — Point in a room that is equal distance from parallel walls
- G. Tile cap — Final tile in a ceramic backsplash when the tile is terminated at some point up the wall

#### II. Locations where at least one receptacle outlet is required

- A. Bathroom — Adjacent to sink
- B. Laundry — Within six feet of appliance to be served
- C. Outside
- D. Basement
- E. Attached garage

#### III. Planning techniques when placing boxes on plans

- A. Keep spacing even where possible
- B. Put boxes in even groups if possible
- C. Check door swing direction so switches are not behind doors
- D. Place outside lighting outlets low enough for any fixture

## INFORMATION SHEET

### IV. Accepted heights for boxes in various locations

(NOTE You should ask the cabinetmaker how tall the cabinets are going to be when you are unfamiliar with the cabinetmaker's work.)

- A. Above kitchen counter tops — 45" to box center

(NOTE: Tops are usually 36";  $\frac{1}{2}$  of 18" backsplash equals 9", total height is then 45")

- B. Above bathroom cabinets — 40" to box center

(NOTE: This allows for a 44" or higher tile cap)

- C. Receptacles along floor line — 12" to box centers

- D. Wall switches — 46" to box centers

(NOTE: This allows plasterboard installers to cut one half of box in each sheet when they run horizontal.)

### V. Procedure for installing boxes in exterior walls to be brick veneered

(NOTE: Before installing any boxes in exterior brick walls, check your local code.)

- A. Punch a small hole in wall sheathing.

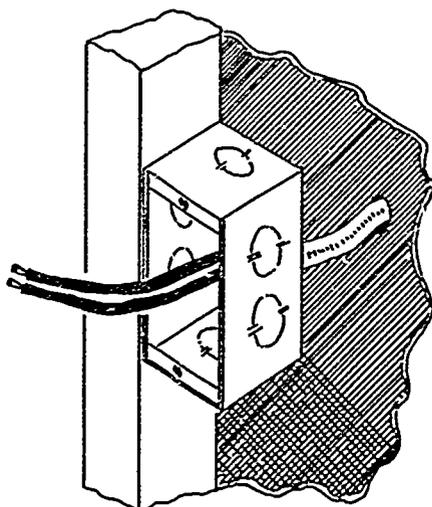
- B. Push cable through newly formed hole.

- C. Put the cable through the back knockout of your box and secure with a cable clamp.

(NOTE: Leave plenty of cable so the mason can move the box to fit the masonry work.)

- D. Put screws in the device securing holes.

(NOTE: This keeps the screw holes from becoming filled with mortar.)



## INFORMATION SHEET

- VI. Box extensions for noncombustible and combustible wall surfaces**
- A. Noncombustible materials — Not more than  $\frac{1}{4}$ " recess from surface
  - B. Combustible materials — Flush with or projecting from surface

**VII. Common methods of finding room centers**

- A. Corner to corner chalk line and plumb bob transfer
- B. Measuring half wall lengths, out at right angles from the walls

**VIII. Required outlets**

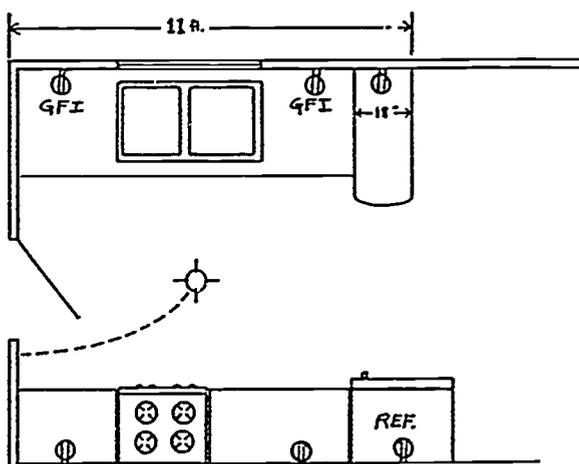
**A. Receptacle outlets**

1. General provisions — In every kitchen, family room, dining room, living room, or similar rooms of dwelling units, receptacle outlets shall be installed so that no point along the floor line in any wall space is more than 6 feet measured horizontally, from an outlet in that space, including any wall space 2 feet or more in width and the space occupied by sliding panels in exterior doors. The wall space afforded by fixed room dividers such as free standing bar type counters, shall be included in the 6' measurement.

(NOTE: A wall space shall be considered a wall unbroken along a floor line by doorways, fireplaces or similar openings. Each wall space 2 ft. wide or greater shall be treated individually and separately from other wall spaces. A wall space can include two or more walls (around corners) where unbroken at the floor line.)

2. Counter tops — In kitchen and dining areas of dwelling units a receptacle outlet shall be installed at each counter space wider than 12 inches.

(NOTE: Counters divided by ranges, sinks, or refrigerators shall be considered separate cabinets.)



## INFORMATION SHEET

3. Bathrooms — At least one receptacle outlet shall be installed adjacent to the basin location.
4. Outdoors — At least one receptacle outlet shall be installed outdoors.
5. Laundry areas — At least one receptacle shall be installed in laundry areas.

(NOTE: Refer to NEC Art: 310-8[a]4)

6. Basements and attached garages — At least one receptacle outlet shall be installed in addition to any for laundry equipment.

(NOTE: Refer to NEC Art: 210-8[a])

- B. Lighting outlets required — At least one wall switch controlling a lighting outlet in every habitable room, hallway, bathroom, stairway, attached garage, outdoor entrance, and in attics, under floor space, utility rooms and basements if used for storage or if containing equipment requiring service.

(NOTE: In habitable rooms, other than kitchens or bathrooms, one or more receptacles controlled by a wall switch shall be permitted in lieu of lighting outlets.)

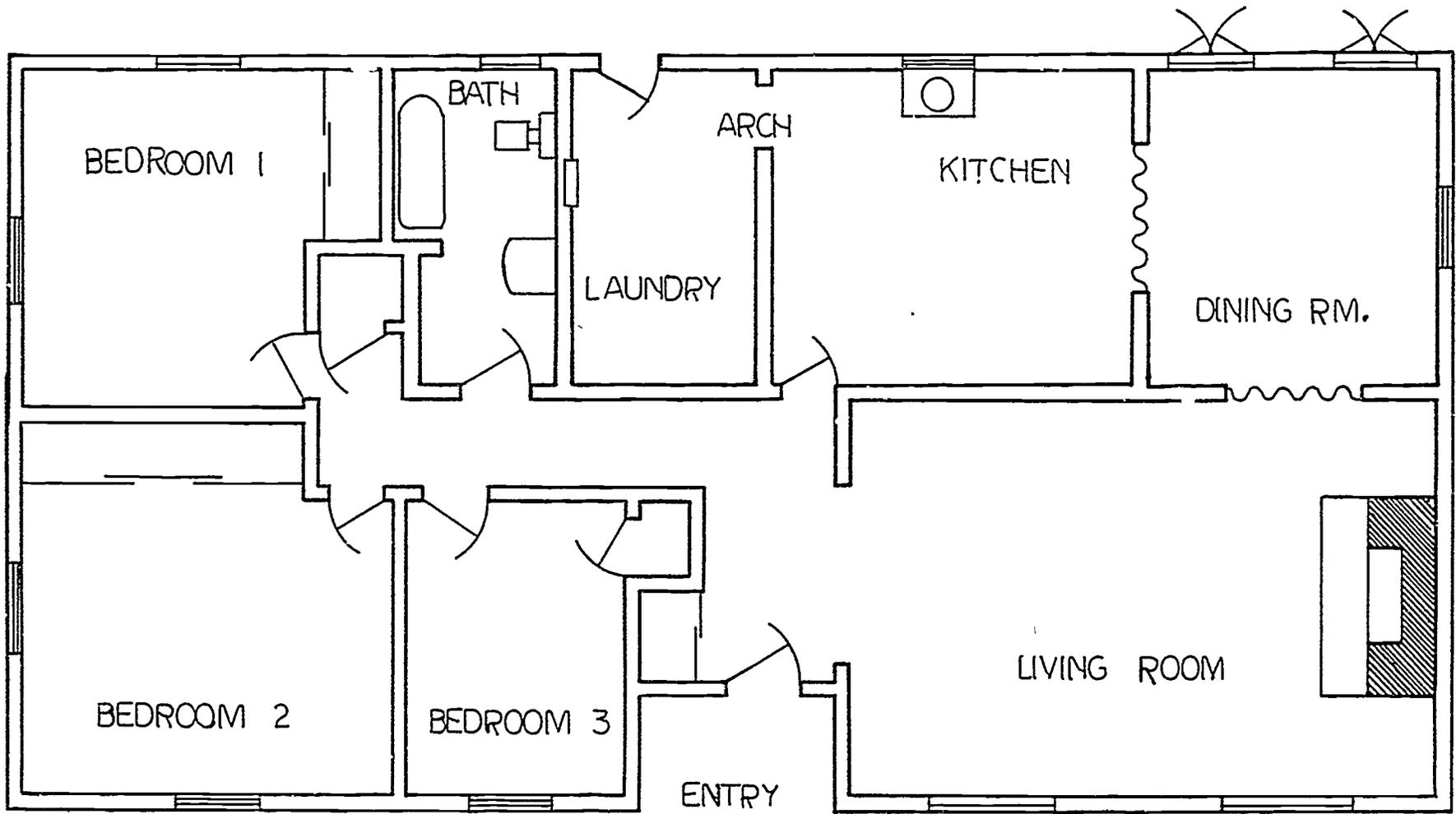
### IX. Rules for electrical installations

- A. Always be safety conscious.
- B. Do work you will be proud of.
- C. Be sure all connections are secure and well insulated.
- D. Always be sure that overcurrent protection is matched to your conductor rating.
- E. Preform conductors before installing devices in boxes.
- F. Use appropriate tools.
- G. Always meet or exceed NEC, state, and local code minimum installation requirements.

**ROUGH-IN  
UNIT II****ASSIGNMENT SHEET #1 — LOCATE RECEPTACLE, SWITCH, AND  
LIGHTING OUTLETS ALONG A FLOOR LINE AND THE  
CEILING ON A BLUEPRINT**

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

Directions: Using appropriate blueprint symbols, locate the minimum required receptacle switch and lighting outlets along the floor line and in the ceiling on the plan on the following page.



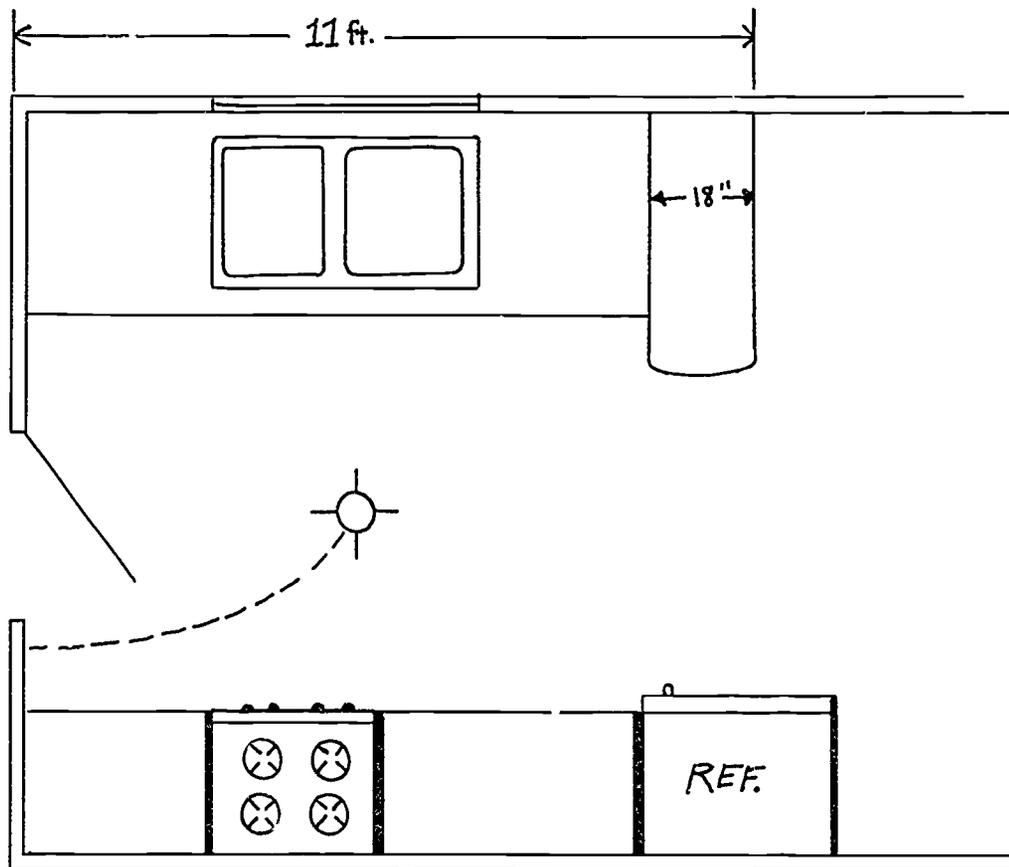
ELECTRICAL FLOOR PLAN

# ROUGH-IN UNIT II

## ASSIGNMENT SHEET #2 — LOCATE RECEPTACLE OUTLETS ALONG KITCHEN CABINETS

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

Directions. Using appropriate blueprint symbols, locate the minimum required receptacle outlets along the cabinet spaces on the print below.



## ROUGH-IN UNIT II

### JOB SHEET #1 — INSTALL A DEVICE BOX WHEN GIVEN CABINET HEIGHT AND WALL COVERING

Locate a device box in a backsplash behind a 36" high counter. The hanging cabinets start 18" from the counter top. The wall will be covered with 1/2" plasterboard.

#### A. Equipment and materials needed

1. Rule
2. Device box
3. Hammer
4. Nails

(NOTE: Some device boxes have nails already attached to the box. If so, no other nails are necessary.)

5. Stud wall

(NOTE: This can be in a new house or a shop mock-up of an unfinished wall with studs exposed.)

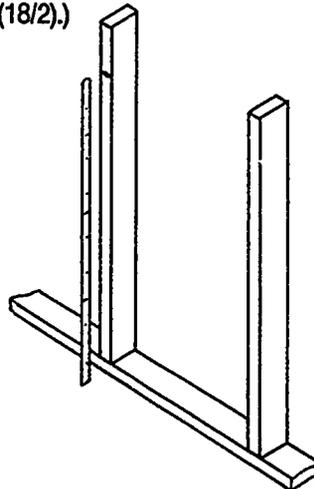
6. Safety glasses
7. Pencil

#### B. Procedure

1. Put on safety glasses and gather equipment and materials.
2. Determine box height and mark the stud for your box center. (Figure 1)

(NOTE: In this job 45" will be acceptable. That is 36" cabinet height plus 1/2 of backsplash which is 9" (18/2).)

FIGURE 1



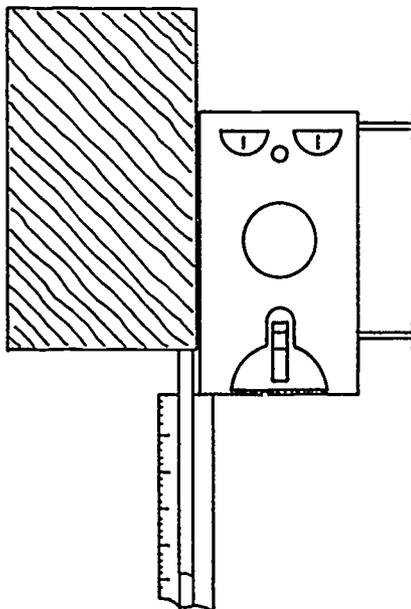
## JOB SHEET #1

3. Determine appropriate box set out for wall covering specified.

(NOTE: In this instance for a noncombustible wall, set out is between one quarter and one half inch.)

4. Locate box on center with correct set out. (Figure 2)

FIGURE 2



5. Drive nails in to secure box.
6. Check set out again.
7. Clean work area and put away all equipment and materials.

## ROUGH-IN UNIT II

### JOB SHEET #2 — INSTALL A LIGHTING OUTLET BOX WHEN GIVEN CEILING COVERING THICKNESS

#### A. Equipment and materials needed

(NOTE: The lighting outlet box is to be installed in a wall to be covered with 1/2" plaster-board.)

1. Rule
2. 4" octagon box

(NOTE: Any type lighting outlet box can be used for this installation.)

3. Hammer
4. Bar hanger

(NOTE: Bar hangers come in various lengths. You need to have a hanger that will fit between your studs.)

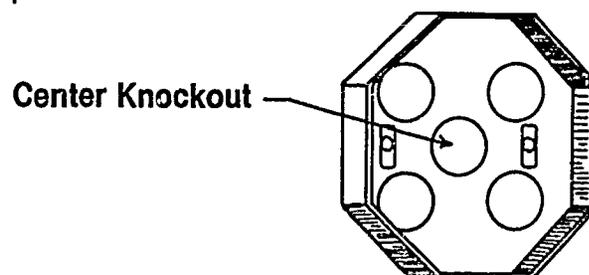
5. Nails
6. Stud wall
7. Safety glasses
8. Pencil

#### B. Procedure

(NOTE: The lighting outlet box is to be installed in a wall to be covered with 1/2" plaster-board.)

1. Put on safety glasses and gather equipment and materials.
2. Remove center knock-out from the back of your box. (Figure 1)

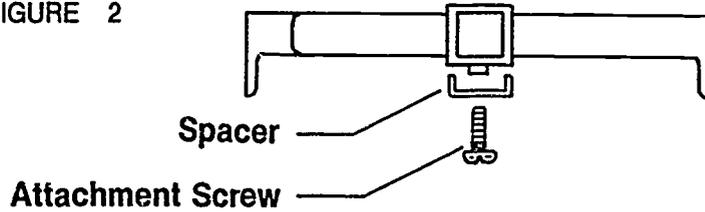
FIGURE 1



## JOB SHEET #2

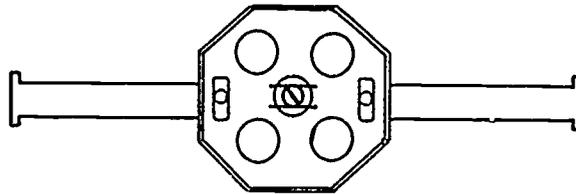
3. Remove attachment screw and spacer from bar hanger. (Figure 2)

FIGURE 2



4. Mount your box on the bar hanger and secure it loosely with your spacer and attachment screw. (Figure 3)

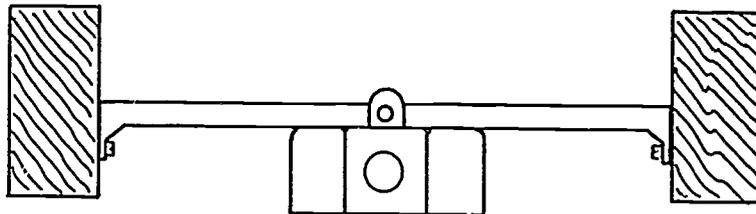
FIGURE 3



5. Place bar and box between stud and check set out. (Figure 4)

(NOTE: Refer to NEC Art: 370-10.)

FIGURE 4



6. Nail hanger in place.
7. Check set out again.
8. Clean work area and put away all equipment and materials.

## ROUGH-IN UNIT II

### JOB SHEET #3 — WIRE A SWITCH CONTROLLED SPLIT-WIRED RECEPTACLE

#### A. Equipment and materials needed

1. 12-2G or 14-2-G NM cable
2. 12-3G or 14-3-G NM cable
3. Two device boxes

(NOTE: Be sure boxes have a NEC capacity rating to accommodate the conductors you will install.)

4. Staples
5. Single pole switch
6. Duplex grounding type receptacle
7. Stud wall or work board
8. 120v supply

(NOTE: The overcurrent protection on this supply should not exceed the conductors NEC ampacity rating.)

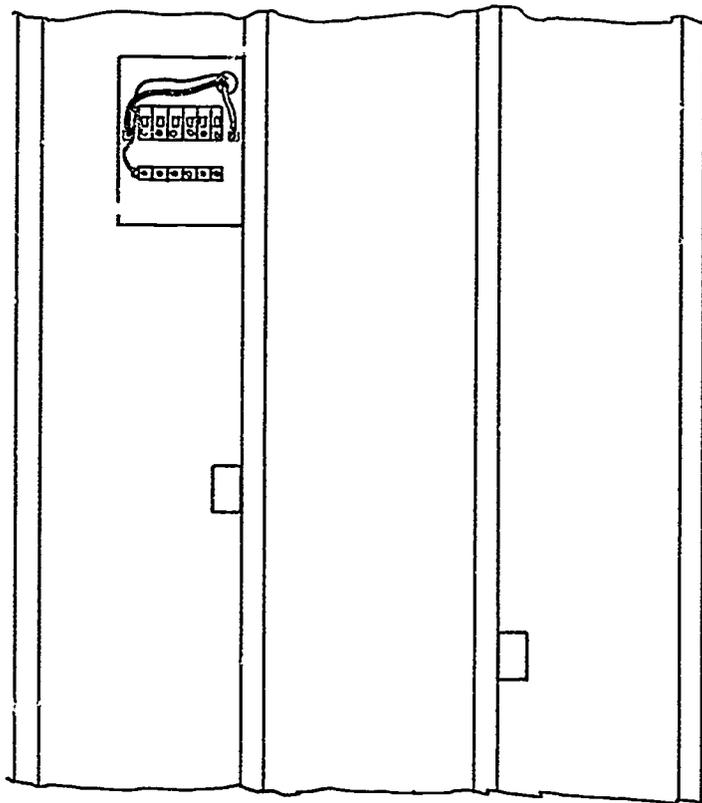
9.  $\frac{3}{8}$ " cable clamp
10. Wire connectors
11. Four 16 penny nails or other fasteners as needed to secure the boxes
12. Electrician's hammer
13. Plain tip screwdriver
14. Lineman's pliers
15. Needle-nose pliers
16. Pocket knife
17. Wire strippers
18. Tool pouch

**JOB SHEET #3**

19. Drill motor or brace
20. 1/2" or larger wood bit
21. Extension cord
22. Safety glasses
23. GFI

**B. Procedure**

1. Put on safety glasses and gather equipment and materials.
2. Mount boxes. (Figure 1)

**FIGURE 1**

3. Remove a half inch knockout from the panel.
4. Install cable connector.

## JOB SHEET #3

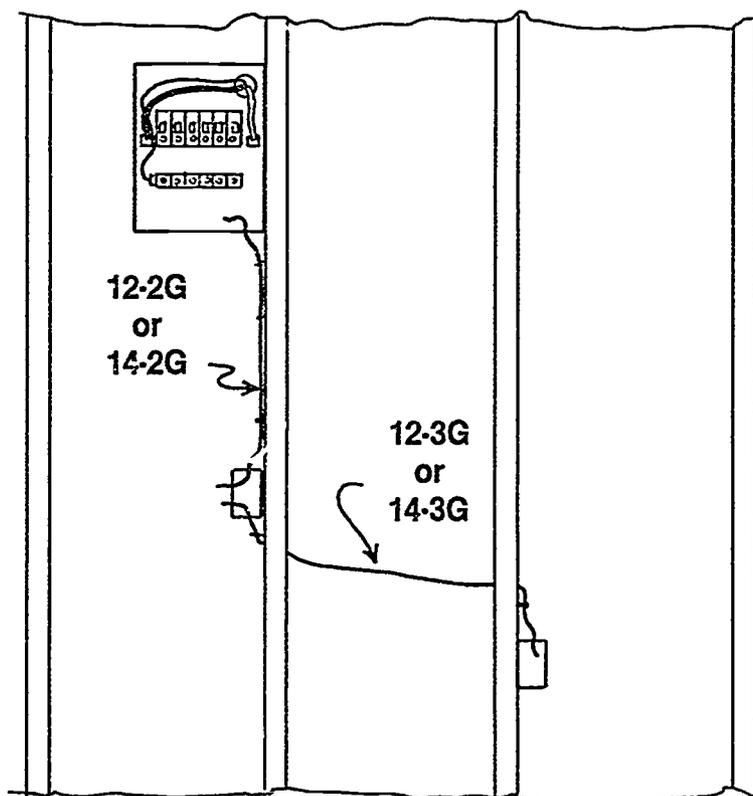
5. Bore holes for cable

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

(CAUTION: Be sure and use a GFI when drilling.)

6. Run cable between boxes and to panel. (Figure 2)

FIGURE 2



(NOTE: Leave at least 6" extending past the surface of your device boxes, and enough to reach the top of your panel plus half the width.)

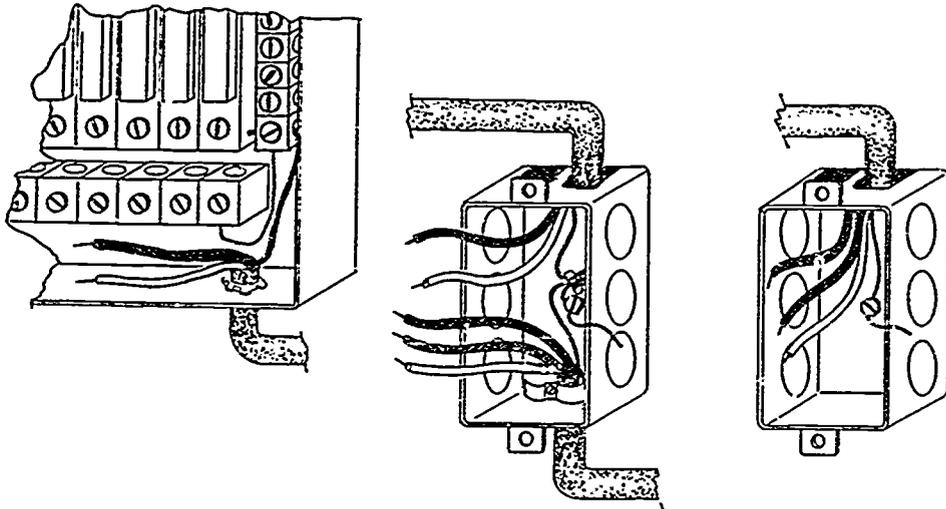
7. Staple cable within 12" of metal boxes, 6" of all nonmetallic boxes.
8. Secure all cable clamps and connectors.

(CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

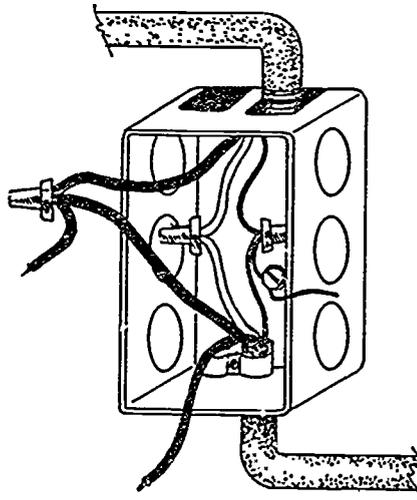
9. Strip cable insulation at device box and panel.

**JOB SHEET #3**

10. Connect equipment grounding conductors. (Figure 3)

**FIGURE 3**

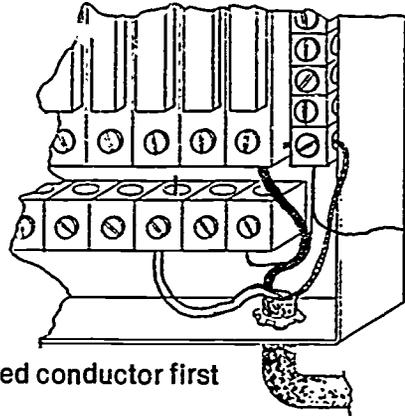
11. Make up switch box. (Figure 4)

**FIGURE 4**

**JOB SHEET #3**

12. Connect grounded and ungrounded conductors. (Figure 5)

FIGURE 5



Connect grounded conductor first

(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

13. Have your instructor evaluate this project.
14. Clean work area and put away all equipment and materials.

## ROUGH-IN UNIT II

### JOB SHEET #4 — WIRE A RECEPTACLE FED FROM A LIGHTING OUTLET THROUGH A SINGLE POLE SWITCH

#### A. Equipment and materials needed

1. 12-2G or 14-2-G NM cable
2. 12-3G or 14-3-G NM cable
3. Two device boxes
4. Octagon box and bar hanger
5. Light socket
6. 120 volt bulb
7. Staples
8. Single pole switch
9. Duplex grounding type receptacle
10. Stud wall or work board
11. 120v supply

(NOTE: The overcurrent protection on this supply should not exceed the conductors NEC ampacity rating.)

12. Wire connectors
13. Four 16 penny nails or other fasteners as needed to secure the boxes
14. Electrician's hammer
15. Plain tip screwdriver
16. Lineman's pliers
17. Long nose pliers
18. Pocket knife
19. Wire strippers

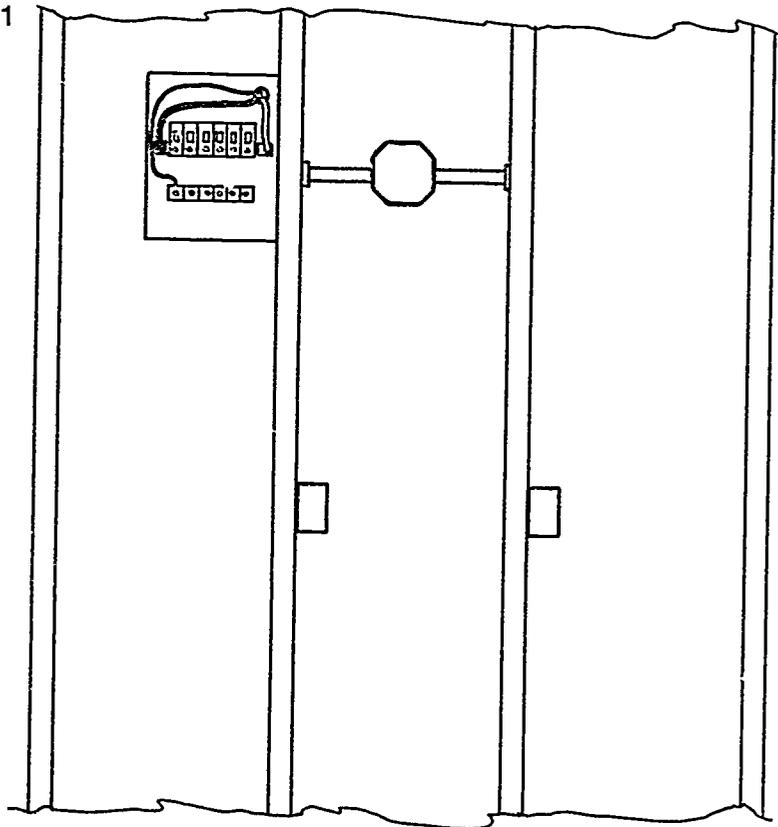
## JOB SHEET #4

20. Tool pouch
21. Drill motor or brace
22.  $\frac{1}{2}$ " or larger wood bit
23. Extension cord
24. Safety glasses
25. GFI

## B. Procedure

1. Put on safety glasses and gather equipment and materials.
2. Mount boxes. (Figure 1)

FIGURE 1



3. Remove a half inch knockout from the panel.
4. install cable connector.

## JOB SHEET #4

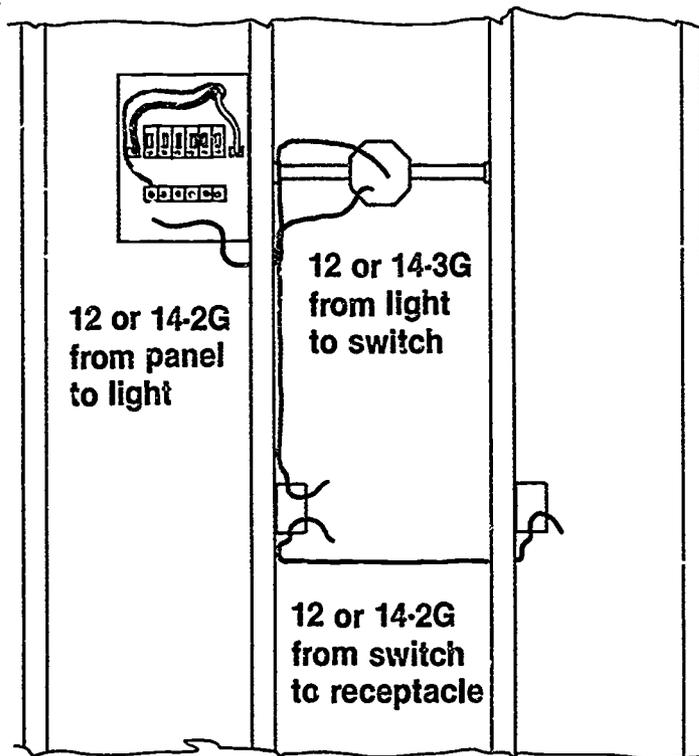
5. Bore holes for cable.

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

(CAUTION: Always use a GFI when drilling.)

6. Run cable between boxes and to panel. (Figure 2)

FIGURE 2



(NOTE: Leave at least 3" extending past the surface of your device boxes, and enough to reach the top of your panel plus half the width.)

7. Staple cable within 12" of metal boxes, 6" of nonmetallic boxes.  
8. Secure all cable clamps and connectors.

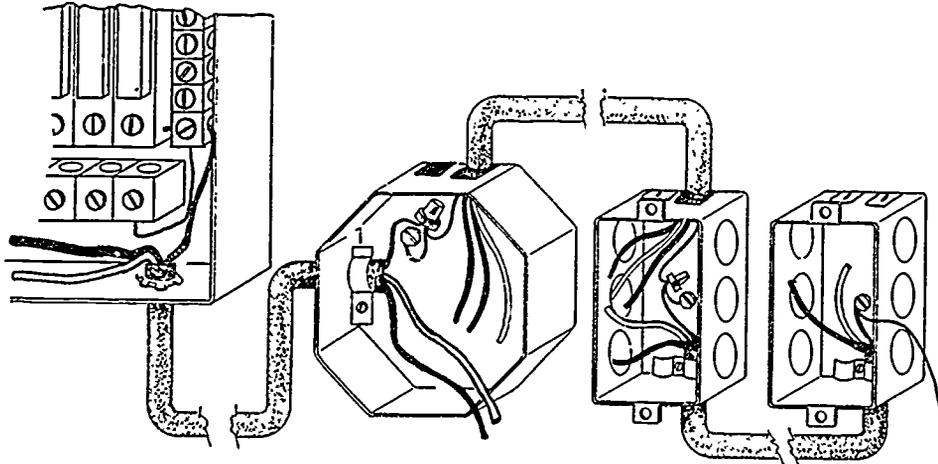
(CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

9. Strip cable insulation at device box and panel.

## JOB SHEET #4

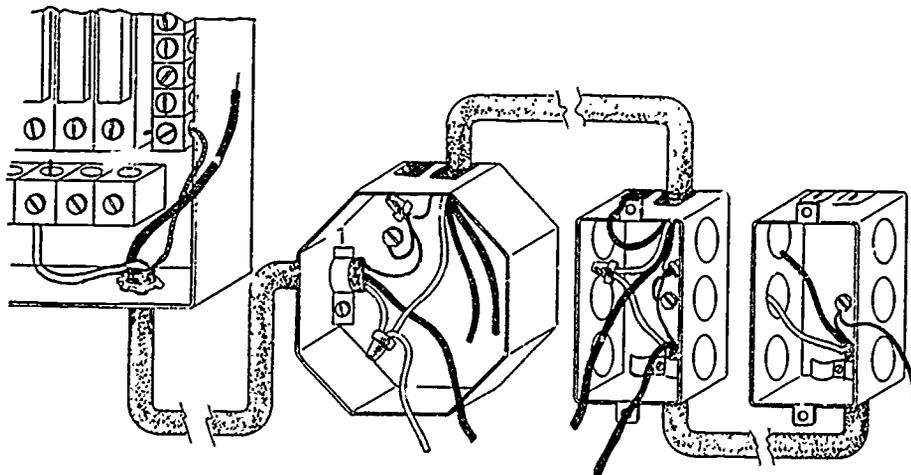
10. Connect equipment grounding conductors. (Figure 3)

FIGURE 3



11. Make up neutral through the system. (Figure 4)

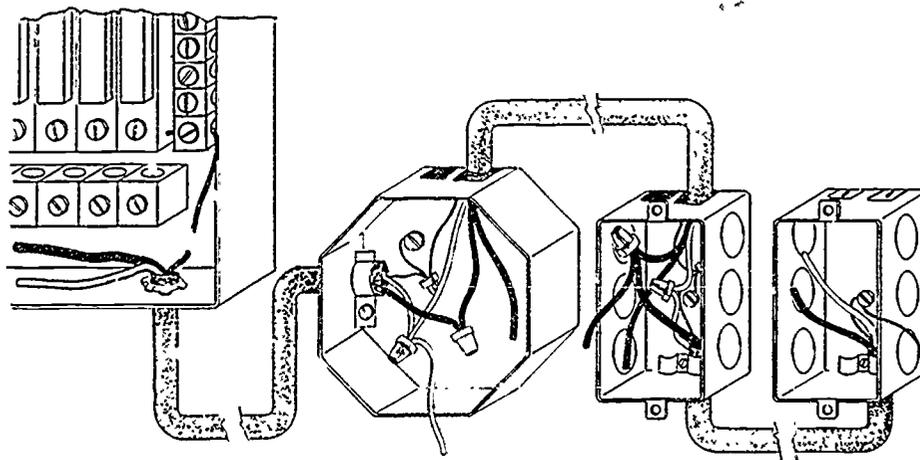
FIGURE 4



## JOB SHEET #4

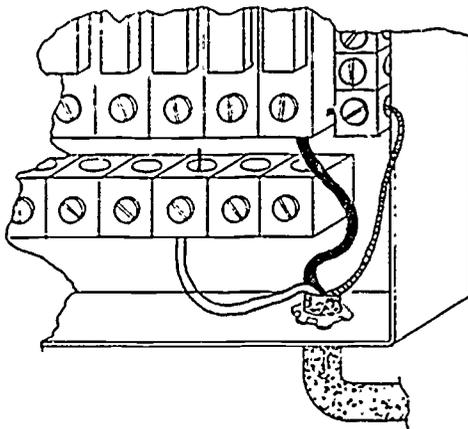
12. Make up switch, return, and feed through conductors. (Figure 5)

FIGURE 5



13. Connect ungrounded conductors. (Figure 6)

FIGURE 6



(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

14. Have your instructor evaluate this project.
15. Clean work area and put away all equipment and materials.

## ROUGH-IN UNIT II

### JOB SHEET #5 — WIRE A RECEPTACLE FED FROM A LIGHTING OUTLET THROUGH A THREE-WAY SWITCH

#### A. Equipment and materials needed

1. 12-2G or 14-2-G NM cable
2. 12-3G or 14-3-G NM cable
3. Three device boxes

(NOTE: One of the device holding boxes will have to be a 4" square box with a plaster ring.)

4. Octagon box and bar hanger

(NOTE: Be sure boxes have a NEC capacity rating to accommodate the conductors to be installed.)

5. Staples
6. Two 3-way switches
7. One duplex grounding type receptacle
8. Light socket
9. Bar hanger

(NOTE: if a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.)

10. Stud wall or work board
11. 120v supply

(NOTE: The overcurrent protection on this supply should not exceed the conductors NEC ampacity rating.)

12.  $\frac{3}{8}$ " cable clamp
13. 120v incandescent bulb
14. Wire connectors

(NOTE: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors or solder would also be acceptable in the trade.)

## JOB SHEET #5

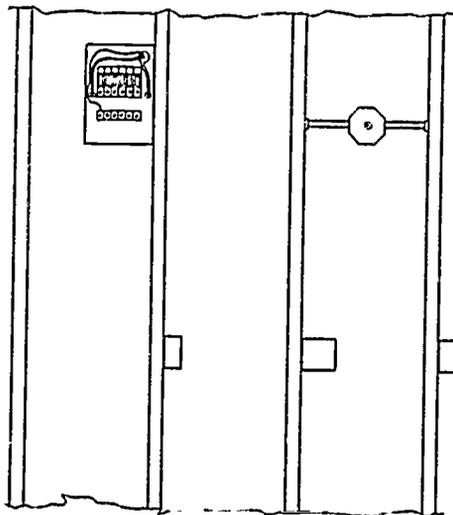
15. Two 16 penny nails
16. Two plasterboard nails
17. Electrician's hammer
18. Plain tip screwdriver
19. Lineman's pliers
20. Long nose pliers
21. Pocket knife
22. Wire strippers
23. Tool pouch
24. Drill motor or brace
25.  $\frac{1}{2}$ " or larger wood bit
26. Extension cord
27. Safety glasses
28. GFI

## B. Procedure

1. Put on safety glasses and gather equipment and materials.
2. Mount boxes. (Figure 1)

(NOTE: Device boxes and ceiling can be mounted at any height in this project.)

FIGURE 1



## JOB SHEET #5

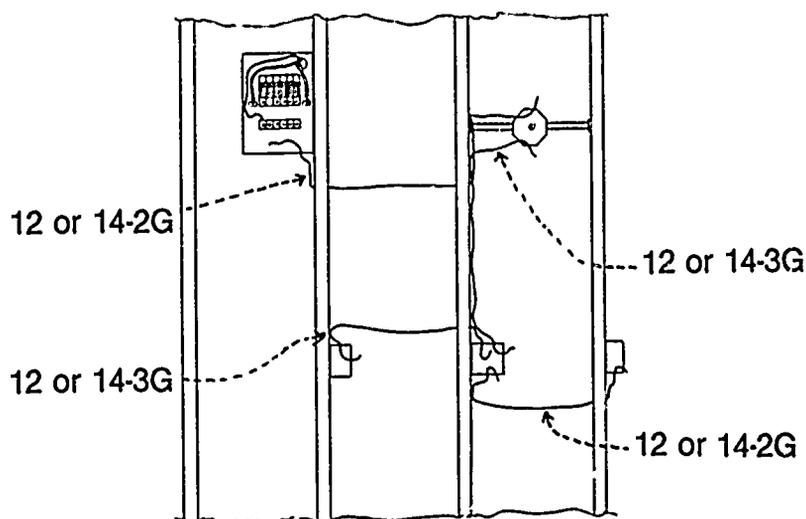
3. Remove a half inch knockout from the panel.
4. Install cable connector.
5. Bore holes for cable.

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

(CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident. Be sure and use a GFI when drilling.)

6. Run cable. (Figure 2)

FIGURE 2



(NOTE: Leave at least 3" extending past the surface of your device on lighting outlet boxes, and enough to reach the top of your panel plus half the width.)

7. Staple cable within 12" of metal boxes, 6" of nonmetallic boxes.
8. Secure all cable clamps and connectors.

(CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

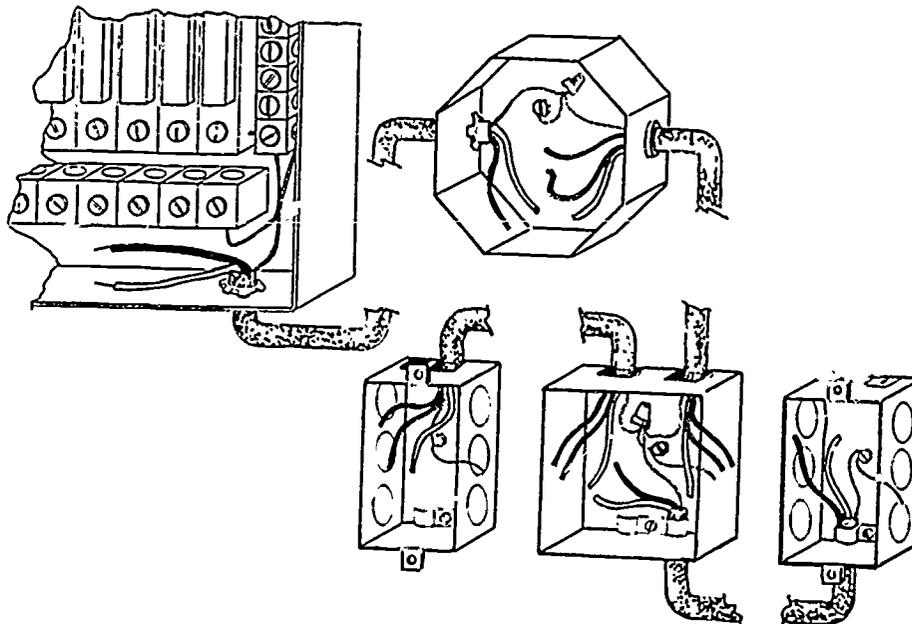
## JOB SHEET #5

9. Strip cable insulation.

(CAUTION: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.)

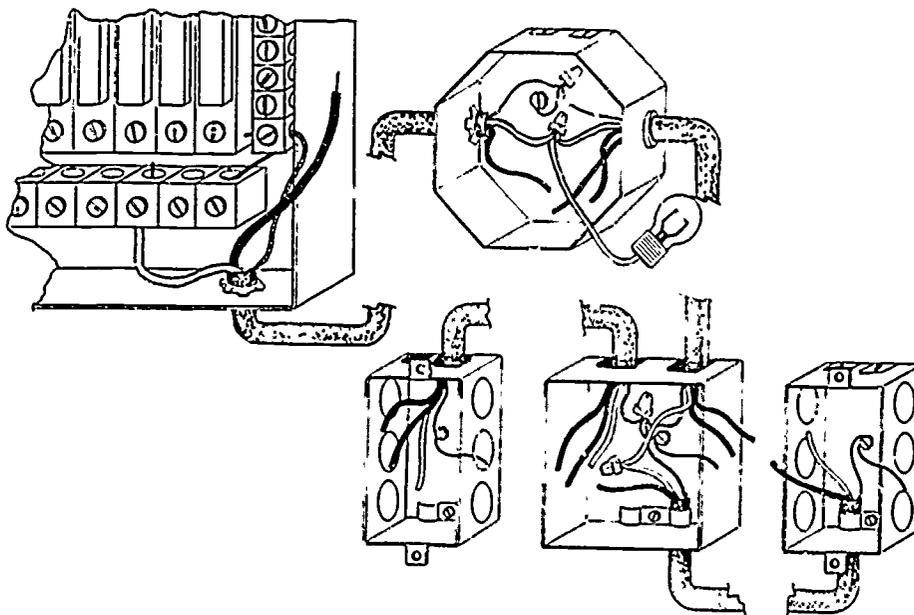
10. Connect all grounding conductors. (Figure 3)

FIGURE 3



11. Connect all neutral conductors. (Figure 4)

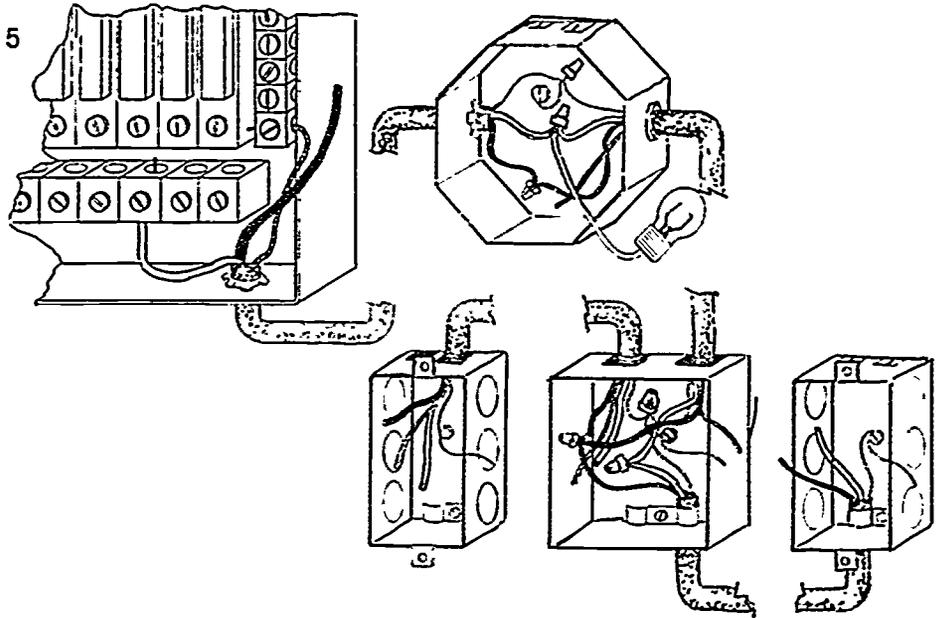
FIGURE 4



## JOB SHEET #5

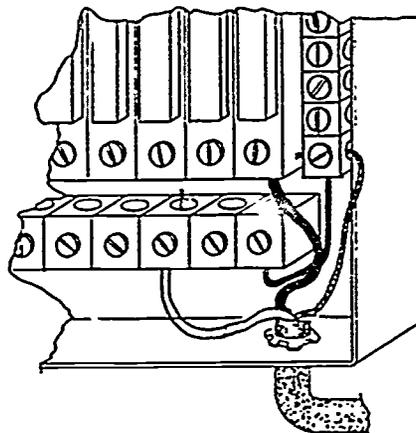
12. Connect switch leg through the system. (Figure 5)

FIGURE 5



13. Connect ungrounded conductor to appropriate overcurrent device. (Figure 6)

FIGURE 6



**(CAUTION: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)**

14. Have your instructor evaluate this project.
15. Clean work area and put away all equipment and materials.

## ROUGH-IN UNIT II

### JOB SHEET #6 — WIRE A FOUR WAY SWITCHING SITUATION WITH THE SUPPLY ENTERING THE LIGHTING OUTLET BOX

#### A. Equipment and materials needed

1. 12-2-G or 14-2-G and  
12-3-G or 14-3-G NM cable
2. Three device boxes
3. Octagon box

(NOTE: Be sure your boxes have a NEC capacity rating to accommodate the conductors you will install.)

4. Staples
5. Two 3 way switches
6. One 4 way switch
7. Light socket
8. Bar hanger

(NOTE: If a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.)

9. Stud wall or work board
10. 120v supply

(NOTE: The overcurrent protection on this supply should not exceed the conductor's NEC ampacity rating.)

11.  $\frac{3}{8}$ " cable clamp
12. 120v incandescent bulb
13. Wire connectors

(NOTE: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.)

14. Two 16 penny nails
15. Two plasterboard nails

## JOB SHEET #6

16. Electrician's hammer
17. Plain tip screwdriver
18. Lineman's pliers
19. Long nose pliers
20. Pocket knife
21. Wire strippers
22. Tool pouch
23. Drill motor or brace
24.  $\frac{1}{2}$ " or larger wood bit

(NOTE: Holes should be large enough to safely accommodate the cables.)

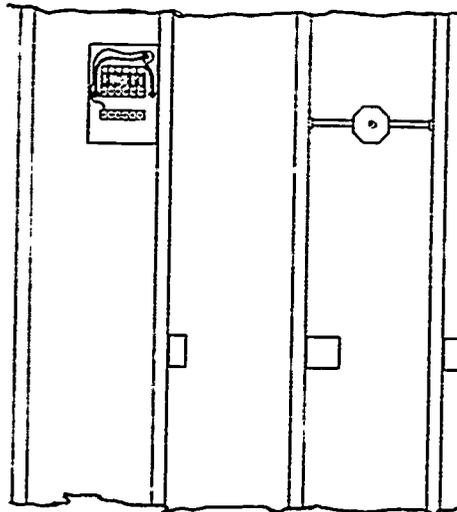
25. Extension cord
26. Safety glasses
27. Portable GFI

**B. Procedure**

1. Put on safety glasses and gather equipment and materials.
2. Mount boxes. (Figure 1)

(NOTE: Switch box and ceiling outlet can be mounted at any height in this project.)

FIGURE 1



## JOB SHEET #6

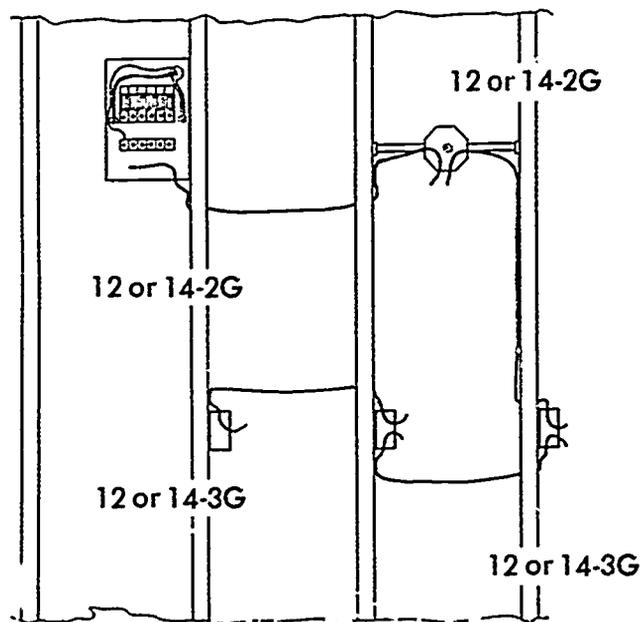
3. Remove a half inch knockout from the panel.
4. Install cable connector.
5. Plug cord into GFI.
6. Bore holes for cable.

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

(CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident.)

7. Run cable. (Figure 2)

FIGURE 2



(NOTE: Leave at least 6" extending past the surface of your device and lighting outlet boxes, and enough to reach the top of your panel plus half the width.)

8. Staple cable within 12" of metal boxes, 6" of nonmetallic boxes.
9. Secure all cable clamps and connectors.

(CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

## JOB SHEET #6

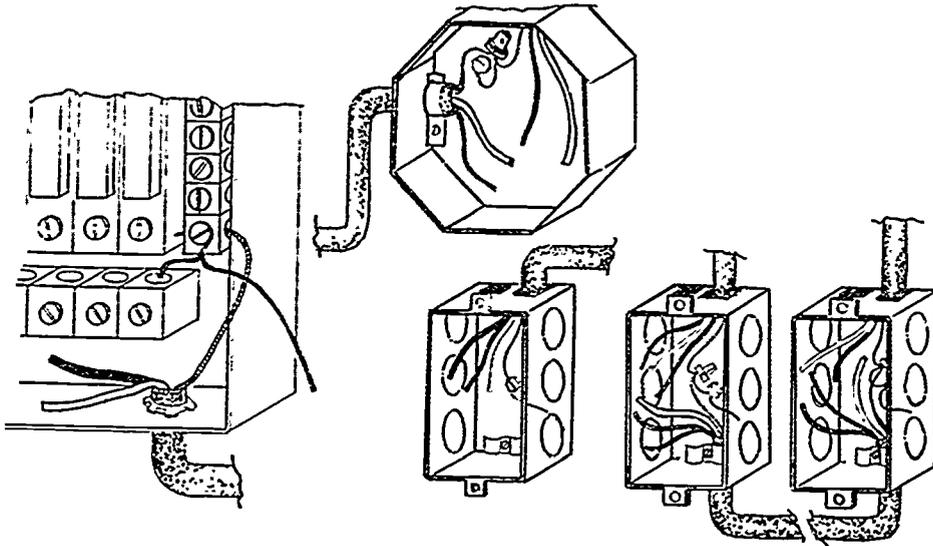
10. Strip cable insulation.

(NOTE: Trim the cable covering to within  $\frac{1}{4}$ " of its point of entry.)

(CAUTION: Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.)

11. Connect all grounding conductors. (Figure 3)

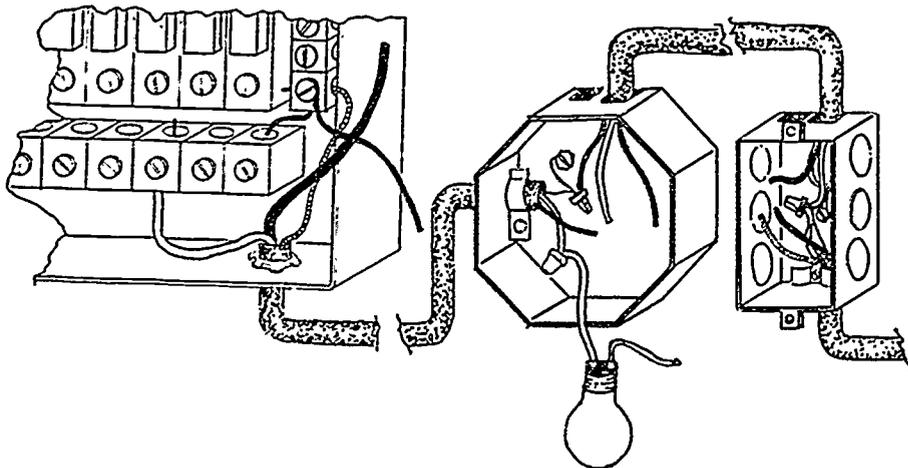
FIGURE 3



(NOTE: Always leave enough conductor to make removal and reconnection easy. Notice extra bend at panel.)

12. Connect neutral conductors. (Figure 4)

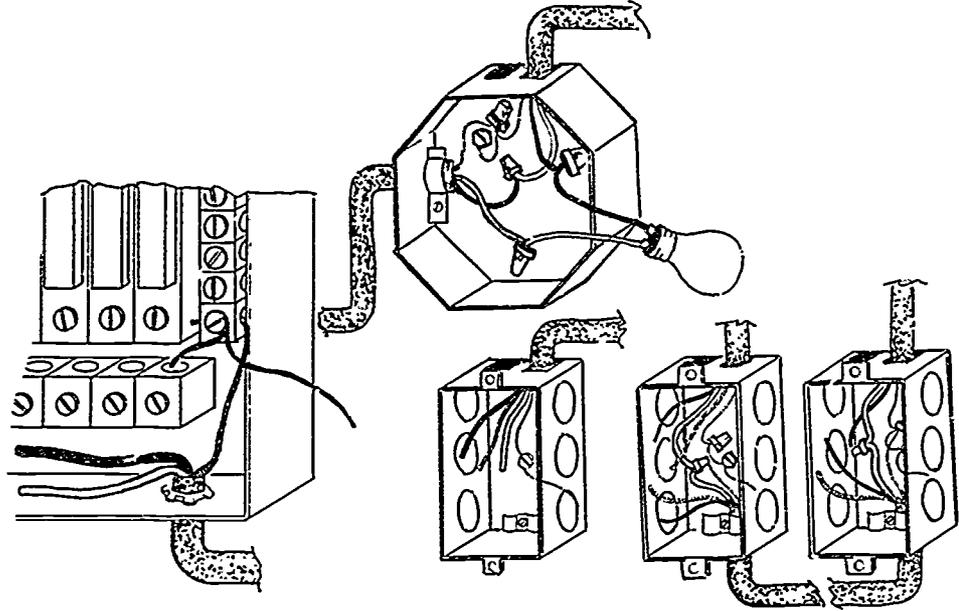
FIGURE 4



### JOB SHEET #6

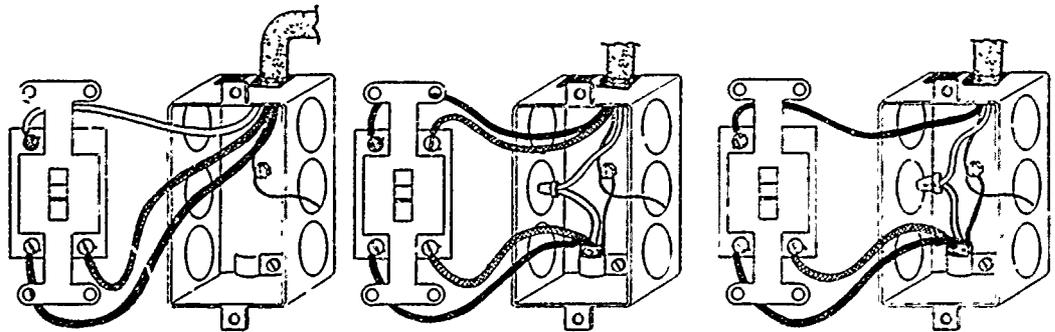
13. Connect switch leg through the system. (Figure 5)

FIGURE 5



14. Install switches. (Figure 6)

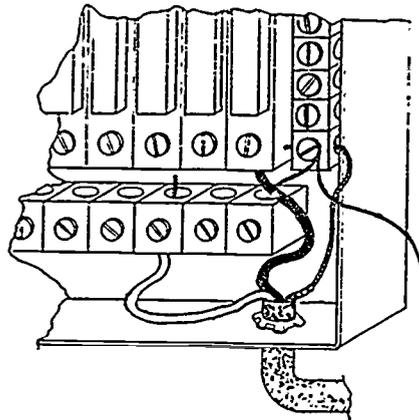
FIGURE 6



## JOB SHEET #6

15. Connect return leg to socket. (Figure 6)
16. Connect ungrounded conductor to appropriate overcurrent device. (Figure 7)

FIGURE 7



**(CAUTION: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)**

17. Turn on breaker.

**(CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.)**

18. Change the position of the switches in alternating movements.

**(NOTE: Be sure you can turn on or off from either switch as well as on at one and off at the other.)**

19. Have your instructor evaluate this project.
20. Turn off breaker.
21. Clean work area and put away all equipment and materials.

## ROUGH-IN UNIT II

### JOB SHEET #1 PRACTICAL TEST — INSTALL A DEVICE BOX WHEN GIVEN CABINET HEIGHT AND WALL COVERING

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:

	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Marked correct height for box.	_____	_____
3. Set box on stud.	_____	_____
4. Nailed box to stud.	_____	_____
5. Checked in/put away tools and materials.	_____	_____
6. Cleaned the work area.	_____	_____
7. Used proper tools correctly.	_____	_____
8. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
9. Practiced safety rules throughout procedure.	_____	_____
10. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #1 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Measurements correct	4	3	2	1
Box is set for Sheetrock	4	3	2	1
Box mounted properly	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_  
 \_\_\_\_\_

PERFORMANCE EVALUATION KEY
4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## ROUGH-IN UNIT II

### JOB SHEET #2 PRACTICAL TEST — INSTALL A LIGHTING OUTLET BOX WHEN GIVEN CEILING COVERING THICKNESS

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Removed center K.O..	_____	_____
3. Installed bar hanger to box.	_____	_____
4. Attached bar hanger and box to wall.	_____	_____
5. Checked in/put away tools and materials.	_____	_____
6. Cleaned the work area.	_____	_____
7. Used proper tools correctly.	_____	_____
8. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
9. Practiced safety rules throughout procedure.	_____	_____
10. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #2 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Bar hanger mounted correctly				
Box and hanger mounted properly				
Box set for Sheetrock				
Workmanship				
Compliance to NEC				

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## ROUGH-IN UNIT II

### JOB SHEET #3 PRACTICAL TEST — WIRE A SWITCH CONTROLLED SPLIT-WIRED RECEPTACLE

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Mounted boxes to studs.	_____	_____
3. Removed K.O. from panel.	_____	_____
4. Installed 1/2 inch connector.	_____	_____
5. Bored hole in studs.	_____	_____
6. Installed Romex.	_____	_____
7. Stapled Romex to studs.	_____	_____
8. Secured cable and clamps.	_____	_____
9. Stripped Romex.	_____	_____
10. Grounded equipment.	_____	_____
11. Made up connections.	_____	_____
12. Checked in/put away tools and materials.	_____	_____
13. Cleaned the work area.	_____	_____
14. Used proper tools correctly.	_____	_____
15. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
16. Practiced safety rules throughout procedure.	_____	_____
17. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #3 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Boxes mounted correctly	4	3	2	1
Romex run properly	4	3	2	1
Holes drilled correctly	4	3	2	1
Romex stapled	4	3	2	1
Make-ups correct	4	3	2	1
Grounding correct	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_  
 \_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## ROUGH-IN UNIT II

### JOB SHEET #4 PRACTICAL TEST — WIRE A RECEPTACLE FED FROM A LIGHTING OUTLET THROUGH A SINGLE POLE SWITCH

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Mounted boxes on studs.	_____	_____
3. Removed 1/2 K.O. from panel.	_____	_____
4. Installed connector.	_____	_____
5. Bored holes in studs.	_____	_____
6. Installed Romex.	_____	_____
7. Stapled Romex to studs.	_____	_____
8. Stripped Romex in boxes.	_____	_____
9. Connected grounding conductors.	_____	_____
10. Made up conductors.	_____	_____
11. Checked in/put away tools and materials.	_____	_____
12. Cleaned the work area.	_____	_____
13. Used proper tools correctly.	_____	_____
14. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
15. Practiced safety rules throughout procedure.	_____	_____
16. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

## JOB SHEET #4 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

Boxes mounted properly	4	3	2	1
Holes bored correctly	4	3	2	1
Romex run properly	4	3	2	1
Romex stapled	4	3	2	1
Make-up correct	4	3	2	1
Grounded properly	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_  
 \_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## ROUGH-IN UNIT II

### JOB SHEET #5 PRACTICAL TEST — WIRE A RECEPTACLE FED FROM A LIGHTING OUTLET THROUGH A THREE-WAY SWITCH

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Mounted boxes to studs.	_____	_____
3. Removed K.O. in panel and installed connector.	_____	_____
5. Bored holes.	_____	_____
7. Stapled Romex to studs.	_____	_____
8. Stripped Romex in boxes.	_____	_____
9. Connected grounding conductors.	_____	_____
10. Made up bores.	_____	_____
11. Checked in/put away tools and materials.	_____	_____
12. Cleaned the work area.	_____	_____
13. Used proper tools correctly.	_____	_____
14. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
15. Practiced safety rules throughout procedure.	_____	_____
16. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #5 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Boxes mounted correctly				
Holes drilled properly				
Romex run correctly				
Grounding connected				
Make-up correct				
Workmanship				
Compliance to NEC				

EVALUATOR'S COMMENTS: \_\_\_\_\_  
 \_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## ROUGH-IN UNIT II

### JOB SHEET #6 PRACTICAL TEST — WIRE A FOUR WAY SWITCHING SITUATION WITH THE SUPPLY ENTERING THE LIGHTING OUTLET BOX

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Box set out correct for wall covering thickness.	_____	_____
3. Bar hanger mounted securely.	_____	_____
4. Box mounted securely to bar hanger.	_____	_____
5. Cable stripped without nicking conductor insulation.	_____	_____
6. Conductor insulation stripped without nicking conductor.	_____	_____
7. Conductors neatly folded inside switch boxes.	_____	_____
8. Proper connection of conductors made at 4 way switch.	_____	_____
9. Proper connection of conductors made at 3 way switches.	_____	_____
10. Proper connection of conductors made at lighting outlet.	_____	_____
11. Proper connection of conductors made at panel.	_____	_____
12. Checked in/put away tools and materials.	_____	_____
13. Cleaned the work area.	_____	_____
14. Used proper tools correctly.	_____	_____
15. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
16. Practiced safety rules throughout procedure.	_____	_____
17. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #6 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Devices installed securely	4	3	2	1
Light is controlled from 3 way switches on/off	4	3	2	1
Light is controlled from 4 way switch	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## ROUGH-IN UNIT II

### TEST

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

1. Match the terms on the right with their correct definitions.

- |         |                                                                                                                                  |                |
|---------|----------------------------------------------------------------------------------------------------------------------------------|----------------|
| _____a. | Midpoint on a box's vertical dimension                                                                                           | 1. Backsplash  |
| _____b. | Point in a room that is equal distance from parallel walls                                                                       | 2. Box center  |
| _____c. | That portion of a wall behind the kitchen cabinet, starting at the countertop and ending at the bottom of the wall hung cabinets | 3. Box set out |
| _____d. | Final tile in a ceramic backsplash when the tile is terminated at some point up the wall                                         | 4. Flush       |
| _____e. | Distance that the box extends past the stud                                                                                      | 5. Habitable   |
| _____f. | Suitable for people to occupy or live in                                                                                         | 6. Room center |
| _____g. | Even with the surface                                                                                                            | 7. Tile cap    |

2. List five locations where at least one receptacle outlet is required.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_
- e. \_\_\_\_\_

3. Select true statements concerning planning techniques when placing boxes on plans by placing an "X" in the blanks preceding the true statements.

- \_\_\_\_\_a. Keep spacing even where possible.
- \_\_\_\_\_b. Put boxes in uneven groups if possible.
- \_\_\_\_\_c. Check door swing direction so switches are behind doors.
- \_\_\_\_\_d. Place outside lighting outlets low enough for any fixture.

## TEST

4. Complete the following accepted heights for boxes in various locations by circling the numbers which best complete each statement.
- Above kitchen counter tops — (40", 45") to box center
  - Above bathroom cabinets — (44", 40") to box center
  - Receptacles along floor line — (12", 10") to box centers
  - Wall switches — (46", 52") to box centers
5. Select true statements concerning the procedure for installing boxes in exterior walls to be brick veneered by placing an "X" in the blanks preceding the correct statements.
- a. Punch a large hole in wall sheeting.
  - b. Push cable through newly formed hole.
  - c. Put the cable through the back knockout of your box and secure with a cable clamp.
  - d. Put screws in the device securing holes.
6. Distinguish between box extensions for noncombustible and combustible wall surfaces by placing an "X" next to the location for combustible materials.
- a. Not more than 1/4" recess from surface
  - b. Flush with or projecting from surface
7. List two common methods of finding room centers.
- \_\_\_\_\_
  - \_\_\_\_\_
8. Select true statements concerning required outlets by placing an "X" in the blanks preceding the true statements.
- a. In every kitchen, family room, dining room, living room, or similar rooms of dwelling units, receptacle outlets shall be installed so that no point along the floor line in any wall space is more than 8 feet measured horizontally, from an outlet in that space, including any wall space 2 feet or more in width and the space occupied by sliding panels in exterior doors. The wall space afforded by fixed room dividers such as free standing bar type counters, shall be included in the measurement.
  - b. In kitchen and dining areas of dwelling units a receptacle outlet shall be installed at each counter space wider than 12 inches.

## TEST

- \_\_\_\_\_c. At least one receptacle outlet shall be installed in a bathroom adjacent to the commode location.
- \_\_\_\_\_d. At least one receptacle outlet shall be installed outdoors.
- \_\_\_\_\_e. At least two receptacle outlets shall be installed in laundry areas.
- \_\_\_\_\_f. At least one wall switch controlling a lighting outlet is required in every habitable room including the hallway, bathroom, stairway, attached garage, outdoor entrance, and in attics, under floor space, utility rooms, and basements if used for storage or if containing equipment requiring service.

9. Complete the following statements concerning rules for electrical installations by inserting the word(s) which best completes each statement.

- a. \_\_\_\_\_ be safety conscious.
- b. Be sure all connections are secure and \_\_\_\_\_.
- c. Always be sure that overcurrent protection is matched to your conductor \_\_\_\_\_.
- d. \_\_\_\_\_ conductors before installing devices in boxes.
- e. Use appropriate \_\_\_\_\_.
- f. Always meet or exceed \_\_\_\_\_, state, and local code minimum installation requirements.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

- 10. Locate receptacle, switch, and lighting outlets along a floor line and the ceiling on a blueprint. (Assignment Sheet #1)
- 11. Locate receptacle outlets along kitchen cabinets. (Assignment Sheet #2)
- 12. Demonstrate the ability to:
  - a. Install a device box when given cabinet height and wall covering. (Job Sheet #1)
  - b. Install a lighting outlet box when given ceiling covering thickness. (Job Sheet #2)
  - c. Wire a switch controlled split-wired receptacle. (Job Sheet #3)
  - d. Wire a receptacle fed from a lighting outlet through a single pole switch. (Job Sheet #4)
  - e. Wire a receptacle fed from a lighting outlet through a three-way switch. (Job Sheet #5)
  - f. Wire a four way switching situation with the supply entering the lighting outlet box. (Job Sheet #6)

## ROUGH-IN UNIT II

### ANSWERS TO TEST

1. a. 2                    e. 3  
   b. 6                    f. 5  
   c. 1                    g. 4  
   d. 7
  
2. a. Bathroom — Adjacent to sink  
   b. Laundry — Within six feet of appliance to be served  
   c. Outside  
   d. Basement  
   e. Attached garage
  
3. a, d
  
4. a. 45"  
   b. 40"  
   c. 12"  
   d. 48"
  
5. b, c, d
  
6. b
  
7. a. Corner to corner chalkline and plumb bob transfer  
   b. Measuring half wall lengths, out at right angles from the walls
  
8. b, d, f
  
9. a. Always  
   b. Well insulated  
   c. Rating  
   d. Preform  
   e. Tools  
   f. NEC
  
- 10-11. Evaluated to the satisfaction of the instructor
  
12. Performance skills evaluated to the satisfaction of the instructor

## **SERVICE UNIT III**

### **UNIT OBJECTIVE**

After completion of this unit, the student should be able to properly design, size, and install a residential service. Competencies will be demonstrated by completing the assignment sheet, job sheets, and the unit tests with a minimum score of 85 percent.

### **SPECIFIC OBJECTIVES**

After completion of this unit, the student should be able to:

1. Match terms related to service with their correct definitions.
2. Match required clearances for service drop conductors with their locations.
3. Select true statements concerning service disconnects.
4. List four facts that should be known before the service installation is started.
5. Identify the parts of a service entrance.
6. Select types of grounding electrodes.
7. Complete statements concerning grounding electrode conductor installations and sizes.
8. Select true statements concerning short circuit protection at service equipment.
9. Select true statements concerning surge protection.
10. Calculate service size and minimum number of circuits. (Assignment Sheet #1)

**OBJECTIVE SHEET**

11. Demonstrate the ability to:
  - a. Install an overhead raceway with service entrance conductors to a meter base. (Job Sheet #1)
  - b. Connect meter base assembly to load center or panel. (Job Sheet #2)
  - c. Install an underground service (lateral) raceway with conductors to a meter base. (Job Sheet #3)

## SERVICE UNIT III

### SUGGESTED ACTIVITIES

- A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

- B. Make transparencies from the transparency masters included with this unit.
- C. Provide students with objective sheet.
- D. Discuss unit and specific objectives.
- E. Provide students with information and assignment sheet.
- F. Discuss information and assignment sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

- G. Provide students with job sheets.
- H. Discuss and demonstrate the procedures outlined in the job sheets.
- I. Integrate the following activities throughout the teaching of this unit:
1. Have students review Unit X: Overcurrent Protection in *Basic Wiring*.
  2. Contact a local sales distributor to discuss and demonstrate fuses and circuit breaker types.
  3. Contact a local electrical utility representative to discuss local requirements for services and meter demonstration.
  4. Contact local code enforcement (inspection) department to schedule visit of inspection to inform class about local regulations and requirements for service installation and grounding.
  5. If possible, plan an on-sight visit to a residence under construction to see rough-in of service installation—underground or overhead or both.
  6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

- J. Give test.
- K. Evaluate test.
- L. Reteach if necessary.

## REFERENCES USED IN WRITING THIS UNIT

- A. *Buss Fuses — Full Line Condensed Catalog*, January 1985. St. Louis, MO: Bussman Division, McGraw Edison Company.

(NOTE: For a copy of this catalog, write to P.O. Box 14460, St. Louis, MO 63178.)

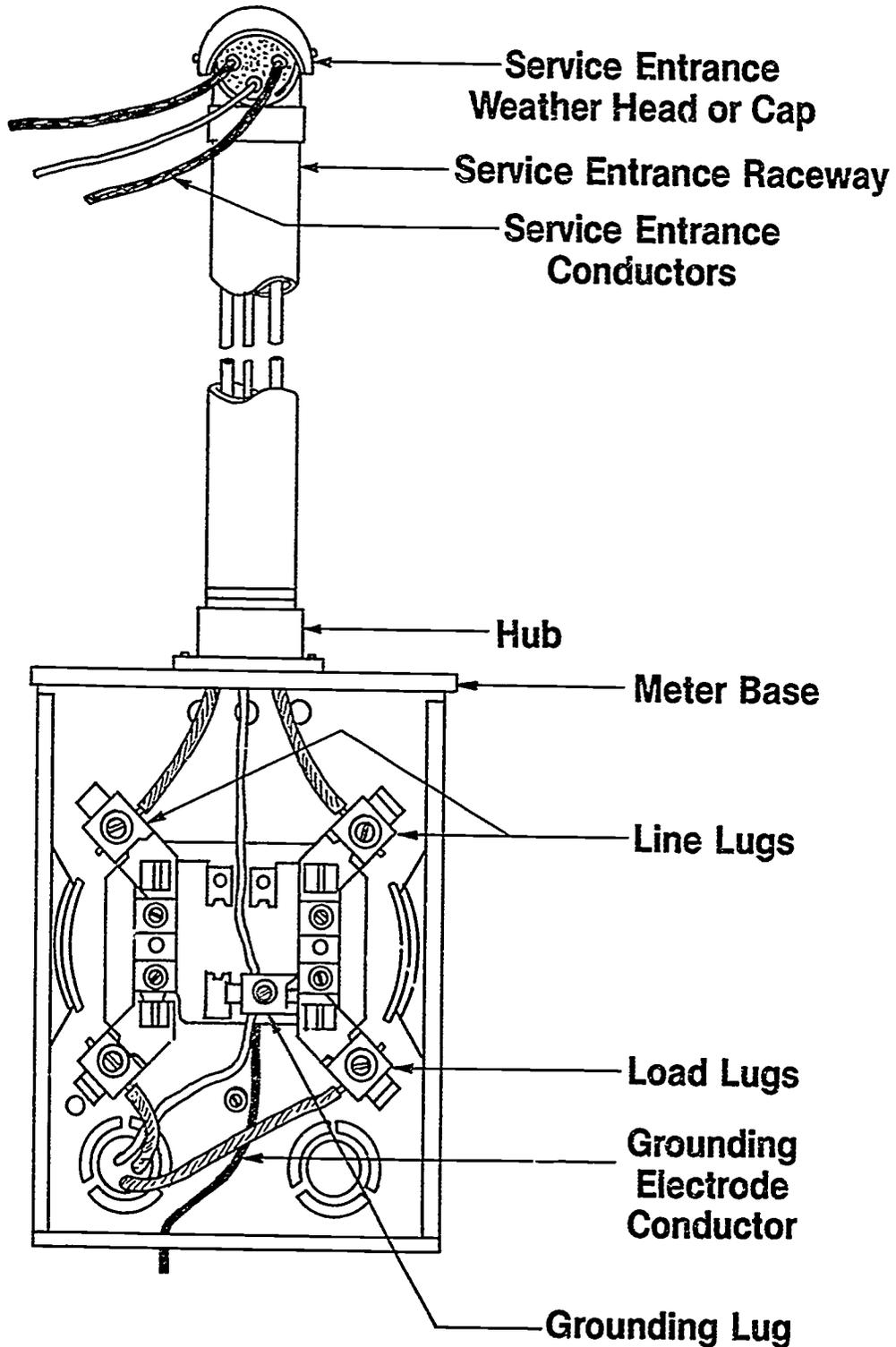
- B. *D Digest 1987*. Palatine, IL: Square D Company.
- C. Earl, John T. *Electrical Wiring Design and Application*. Englewood Cliffs, NJ: Prentice Hall, 1983.
- D. Foley, Joseph H. *Electrical Wiring Fundamentals*. New York: Gregg, McGraw-Hill Book Company, 1981.
- E. Gray, Elliott C.; R. Bailey; and E. Melbourne. *Electrical Construction and Maintenance Techniques*. Englewood Cliffs, NJ: Prentice Hall, 1986.
- F. *National Electrical Code, 1987*. Quincy, MA: National Fire Protection Association, 1986.
- G. *Pass and Seymore — Wiring Devices Catalog #486*. Syracuse, NY.
- (NOTE: For a copy of this catalog, write to P.O. Box 4822, Syracuse, NY 13221.)
- H. Richter, Herbert P. and W. Creighton Schwan. *Practical Electrical Wiring*. Thirteenth Edition. Englewood Cliffs, NJ: Prentice Hall, 1984.
- I. Stallcup, James G. *Designing Electrical Systems*. Homewood, IL: American Technical Publishers, Inc., 1985.
- J. Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

## SUGGESTED SUPPLEMENTAL MATERIAL

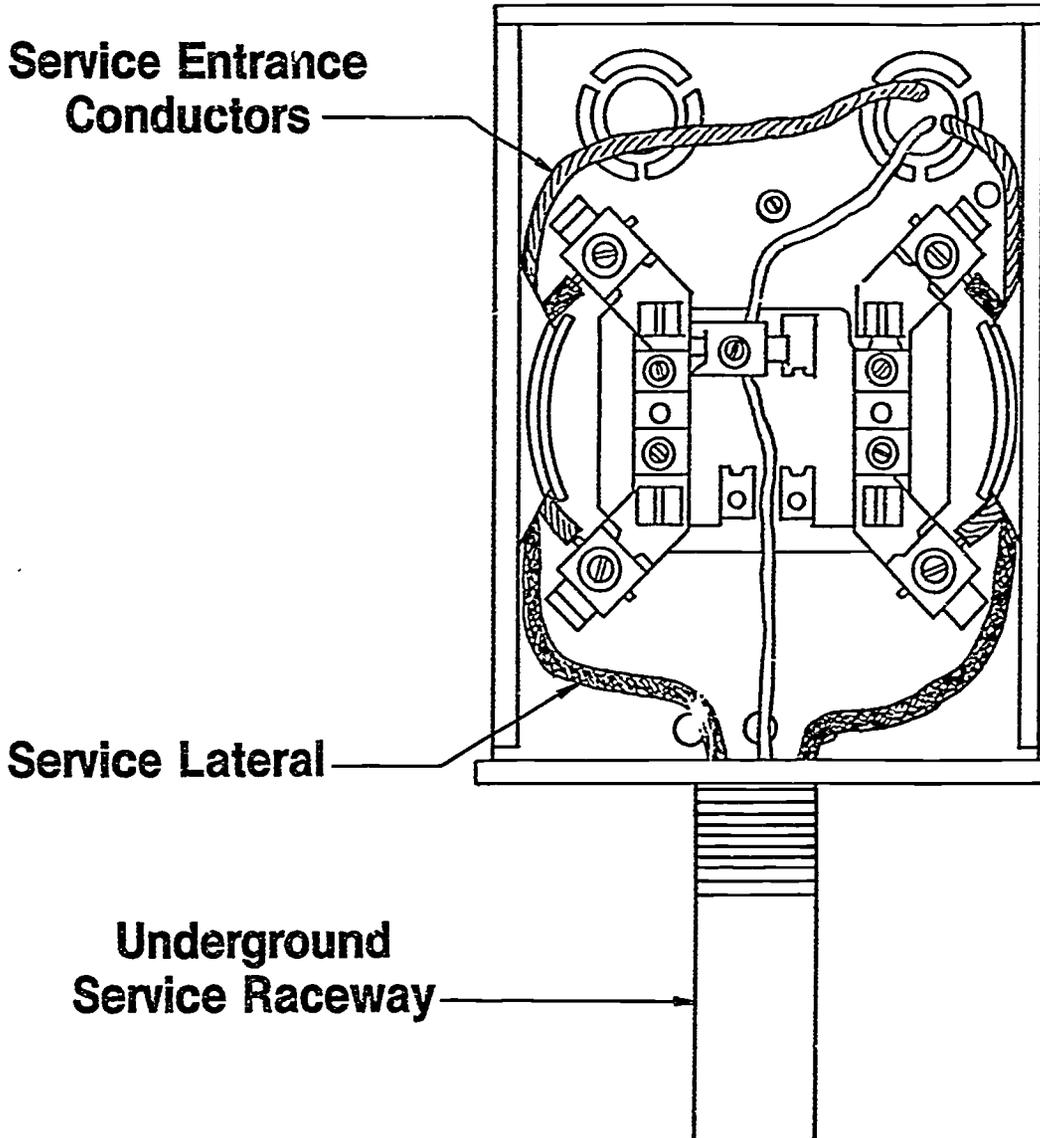
### Filmstrips

- A. *Electrical Wiring*. Unit IV, Installing Service Equipment. American Association for Vocational Instructional Materials, 120 Engineering Center, Athens, GA 30602.
- B. *Electrical House Wiring Explained #803 — #6 Fuse and Circuit Breaker Panels*. Bergwall Productions, Inc., 839 Stewart Ave., Garden City, NY 11530.
- C. *Residential Electrical Wiring Explained #804 — 804A.3, Underground Service Entrance*. Bergwall Productions, Inc., 839 Stewart Ave., Garden City, NY 11530.
- D. *Electrical Wiring, Unit 1, Number 3, Fuses, Circuit Breakers and GFCI's, Unit 1, Number 2, Grounding*. DCA Educational Products, 424 Valley Rd., Warrington, PA 18976.
- E. *Wiring A House — Unit 3, Number 1, Overheat Service and Unit 3, Number 2, Installing the Panel*. DCA Educational Products, 424 Valley Rd., Warrington, PA 18976.

# Parts of a Service Entrance

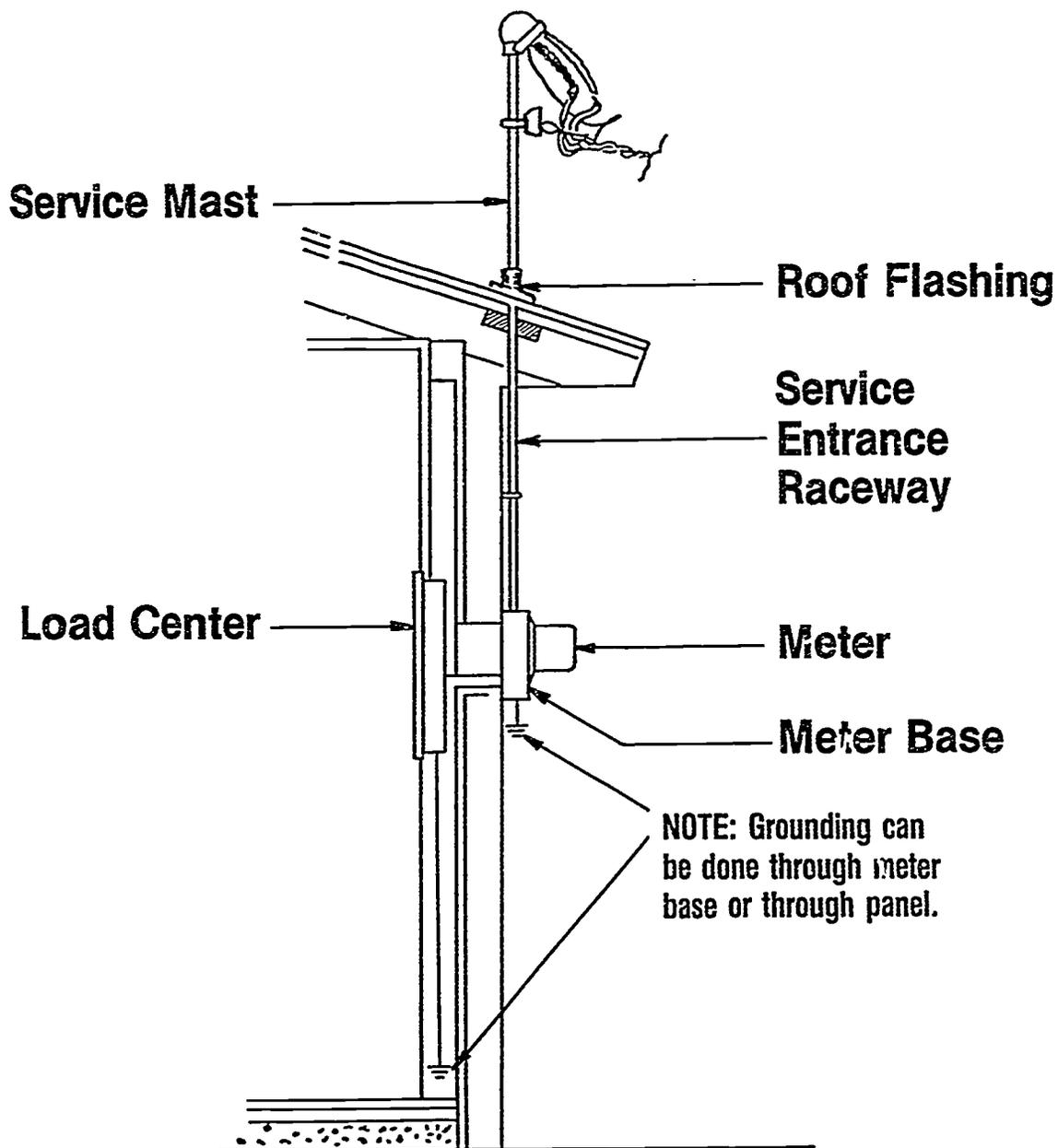


# Parts of a Service Entrance (Continued)

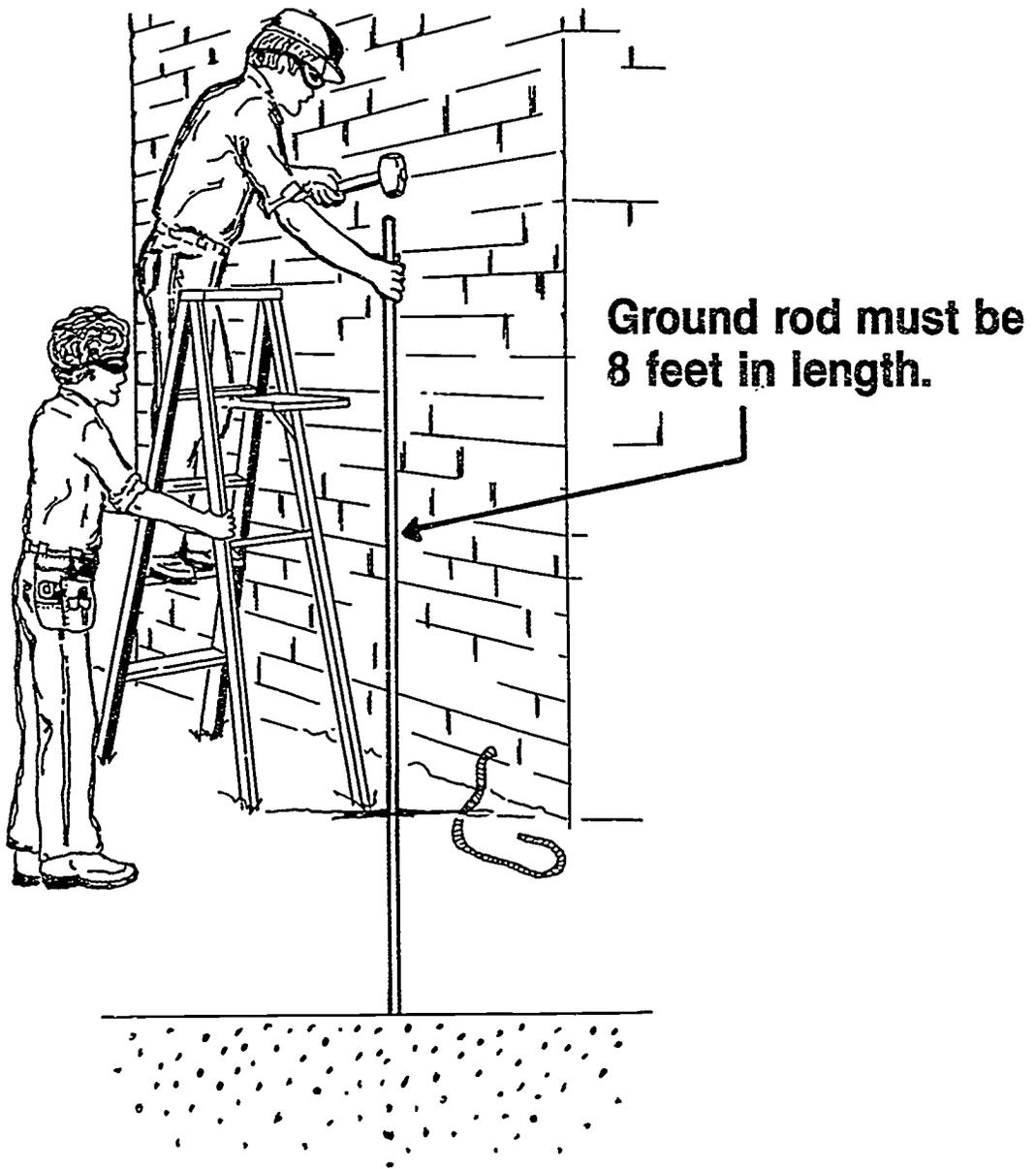


# Parts of a Service Entrance

(Continued)



# Installing Grounding Rod



## SERVICE UNIT III

### INFORMATION SHEET

#### I. Terms and definitions

- A. **Circuit breaker** — Automatic overcurrent device that trips on overloads or shorts and is resettable
- B. **Cutout box** — An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper
- C. **Disconnecting means** — A device or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply
- D. **Grounding electrode conductor** — Conductor used to connect the grounding electrode to the equipment grounding conductor and/or the grounded conductor of the circuit at the service
- E. **Overcurrent protection** — Weak link in the circuit that limits the amperage to a specified amount
- F. **Roof flashing** — Protective equipment used where the mast emerges from the roof or eave to seal around the raceway and protect against water damage

(NOTE: The majority of the following definitions are from NEC Article 100.)

- G. **Service** — Where power is metered or is first attached to the structure
- H. **Service cable** — Service conductors made up in the form of a cable
- I. **Service conductors** — Supply conductors that extend from the street main or from transformers to the service equipment of the premises to be supplied
- J. **Service drop** — Power conductors coming into building from power company
- K. **Service entrance conductors, underground system** — Service conductors between the terminals of the service equipment and the point of connection to the service lateral
- L. **Service entrance conductors, overhead system** — Service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop

## INFORMATION SHEET

- M. Service equipment — Necessary equipment, usually consisting of a circuit breaker or fuses and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply

(NOTE: Overcurrent devices shall not be located in the vicinity of easily ignitable material such as in clothes closets.)

- N. Service lateral — Underground service conductors between the street main, including any risers at a pole or other structure or from transformers and the first point of connection to the service entrance conductors in a terminal box or meter or other enclosure with adequate space inside or outside the building wall

(NOTE: Where there is no terminal box, meter, or other enclosure with adequate space, the point of connection shall be considered to the point of entrance of the service conductors into the building.)

- O. Service mast — That portion of a service raceway that extends through a roof or eave
- P. Service raceway — Raceway that encloses the service entrance conductors
- Q. Short circuit — Unintentional contact of a conductor

### II. Clearances for service drop conductors not in excess of 600v

(NOTE: NEC Art: 230 deals with services.)

- A. Over roofs — Not less than 8' from highest point except where the voltage between conductors does not exceed 600 and:
1. If the roof has a slope of not less than 4" in 12", a 3' minimum is permitted on systems which do not exceed 300v between conductors
  2. If the conductors do not pass over more than 4' of overhang and are terminated at a through-the-roof raceway or support, an 18" minimum is permitted on systems which do not exceed 300v between conductors.
- B. From ground vertically
1. 10 feet — At the electric service entrance to buildings, or at the drip loop of the building electric entrance, measured from final grade or other accessible surface only for service-drop cables supported on and cabled together with a grounded bare messenger and limited to 150 volts to ground

## INFORMATION SHEET

2. 12 feet — For those areas listed in the 15 foot classification when the voltage is limited to 300 volts to ground
3. 15 feet — Over residential property and driveways, and those commercial areas are not subject to truck traffic
4. 18 feet — Over public streets, alleys, roads, parking areas subject to truck traffic, driveways on other than residential property, and other land traversed by vehicles such as cultivated, grazing, forest, and orchard

### III. Service disconnects

- A. Maximum number of service entrance disconnects — Not more than six switches or circuit breakers in single enclosure or grouped on a switchboard

(NOTE: NEC Art: 230 deals with services. Where a residence requires more than six circuits, a main breaker is generally used.)

- B. Transfer switches — A double throw switch is used to transfer the alternate source of supply in case main service is lost. The transfer switch must disconnect the main service before connecting the alternate source. This switch may be manually or automatically operated.

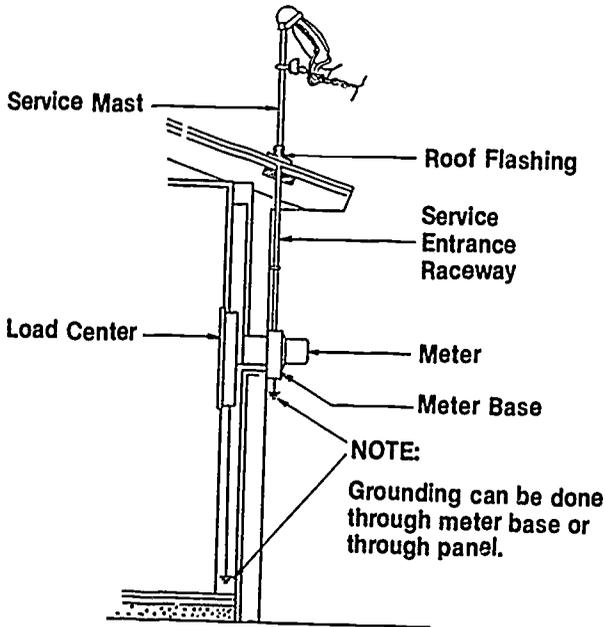
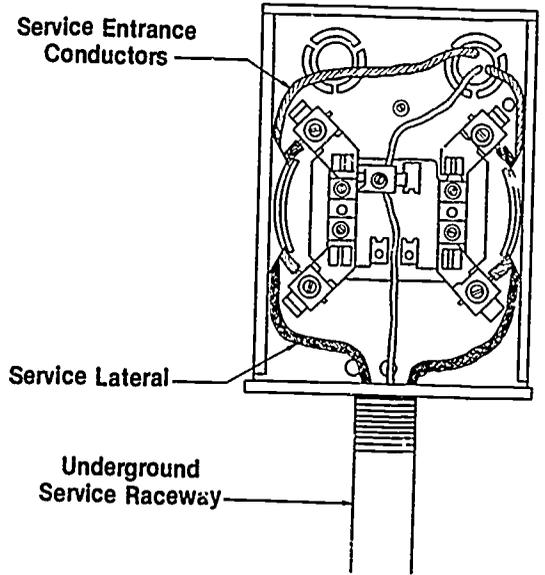
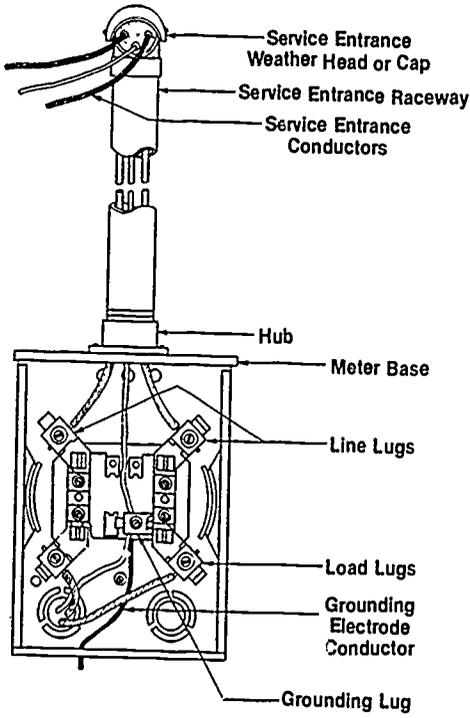
(NOTE: NEC Art: 230-83 deals with transfer switches.)

### IV. Facts that should be known before the service installation is started

- A. Whether underground or overhead service will be used
- B. Voltage and amperage of service needed
- C. Point at which service conductors are to enter the building
- D. Size of service equipment needed

# INFORMATION SHEET

## V. Parts of a service entrance



## INFORMATION SHEET

### VI. Types of grounding electrodes

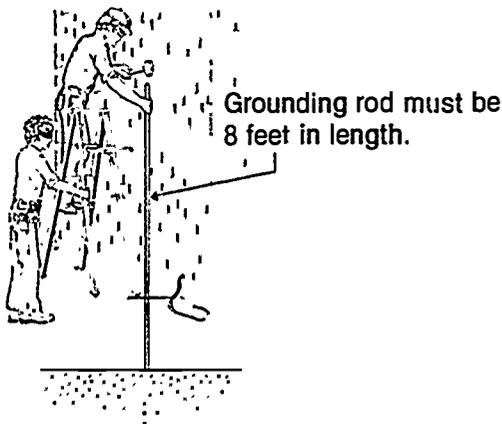
(NOTE: NEC Art: 250 deals with grounding.)

- A. Structural metal — Nearest available effectively grounded structural metal member of the structure
- B. Water pipe — Metal water pipe shall be used when available

(NOTE: It should be in direct contact with earth for 10 feet or more and electrically continuous to the points of connection of the grounding electrode conductor and the bonding conductors.)

#### C. Made electrodes

1. At least 20' of bare copper conductor not smaller than No. 4 AWG or one or more steel reinforced bars or rods of not less than 1/2" diameter encased in at least 2" of concrete in a foundation or footing
2. 8' lengths of:
  - a. 3/4" galvanized pipe
  - b. 5/8" iron or steel rod
  - c. 1/2" nonferrous rod (copper, brass, and other noncorrosive metals)



(NOTE: Where a rock bottom is not encountered the electrode shall be driven to a length of 8'. Where rock is hit at less than 4' the electrode shall be buried in a trench. A metal underground water pipe shall be supplemented by an additional electrode as specified in NEC Articles 250-81 or 250-3)

3. At least 20' of #2 bare copper 2 1/2' undergrade encircling the structure

## INFORMATION SHEET

### VII. Grounding electrode conductor installations and sizes

(NOTE: NEC Article 250 deals with grounding.)

- A. Conductors and enclosures shall be secured to the surface they follow
- B. #6 or larger conductors
  - 1. Must be in conduit if subject to physical damage
  - 2. If free from physical damage it may follow the surface of building if stapled securely.
  - 3. Aluminum or copper clad aluminum cannot be used in contact with masonry or earth.

(NOTE: Grounding electrode conductor sizes are determined by referring to NEC Table 250-94.)

### VIII. Short circuit protection at service equipment

- A. Service equipment must be able to withstand the fault-current that the power company's transformer could deliver in case of a short-circuit condition.
- B. Overcurrent protection devices must be selected to interrupt instantaneous short-circuit currents (fault currents).

(NOTE: The following table represents the "Rule of Thumb" method for finding IC (interrupting capacity) ratings for fuses or circuit breakers.)

Ampacity of Service	Service Rating	IC Rating
120/240V 1 Ph	Less than 200A	10,000 A
120/240V 1 Ph	Less than 600A	42,000 A
120/240V 3 Ph	Less than 2000A	42,000 A

#### C. Formulas for short circuit calculations include:

1. Single phase,  $I = \frac{KVA \times 1000}{E}$

2. Three phase,  $I = \frac{KVA \times 1000}{E \times 1.73}$

## INFORMATION SHEET

### IX. Surge protection

- A. Voltage surges with peaks of several thousand volts, even on 120V circuits, are not uncommon. These surges occur because of induced voltages in power lines resulting from lightning strikes in the vicinity of the line. Surge arresters for installation as part of an electric service and for use with cord-and-plug-connected electronic equipment are commercially available.
- B. Lightning surge arresters must fulfill the following functions:
1. They must not allow the passage of current to ground as long as the voltage is normal.
  2. When the voltage rises to a definite amount above normal, they must provide a path to ground for discharge of surge energy.
  3. As soon as the voltage has returned below the setting of the arrester the arrester must stop the flow of current to ground and re-insulate itself so as to insulate the supply conductor from ground.
  4. Arresters must not be damaged by the discharge and be capable of automatically repeating their action as frequently as is required.

## INFORMATION SHEET

### X. Sizing the service entrance conductors

(NOTE: In Unit I, Blueprint Reading and Load Calculations, we learned the procedure for various circuit calculations. It is now necessary to carry those calculations one step further to determine the size of service entrance conductors.)

#### A. Using the examples shown below, determine the size of the service entrance required for the described dwelling.

**PROBLEM:** Determine the size service-entrance conductors required for Phases A and B and the neutral of a 2,000 sq. ft. dwelling unit with the following loads:

- General lighting and receptacle loads
- Two small appliance loads and one laundry load
- Special appliance loads
 

Two wall-mounted 4-kVA ovens	8,000 VA
Cooktop	6,500 VA
Heating	25,000 VA
Air conditioning	9,000 VA
Water heater	5,000 VA
Dishwasher	1,200 VA
Disposal	1,000 VA

#### OTHER LOADS

Step 1: *Table 220-30.*

General lighting and receptacle loads:  
2,000 sq. ft.  $\times$  3 VA = 6,000 VA

Small appliance loads:  
1,500 VA  $\times$  2 = 3,000 VA

Laundry  
1,500 VA  $\times$  1 = 1,500 VA

Wall-mounted ovens:  
4 kVA  $\times$  2 = 8,000 VA

Cooktop = 6,500 VA

Water heater = 5,000 VA

Dishwasher = 1,200 VA

Disposal = 1,000 VA

Total loads = 32,200 VA

ANSWER: The other loads are 32,200 volt-amps.

#### HEATING LOAD

Step 1: *220-21.*

Drop smallest of heating or air conditioning load

ANSWER: The heating load is 25,000 volt-amps.

#### APPLYING DEMAND FACTORS

Other Loads

Step 1: *Table 220-30.*

First 10,000 VA at 100 % = 10,000 VA

Next 22,200 VA at 40% = 8,800 VA

ANSWER: The demand load is 18,880 volt-amps.

#### Heating Load

Step 1: *Table 220-30.*

25,000 VA  $\times$  65% = 16,250 VA

ANSWER: The demand load is 16,250 volt-amps.

Step 1: Add all loads:

Other loads = 18,880 VA

Heating load = 16,250 VA

18,880 VA + 16,250 VA = 35,130 VA

#### B. Take the total connected demand load of 35,130 VA and divide it by the voltage

$$\frac{35,130 \text{ VA}}{240 \text{ Volts}} = 146 \text{ Amps}$$

## INFORMATION SHEET

- C. Go to Table 310-16, Column 2 of the NEC to find that 2 #1/0 THW copper conductors are required. The neutral loads should now be determined. See Example.

### TOTAL NEUTRAL LOADS

Step 1:

220-22. General lighting and receptacle loads:  
6,000 VA

220-16(a,b). Small appliance loads: 4,500 VA  
4,500 VA

6,000 VA + 4,500 VA = 10,500 VA

General lighting and receptacle loads and small  
appliance loads: 10,500 VA

Table 220-11. First 3,000 VA at 100% = 3,000 VA  
Next 7,500 VA at 35% = 2,625 VA

3,000 VA + 2,625 VA = 5,625 VA

Table 220-19, Column C. Cooking Equipment  
14,500 VA × 55% = 7,975 VA

220-22 7,975 VA × 70% = 5,583 VA

220-3(c)(1). Dishwasher = 1,200 VA

220-3(c)(2). Disposal = 1,000 VA

220-14. Largest motor × 25%  
1,000 VA × 25% = 250 VA

Total neutral loads = 13,658 VA

$$\text{STEP 2: } I = \frac{\text{VA}}{V}$$

$$I = \frac{13,658 \text{ VA}}{240 \text{ V}} = 57 \text{ A}$$

ANSWER: The neutral load is 57 amps.

- D. Size of the service entrance conductors required for this dwelling are:

1. Phases A and B:  
*Table 310-16, Column 2:* Two #1/0 THW copper conductors are required.
2. Neutral:  
*Table 310-16, Column 2:* One #6 THW copper conductor is required.

(NOTE: Note 3 to NEC Tables 310-16-310-31 may be applied.)

## SERVICE UNIT III

### ASSIGNMENT SHEET #1 — CALCULATE SERVICE SIZE AND MINIMUM NUMBER OF CIRCUITS

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

Directions: Using the standard code procedure listed below calculate service size and minimum number of circuits on the following single family dwelling.

(NOTE: Refer to NEC Chapter 9 - Tables and Examples. Example No. 1[a]).

Dwelling has a floor space of 2,100 square feet. It also has an 11 kw electric range.

General lighting load

1. \_\_\_\_\_ sq. ft. × 3 watts per sq. ft. = 2. \_\_\_\_\_

Minimum number of branch circuits

General lighting load 3. \_\_\_\_\_ ÷ 115 = 4. \_\_\_\_\_ ÷ 20 = 5. \_\_\_\_\_ or  
number of general lighting circuits

(NOTE: This number always rounds to next whole number if a fraction appears.)

Small appliance load: Two 2-wire 20 ampere circuits

Laundry load: One 2-wire 20 ampere circuit.

Minimum size feeders required

Computed load

General lighting 6. \_\_\_\_\_ watts

Small appliance +3,000 watts

Laundry +1,500 watts

Total (without range) 7. \_\_\_\_\_ watts

3,000 watts at 100% = 3,000 watts

Total (without range) 8. \_\_\_\_\_ - 3,000 =

\_\_\_\_\_ watts × 35% = 9. \_\_\_\_\_ watts

Net computed load (without range) 10. \_\_\_\_\_ watts

Range load 8,000 watts

Net computed load (with range) 11. \_\_\_\_\_ watts

For 120/240 volt 2-wire system feeders, net computed load (with range)

12. \_\_\_\_\_ ÷ 240 = 13. \_\_\_\_\_ amperes

Net computed load exceeds 10 kw so service conductors shall be 100 amperes

Reduced size neutral shall be permitted, usually two trade sizes smaller than the ungrounded conductors

Feeder and service neutral

Lighting small appliance load (net without range) 14. \_\_\_\_\_ watts

Range load 8,000 watts at 70% 5,600 watts

Total 15. \_\_\_\_\_ watts

Total 16. \_\_\_\_\_ ÷ 240 = 17. \_\_\_\_\_ amperes

(NOTE: Refer to NEC Table 310-16, notes to Tables - No. 3, for proper conductor sizing.)

**SERVICE  
UNIT III****ANSWERS TO ASSIGNMENT SHEET #1**

1. 2,100
2. 6,300
3. 6,300
4. 54.8
5. 3
6. 6,300
7. 10,800
8. 10,800
9. 2,730
10. 5,730
11. 13,730
12. 13,730
13. 57.21
14. 5,730
15. 11,330
16. 11,330
17. 47.21

## SERVICE UNIT III

### JOB SHEET #1 — INSTALL AN OVERHEAD RACEWAY WITH SERVICE ENTRANCE CONDUCTORS TO A METER BASE

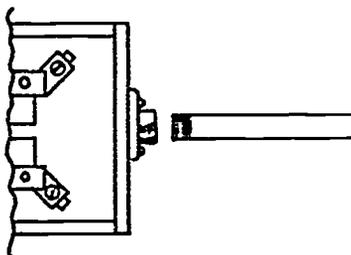
#### A. Equipment and materials needed

1. Flat blade screwdriver
2. Lineman's pliers
3. Hammer
4. Knife
5. Hacksaw
6. Folding rule with sliding scale
7. Meter base
8. Service entrance cap (1 1/2" clamp-on type)
9. 3' of 1 1/2" rigid metal conduit (threaded on one end)
10. 12' of #2 copper TW (two 6' pieces)
11. 6' of #4 copper
12. Safety glasses

#### B. Procedure

1. Put on safety glasses and gather equipment and materials.
2. Screw threaded end of raceway into hub. (Figure 1)

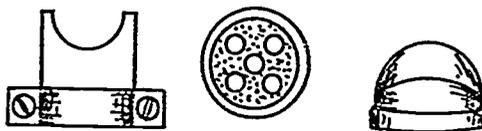
FIGURE 1



## JOB SHEET #1

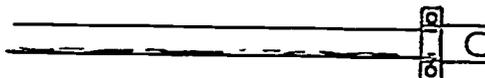
3. Remove cover and separator from weatherhead. (Figure 2)

FIGURE 2



4. Clamp weatherhead base onto the end of the service raceway. (Figure 3)

FIGURE 3

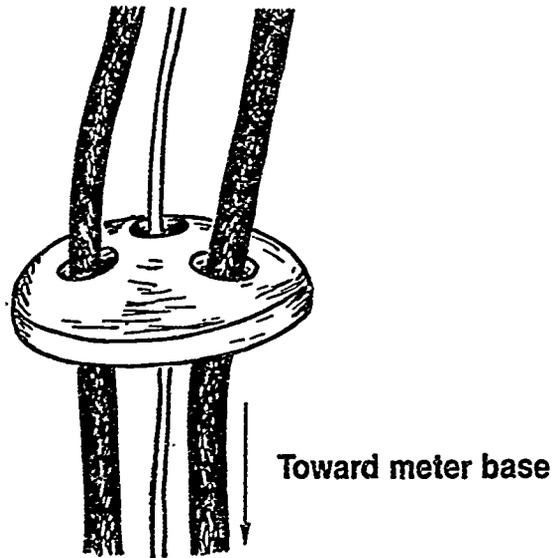


5. Install conductors in the raceway.  
(NOTE: Start at weatherhead end.)
6. Connect grounded conductor to grounding lug.  
(NOTE: When possible leave grounded conductor long enough to connect to disconnect equipment grounding bar.)
7. Remove 1" to 1 1/2" of insulation from ungrounded conductors and connect to line lugs.
8. Knock out three outlined holes in the entrance cap separator.
9. Put grounded conductor through center hole.

## JOB SHEET #1

10. Put ungrounded conductors through side holes. (Figure 4)

FIGURE 4



11. Gently start forming conductors so the separator will fit back in the base.

(NOTE: Care must be taken while you are bending the curvature in the conductors to prevent damage to the plastic conductor separator.)

12. Replace service entrance cap cover.
13. Have instructor check your work.
14. Clean work area and put away all equipment and materials.

## SERVICE UNIT III

### JOB SHEET #2 — CONNECT METER BASE ASSEMBLY TO LOAD CENTER OR PANEL

#### A. Equipment and materials needed

1. Screwdriver
2. Lineman's pliers
3. Hammer
4. Knife
5. Level
6. Rule
7. Awl
8. Meter base assembly from Job Sheet #1
9. Two 1 1/4" insulating bushings
10. Four 1 1/4" locknuts
11. One 1 1/4" reamed nipple long enough to connect meter base to distribution panel  
  
(NOTE: Nipple, bushings, and locknuts can be larger than 1 1/4" if conductor size or necessity mandates.)
12. #4 copper (1 piece)
13. #2 TW copper (2 pieces)
14. Eight 1" #12 metal tapping screws
15. One 100 amp 1 phase 3 wire SN. load center
16. One 1 1/2" rigid conduit strap
17. 2" x 4" mock up wall or roughed in residential dwelling
18. Safety glasses

## JOB SHEET #2

## B. Procedure

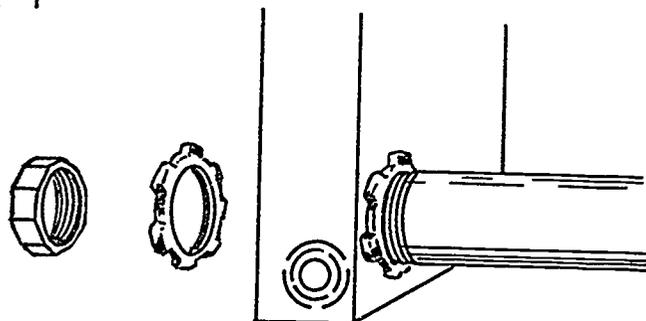
1. Put on safety glasses and gather equipment and materials.
2. Mount load center between studs with metal tapping screws.

(NOTE: Panel height should be adjusted so that knockouts will line up with meter base between 5' and 6'. The utility company will give you their recommended height.)

3. Remove load center knockout that will align with meter base at correct height.
4. Install nipple in opening with a locknut on the backside of load center and a locknut and bushing on the inside. (Figure 1)

(NOTE: Be sure that locknuts are installed tightly with teeth into the metal. Also be sure to check local codes on bonding.)

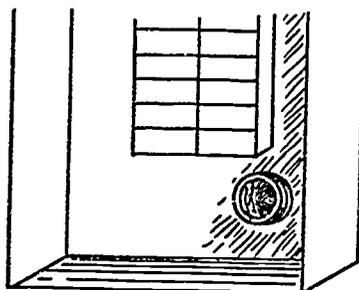
FIGURE 1



5. Remove appropriate knockout from meter base.
6. Put back up locknut for meter base on nipple.
7. Place nipple through meter base knockout and secure loosely with one screw. (Figure 2)

(NOTE: Cut off excess nipple; leave only what is needed for locknut and bushing.)

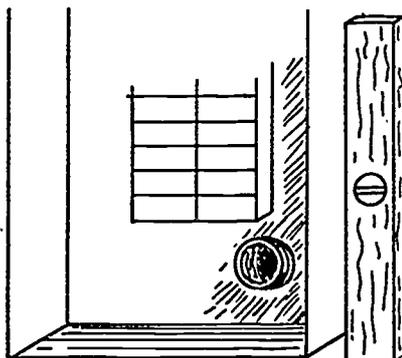
FIGURE 2



## JOB SHEET #2

8. Install internal locknut and bushing.
9. Place level on side of meter base and secure with mounting screws when leveled. (Figure 3)

FIGURE 3



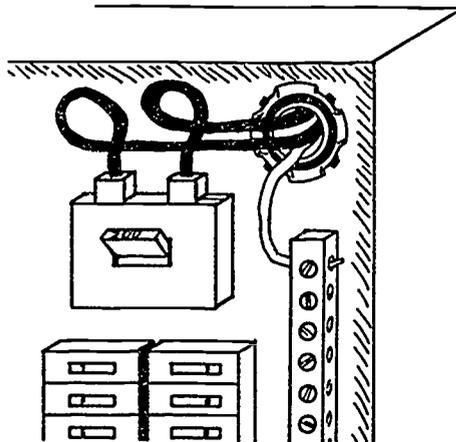
10. Put level on service raceway and secure with strap when leveled.
11. Install grounded conductor in nipple and connect to meter base and load center grounded lugs.  

(NOTE: Make all bends in conductors as square as possible while maintaining a radius equal to at least five times the diameter. Make sure you stay as far as possible from load and line lugs in your routing of the grounded conductors.)
12. Install ungrounded conductors in nipple.
13. Strip about 1 1/2" insulation from each of the ungrounded conductors, form them and connect to meter load lugs.
14. Form ungrounded conductors in load center.

## JOB SHEET #2

15. Cut off excess and connect to load center line lugs. (Figure 4)

FIGURE 4



(NOTE: The service system is still without a grounding electrode conductor. This conductor can originate at the load center or in the meter base. It can terminate at a cold water pipe or made electrode.)

16. Have instructor check your work.
17. Clean work area and put away all equipment and materials.

## SERVICE UNIT III

### JOB SHEET #3 — INSTALL AN UNDERGROUND SERVICE (LATERAL) RACEWAY WITH CONDUCTORS TO A METER BASE

#### A. Equipment and materials needed

1. Flat blade screwdriver
2. Lineman's screwdriver
3. Knife
4. Hacksaw
5. Folding rule or tape measure
6. Meter base
7. 3' of 2" rigid nonmetallic tubing (PVC)
8. One — 2" PVC 90° elbow
9. One — 2" PVC coupling
10. One — 2" PVC male adapter
11. One — 2" lock nut
12. 10' of 3 conductor #1/0 use (underground service entrance, suitable for direct burial)
13. Safety glasses

#### B. Procedure

1. Put on safety glasses and gather equipment and materials.

2. Mount meterbase.

(NOTE: Meter base height should be adjusted to conform with local utility company requirements. [See your instructor].)

3. Install PVC 90° elbow onto 2" conduit, using the 2" coupling.

(NOTE: For the purpose of this procedure it will not be necessary to use the PVC cement to bond the parts together.)

## JOB SHEET #3

4. Measure the assembled conduit to fit the bottom of the meter base.

(NOTE: Deduct approximately  $\frac{1}{4}$ " for the space needed by the male adapter.)

5. Cut off excess conduit from opposite end of 90° elbow.

6. Install male adapter onto conduit.

7. Remove knock-out in bottom of meter base (only 2").

8. Install conduit assembly (conduit, male adapter, coupling, and 90° elbow) into meter base knock-out.

9. Install locknut onto male adapter threads inside meter base and tighten.

(NOTE: Be sure teeth of locknut are turned into metal.)

10. Feed conductors up through raceway into meter base.

11. Strip approximately 1-1  $\frac{1}{2}$ " of insulation from each of the ungrounded conductors.

(NOTE: Ground conductor of 3 wire USE cable will be marked with a white or yellow stripe.)

12. Form and install ungrounded conductor to the line legs of meter base.

(NOTE: Supply conductors always attach to the line lugs of a meter base. With underground service installation these conductors must form through the meter base and connect to the top line lugs. NEVER attach supply conductors to the bottom lugs; these are for load conductors only.)

13. Strip form and install the grounded conductor.

(NOTE: This conductor should be formed through the meter base and attached to the top lug of the grounded terminal in the meter base.)

(NOTE: This service is still without a grounding electrode conductor. This conductor can originate at the load center or in the meter base. It can terminate at a cold winter pipe or made electrode. Consult local inspection authority for requirements or see your instructor.)

## SERVICE UNIT III

### JOB SHEET #1 PRACTICAL TEST — INSTALL AN OVERHEAD RACEWAY WITH SERVICE ENTRANCE CONDUCTORS TO A METER BASE

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:

	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Threaded end of raceway screwed into hub.	_____	_____
3. Cover and separator removed from weatherhead.	_____	_____
4. Installed conductors in raceway.	_____	_____
5. Grounding conductor installed in correct hole.	_____	_____
6. Replaced service cap cover securely.	_____	_____
7. Checked in/put away tools and materials.	_____	_____
8. Cleaned the work area.	_____	_____
9. Used proper tools correctly.	_____	_____
10. Performed steps in a timely manner. (____hrs. ____min. ____sec.)	_____	_____
11. Practiced safety rules throughout procedure.	_____	_____
12. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #1 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

**Criteria:**

	4	3	2	1
Service mast straight and tight				
	4	3	2	1
Service conductor formed properly				
	4	3	2	1
Service conductors extend beyond riser cap proper length				
	4	3	2	1
Proper connection of line conductor to supply lugs				
	4	3	2	1
Proper connection of neutral conductor to neutral lugs				
	4	3	2	1
Workmanship				
	4	3	2	1
Compliance to NEC				

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

**SERVICE  
UNIT III**

**JOB SHEET #2 PRACTICAL TEST — CONNECT METER BASE  
ASSEMBLY TO LOAD CENTER OR PANEL**

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

**PROCESS EVALUATION**

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Panel mounted at proper height.	_____	_____
3. Correct K.O.'s removed from panel (location and size).	_____	_____
4. Installed nipple to the backside of panel.	_____	_____
5. Installed locknut and bushing inside panel.	_____	_____
6. Correct K.O.'s removed from meter base (location size).	_____	_____
7. Both bushings installed before installing conductors.	_____	_____
8. Care used in installing conductor to prevent damage to installation.	_____	_____
9. Conductor insulation removed in such a way that no conductor was cut away (nicks in conductor).	_____	_____
10. Checked in/put away tools and materials.	_____	_____
11. Cleaned the work area.	_____	_____
12. Used proper tools correctly.	_____	_____
13. Performed steps in a timely manner. (____hrs. ____min. ____sec.)	_____	_____
14. Practiced safety rules throughout procedure.	_____	_____
15. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #2 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

**Criteria:**

Meter base is straight and level	4	3	2	1
Raceway is mounted securely	4	3	2	1
Correct connection made (ungrounded conductor to ungrounded [top] lugs)	4	3	2	1
Correct connection made (grounded conductor to grounded lug)	4	3	2	1
All conductors formed correctly	4	3	2	1
All connections secure	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

# SERVICE UNIT III

## JOB SHEET #3 PRACTICAL TEST — INSTALL AN UNDERGROUND SERVICE (LATERAL) WITH CONDUCTORS TO A METER BASE

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Coupling installed completely onto conduit.	_____	_____
3. 90°/0 elbow installed completely into coupling.	_____	_____
4. Male adapter installed completely onto raceway.	_____	_____
5. Lock nut installed with teeth toward metal of meter base.	_____	_____
6. Care taken to protect insulation of cable while feeding through raceway.	_____	_____
7. Care taken to not nick conductor during removal of insulation at strip.	_____	_____
8. Checked in/put away tools and materials.	_____	_____
9. Cleaned the work area.	_____	_____
10. Used proper tools correctly.	_____	_____
11. Performed steps in a timely manner. (____hrs. ____min. ____sec.)	_____	_____
12. Practiced safety rules throughout procedure.	_____	_____
13. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #3 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

**Criteria:**

Assembly mount at proper height	4	3	2	1
Correct connections made (ungrounded conductor to ungrounded lugs and main breaker)	4	3	2	1
Correct connection made (grounded conductor to grounded lugs in panel and meter base)	4	3	2	1
All threaded connections tight	4	3	2	1
All conductor connections secure	4	3	2	1
Assembly level and straight	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_

PERFORMANCE EVALUATION KEY	
4	— Skilled — Can perform job with no additional training.
3	— Moderately skilled — Has performed job during training program; limited additional training may be required.
2	— Limited skill — Has performed job during training program; additional training is required to develop skill.
1	— Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## SERVICE UNIT III

### TEST

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

1. Match the terms on the right with their correct definitions.

- |         |                                                                                                                                                                                        |                                  |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| _____a. | Weak link in the circuit that limits the amperage to a specified amount                                                                                                                | 1. Cutout box                    |
| _____b. | Supply conductors that extend from the street main or from transformers to the service equipment of the premises to be supplied                                                        | 2. Circuit breaker               |
| _____c. | An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper                                    | 3. Disconnecting means           |
| _____d. | Power conductors coming into building from power company                                                                                                                               | 4. Grounding electrode conductor |
| _____e. | Service conductors between the terminals of the service equipment and the point of connection to the service lateral                                                                   | 5. Overcurrent protection        |
| _____f. | Protective equipment used where the mast emerges from the roof or eave to seal around the raceway and protect against water damage                                                     | 6. Roof flashing                 |
| _____g. | Service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop | 7. Service                       |
| _____h. | Service conductors made up in the form of a cable                                                                                                                                      | 8. Service cable                 |
| _____i. | A device or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply                                                      | 9. Service conductors            |

## TEST

- |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>____j. Conductor used to connect the grounding electrode to the equipment grounding conductor and/or the grounding conductor of the circuit at the service</p> <p>____k. Where power is metered or is first attached to the structure</p> <p>____l. That portion of a service raceway that extends through a roof or eave</p> <p>____m. Necessary equipment, usually consisting of a circuit breaker or fuses and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply</p> <p>____n. Underground service conductors between the street main, including any risers at a pole or other structure or from transformers and the first point of connection to the service entrance conductors in a terminal box or meter or other enclosure with adequate space inside or outside the building wall</p> <p>____o. Automatic overcurrent device that trips on overloads or shorts and is resettable</p> <p>____p. Unintentional contact of a conductor</p> <p>____q. Raceway that encloses the service entrance conductors</p> | <p>10. Service drop</p> <p>11. Service entrance conductors, underground system</p> <p>12. Service entrance conductors, overhead system</p> <p>13. Service equipment</p> <p>14. Service lateral</p> <p>15. Service mast</p> <p>16. Service raceway</p> <p>17. Short circuit</p> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## TEST

2. Match the required clearances of service drop conductors on the right to the various construction locations.

- |         |                                                                                                                                                                                   |        |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| _____a. | Above grade, sidewalks and platforms, or projections                                                                                                                              | 1. 3'  |
| _____b. | Over a roof with a slope of not less than 4" in 12" on systems which do not exceed 300V between conductors                                                                        | 2. 18" |
| _____c. | Over commercial areas subject to truck traffic                                                                                                                                    | 3. 10' |
| _____d. | Over public streets, alleys, roads, and nonresidential driveways                                                                                                                  | 4. 12' |
| _____e. | If the conductors do not pass over more than 4' of overhang and are terminated at a through-the-roof raceway or support on a system which does not exceed 300v between conductors | 5. 15' |
| _____f. | Over residential driveways, and commercial areas not subject to truck traffic                                                                                                     | 6. 18' |

3. Select true statements concerning service disconnects by placing an "X" in the blank preceding the true statement.

- \_\_\_\_\_a. Not more than seven switches or circuit breakers are allowed in a single enclosure or grouped on a switchboard.
- \_\_\_\_\_b. The transfer switch must disconnect the main service before connecting the alternate source. This switch may be manually or automatically operated.

4. List four facts that should be known before the service installation is started.

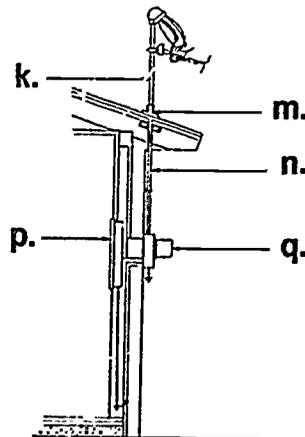
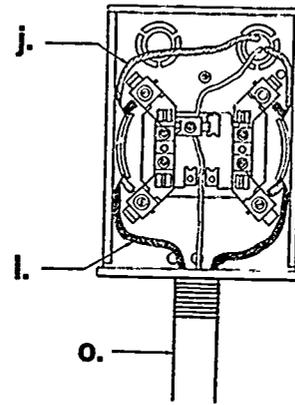
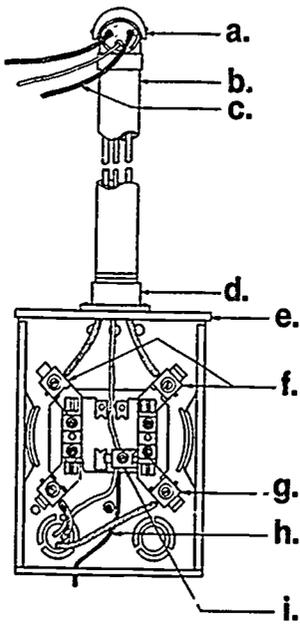
- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_

TEST

5. Identify the parts of a service entrance.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_
- e. \_\_\_\_\_
- f. \_\_\_\_\_
- g. \_\_\_\_\_
- h. \_\_\_\_\_
- i. \_\_\_\_\_

- j. \_\_\_\_\_
- k. \_\_\_\_\_
- l. \_\_\_\_\_
- m. \_\_\_\_\_
- n. \_\_\_\_\_
- o. \_\_\_\_\_
- p. \_\_\_\_\_
- q. \_\_\_\_\_



## TEST

6. Select from the following list types of grounding electrodes by placing an "X" in the blanks preceding the correct types.
- \_\_\_\_\_a. Water pipe
  - \_\_\_\_\_b. 8' length of  $\frac{5}{8}$ " iron or steel rod
  - \_\_\_\_\_c. Nearest effectively grounded structural metal member of the structure
  - \_\_\_\_\_d. 8' length of  $\frac{1}{2}$ " galvanized pipe
  - \_\_\_\_\_e. At least 10' of #2 bare copper  $4\frac{1}{2}$ ' undergrade encircling the structure
7. Complete the following statements concerning grounding electrode conductor installations and sizes by inserting the words which best complete each statement.
- a. Conductors and enclosures shall be secured to the \_\_\_\_\_ they follow.
  - b. #6 or larger conductors
    - 1) Must be in \_\_\_\_\_ if subject to physical damage.
    - 2) If free from physical damage it may follow the surface of building if \_\_\_\_\_ securely.
    - 3) Aluminum or copper clad aluminum cannot be used in contact with masonry or \_\_\_\_\_.
8. Select true statements concerning short circuit protection at service equipment by placing an "X" in the blanks preceding the true statements.
- \_\_\_\_\_a. Service equipment must be able to withstand the fault-current that the power company's transformer could deliver in case of a short-circuit condition.
  - \_\_\_\_\_b. Overcurrent protection devices must be selected to interrupt instantaneous short-circuit currents.
  - \_\_\_\_\_c. Formulas for short circuit calculations include:
    - 1) Single phase,  $I = \frac{KVA \times 1000}{E}$
    - 2) Three phase,  $I = \frac{KVA \times 1000}{E \times 1.73}$

## TEST

9. Select true statements concerning surge protection by placing an "X" in the blanks preceding the true statements.
- \_\_\_\_a. Voltage surges with peaks of several thousand volts, even on 120V circuits, are uncommon.
- \_\_\_\_b. Surges occur because of induced voltages in power lines resulting from lightning strikes in the vicinity of the line.
- \_\_\_\_c. Lightning surge arresters allow the passage of current to ground as long as the voltage is normal.
- \_\_\_\_d. When the voltage rises to a definite amount above normal, the surge arrester must provide a path to ground for discharge of surge energy.
- \_\_\_\_e. Arresters must not be damaged by the discharge and be capable of automatically repeating their actions as frequently as is required.
10. Calculate the size of service and minimum number of circuits on the following dwelling.  
1,900 sq. ft. with a 12 kw range
- General lighting load  
a. \_\_\_\_\_ sq. ft. x 3 watts per sq. ft. = b. \_\_\_\_\_
- Minimum number of branch circuits  
General lighting load c. \_\_\_\_\_ ÷ 120 = d. \_\_\_\_\_ ÷ 20 =  
e. \_\_\_\_\_ or number of general lighting circuits
- Small appliance load: Two 2-wire 20 ampere circuits.  
Laundry load: One 2-wire 20 ampere circuit.
- Minimum size feeders required
- |                                          |                |
|------------------------------------------|----------------|
| Computed load                            |                |
| General lighting                         | f. _____ watts |
| Small appliance                          | +3,000 watts   |
| Laundry                                  | +1,500 watts   |
| Total (without range)                    | g. _____ watts |
| 3,000 watts at 100% =                    | 3,000 watts    |
| Total (without range) h. _____ - 3,000 = |                |
| _____ watts x 35% =                      | i. _____ watts |
| Net computed load (without range)        | j. _____ watts |
| Range load                               | +8,000 watts   |
| Net computed load (with range)           | k. _____ watts |
- For 120/240 volt 3-wire system feeders, net computed load (with range.) l. \_\_\_\_\_  
÷ 240 = m. \_\_\_\_\_ amperes.

## TEST

Net computed load exceeds 10 kw so service conductors shall be 100 amperes.

Reduced size neutral shall be permitted, usually two trade sizes smaller than the ungrounded conductors

Feeder and service neutral

Lighting: Small appliance load (net without range)	n.			watts
Range load 8,000 watts at 70%		+5,600		watts
Total	o.			watts

Total p. \_\_\_\_\_  $\div$  240 = q. \_\_\_\_\_ amperes

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

11. Demonstrate the ability to:
  - a. Install an overhead raceway with service entrance conductors to a meter base. (Job Sheet #1)
  - b. Connect meter base assembly to load center or panel. (Job Sheet #2)
  - c. Install an underground service (lateral) raceway with conductors to a meter base. (Job Sheet #3)

## SERVICE UNIT III

### ANSWERS TO TEST

1.   a.   5                   e.   11                   i.   3                   m.   13                   q.   16  
       b.   9                   f.   6                   j.   4                   n.   14  
       c.   1                   g.   12                  k.   7                   o.   2  
       d.   10                  h.   8                   l.   15                  p.   17
2.   a.   3                   d.   6  
       b.   1                   e.   2  
       c.   5                   f.   4
3.   b
4.   a.   Whether underground or overhead service will be used  
       b.   Voltage and amperage of service needed  
       c.   Point at which service conductors are to enter the building  
       d.   Size of service equipment needed
5.   a.   Service entrance weatherhead or cap  
       b.   Service entrance raceway  
       c.   Service entrance conductors  
       d.   Hub  
       e.   Meter base  
       f.   Line lugs  
       g.   Load lugs  
       h.   Grounding electrode conductor  
       i.   Grounding lugs  
       j.   Service entrance conductors  
       k.   Service mast  
       l.   Service lateral  
       m.   Roof saddle  
       n.   Service entrance raceway  
       o.   Underground service raceway  
       p.   Load center or panel  
       q.   Meter
6.   a, b, c
7.   a.   Surface  
       b.   Conduit  
       c.   Stapled  
       d.   Earth

## ANSWERS TO TEST

8. All are correct

9. b, c, e

10.	a.	1,900	g.	10,200	m.	56.3
	b.	5,700	h.	10,200	n.	5,520
	c.	5,700	i.	2,520	o.	11,120
	d.	47.5	j.	5,520	p.	11,120
	e.	3	k.	13,520	q.	46.3
	f.	5,700	l.	13,520		

11. Performance skills evaluated to the satisfaction of the instructor

# TRIM OUT AND TROUBLESHOOTING UNIT IV

## UNIT OBJECTIVE

After completion of this unit, the student should be able to perform trim out for a residential wiring system and troubleshoot electrical problems for new and existing dwellings. Competencies will be demonstrated by completing the job sheets and the unit tests with a minimum score of 85 percent.

## SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to trim out and troubleshooting with their correct definitions.
2. Identify common residential receptacle types and cover plates.
3. Identify common residential switch types and cover plates.
4. Match common residential fixture locations with their types.
5. Complete statements related to appliance classifications.
6. Distinguish between requirements for appliance disconnect means.
7. State the grounding requirement for appliances.
8. Identify the parts of a duplex grounding type receptacle.
9. Identify the parts of an equipment grounding system.
10. Arrange in order the steps for panel trim out.
11. Select true statements concerning troubleshooting procedures.

**OBJECTIVE SHEET**

12. Demonstrate the ability to:
  - a. Install a duplex grounding type receptacle. (Job Sheet #1)
  - b. Install a range or dryer receptacle. (Job Sheet #2)
  - c. Install a multi-circuit split-wired duplex grounding type receptacle. (Job Sheet #3)
  - d. Wire a receptacle fed from a lighting outlet through a single pole switch. (Job Sheet #4)
  - e. Connect a supply cord to a free standing range. (Job Sheet #5)
  - f. Install a fixed appliance equipped with a pigtail to a branch circuit. (Job Sheet #6)
  - g. Install a fusible safety switch for an air-conditioning condenser. (Job Sheet #7)
  - h. Troubleshoot an electrical system problem. (Job Sheet #8)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### SUGGESTED ACTIVITIES

- A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

- B. Make transparencies from the transparency masters included with this unit.
- C. Provide students with objective sheet.
- D. Discuss unit and specific objectives.
- E. Provide students with information sheet.
- F. Discuss information sheet.

(NOTE: Use the transparencies to enhance the information as needed.)

- G. Provide students with job sheets.
- H. Discuss and demonstrate the procedures outlined in the job sheets.
- I. Integrate the following activities throughout the teaching of this unit:
1. Design and construct a problem board that will facilitate set up and diagnosis of circuit malfunctions.
  2. Invite local electricians to visit class to show examples of troubleshooting techniques they employ. Also have them share some their toughest troubleshooting problems and the outcome.
  3. Design and construct work boards for students to use in their performance of the job sheets included in this unit.
  4. Collect used appliances from equipment dealers or through private donations for use in completing job sheets in this unit.
  5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.
- J. Give test.
- K. Evaluate test.
- L. Reteach if necessary.

## REFERENCES USED IN WRITING THIS UNIT

- A. Gebert, Kenneth L. *Blueprint Reading*. Ninth Edition. Alsip, IL: American Technical Publishers Inc., 1983.
- B. Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- C. Gray, Elliot C. Jr. and Melbourne E. Bailey. *Electrical Construction and Maintenance Techniques*. Englewood Cliffs, N.J.: Prentice Hall, 1984.
- D. Hunzicker Brothers Catalog. Oklahoma City, OK.

## SUGGESTED SUPPLEMENTAL MATERIAL

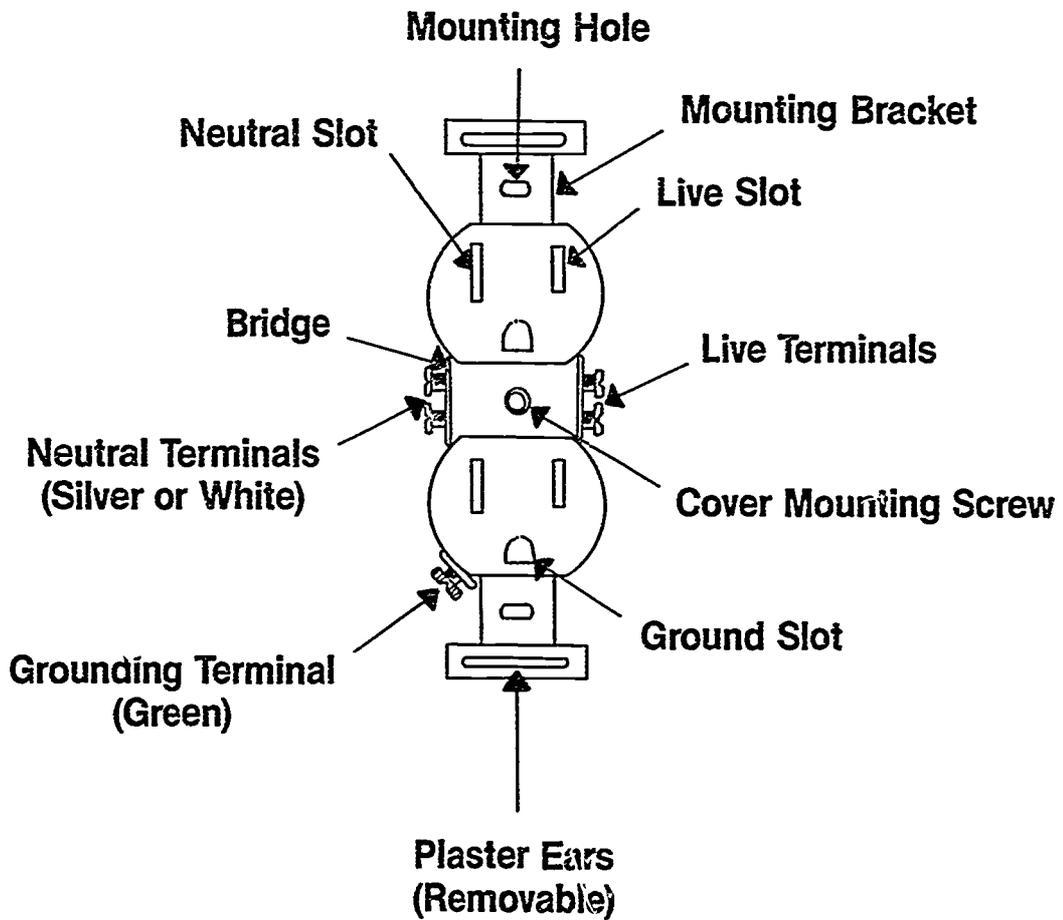
### Audiovisual Cassette Filmstrips

- A. *Electrical Wiring and Wiring a House*. OCA Educational Products, 424 Valley Road, Warrenton, PA 18976.
- B. *Residential Electrical Wiring Explained #804 and Electrical House Wiring Explained #803*. Bergwall Productions, Inc., 839 Stewart Ave., Gordon City, NY 11530.

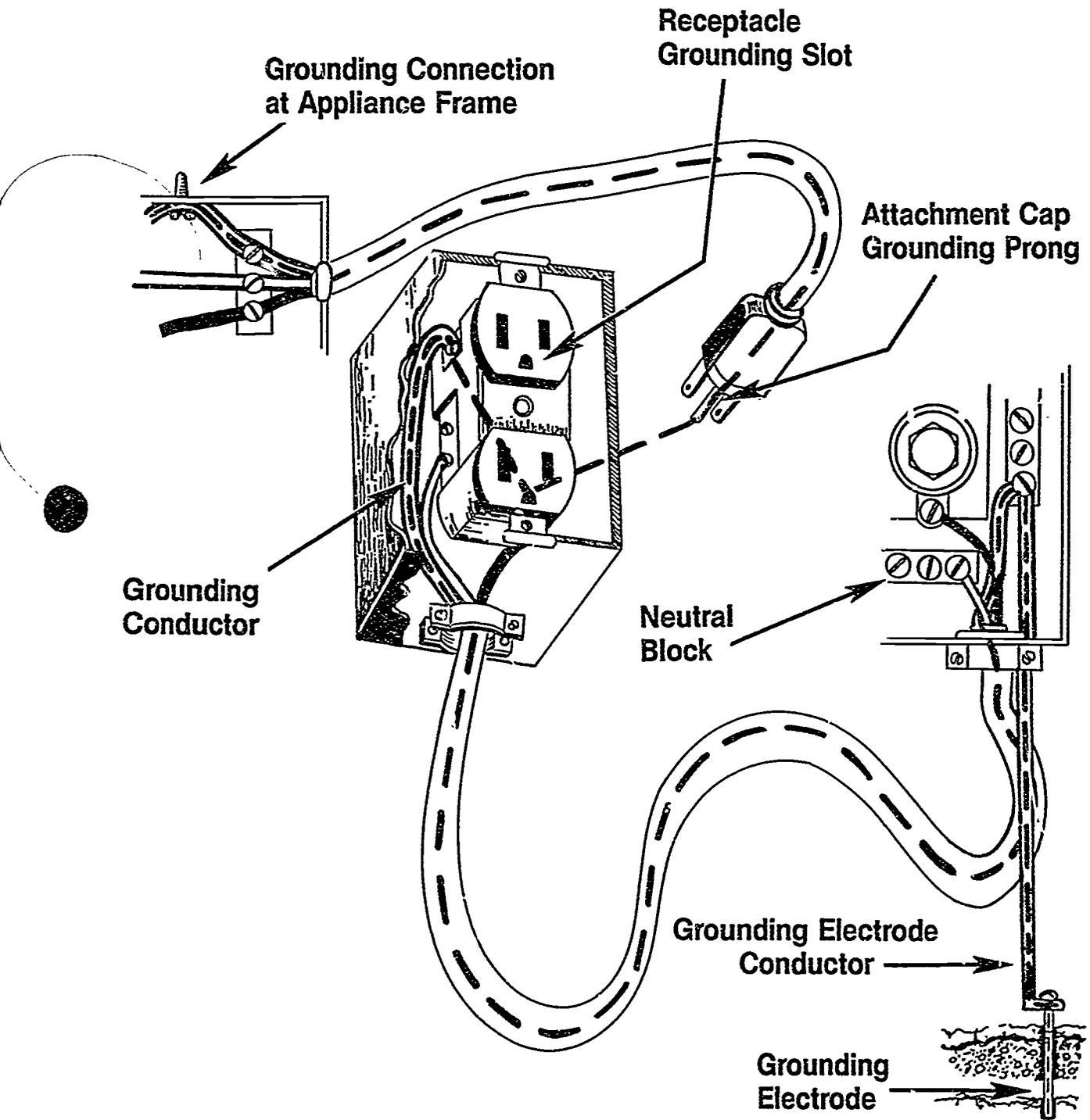
### Texts

- A. Holzman, Harvey N. *Modern Residential Wiring*. Goodheart-Willcox, 1986.  
(NOTE: This text may be obtained by writing to Goodheart-Willcox, 123 West Taft Drive, South Holland, IL 60463.)
- B. *The National Electrical Code Handbook*, 1987. Quincy, MA: National Fire Protection Association, 1986.

# Parts of a Duplex Grounding Type Receptacle



# Equipment Grounding Circuit



# TRIM OUT AND TROUBLESHOOTING UNIT IV

## INFORMATION SHEET

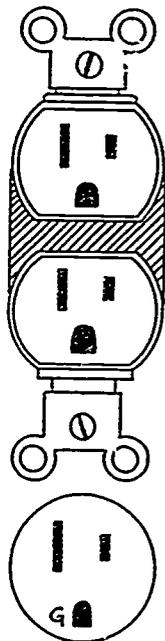
### I. Terms and definitions

- A. Appliance — Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, or deep frying
- B. Appliance branch circuit — A branch circuit supplying energy to one or more outlets to which appliances are to be connected
- C. Cable clamp — Piece of equipment used to secure cables
- D. Device — Unit of an electrical system which is intended to carry but not utilize electrical energy
- E. Disconnecting means — A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply
- F. Duplex grounding receptacle — A single device with two grounding type receptacles
- G. Feed through — The use of a box for splicing or rerouting conductors to get to another location
- H. Individual branch circuit — Branch circuit that supplies only one piece of utilization equipment
- I. Line leg — Conductor that supplies electrical energy to a switch
- J. Multiple receptacle — A single device with two or more receptacles
- K. Pigtail — Splicing technique that leaves an accessible conductor for termination at a device, load, or grounding terminal
- L. Poles — Current carrying conductors, both grounded and ungrounded, on a receptacle
- M. Receptacle connecting fin — Detachable design feature that makes terminals common connections
- N. Single receptacle — A single contact device with no other contact device on the same yoke
- O. Split-wired receptacle — Receptacle that has had a connecting fin removed for remote control or separate circuit connections

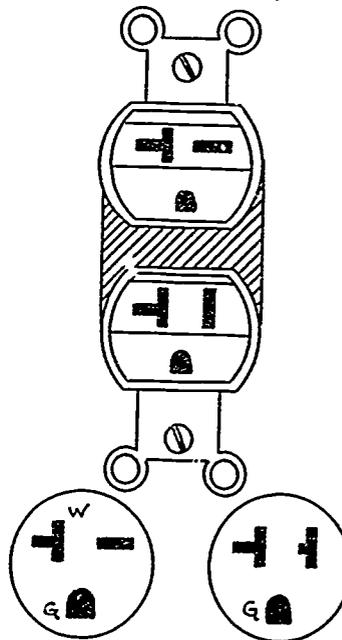
## INFORMATION SHEET

- P. Strap or yoke — Metal strip containing one or more devices
  - Q. Switch — Device used to open or transfer circuit direction
  - R. Switch leg — Conductor that carries electrical energy from the switch to the load
  - S. Switch loop — Conductors between light and switch when supply enters the light
  - T. Terminal — Point of attachment for conductors
  - U. Traveler — Transfer conductors in a switching situation; they are used between 3-ways and 4-ways
  - V. Trim out — Final stage in a residential wiring project; involves devices and plates, connecting and securing equipment, hanging fixtures, and testing the system
  - W. Troubleshooting — The systematic diagnosis of a malfunction
  - X. Volt ampere — Voltage multiplied times amperage
  - Y. Wires — Current carrying conductors and grounding conductors
- II. Common residential receptacle types and cover plates

A. Duplex grounding receptacle  
125v, 15 amp



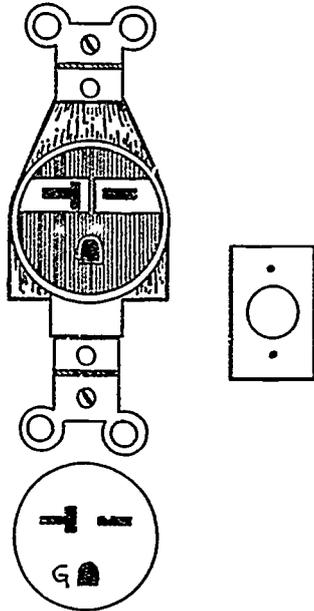
B. Dual voltage receptacle  
125/250v, 20 amp



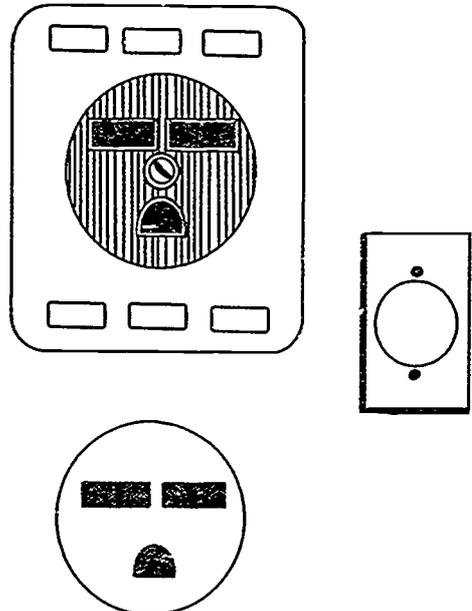
(NOTE: This outlet is configured so as to not allow plug attachment to wrong voltage.)

INFORMATION SHEET

C. Air conditioner receptacle  
250v, 20 amps

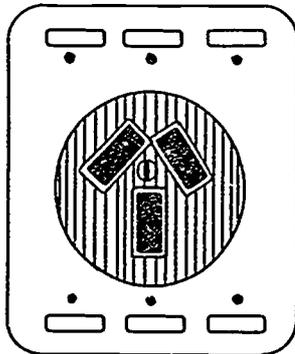


D. Air conditioning receptacle  
250 volt, 30 amp

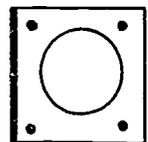
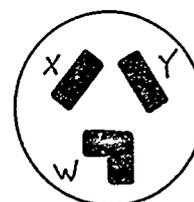
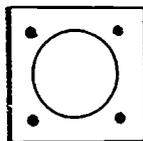
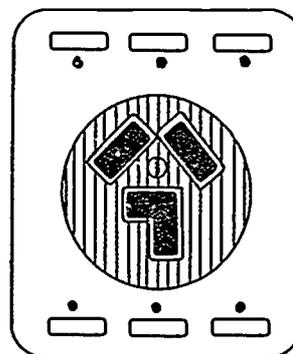


(NOTE: This is often referred to as a "T" blade receptacle.)

E. Range receptacle  
125/250v, 50 amp

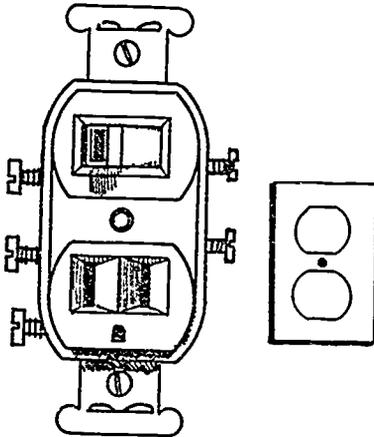


F. Dryer receptacle  
125/250 volt, 30 amp

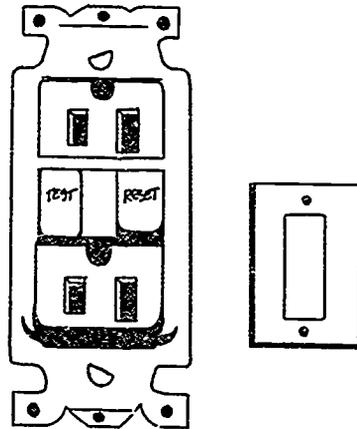


## INFORMATION SHEET

G. Switch and receptacle combination

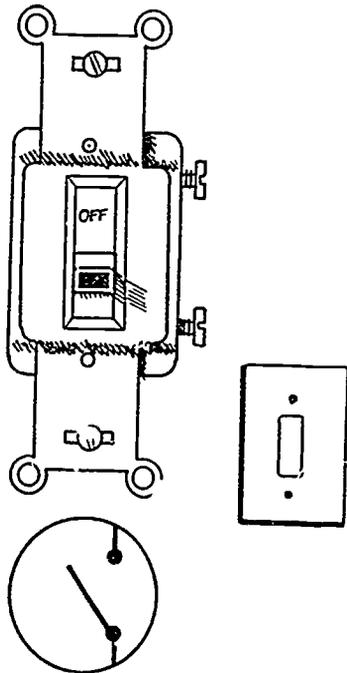


H. Ground fault receptacle 125v, 15 amp

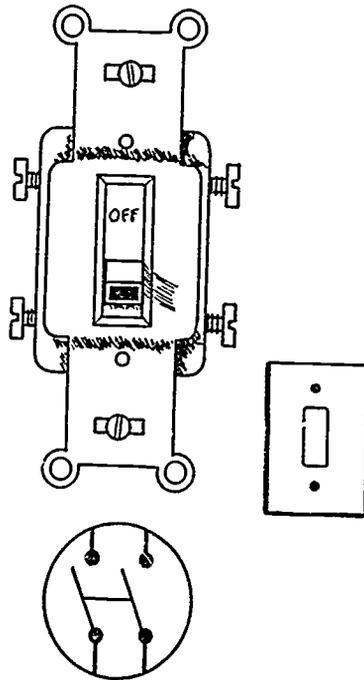


### III. Common residential switch types and cover plates

A. Single pole

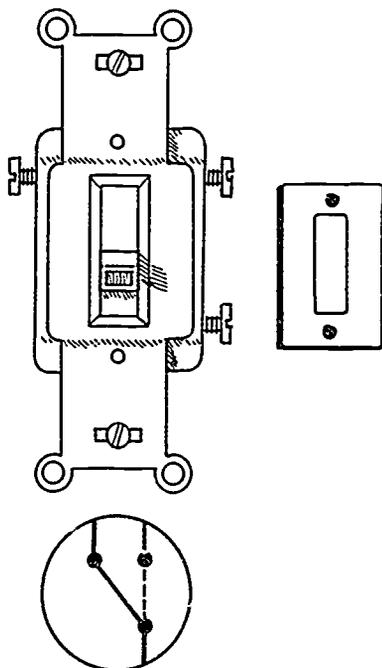


B. Double pole

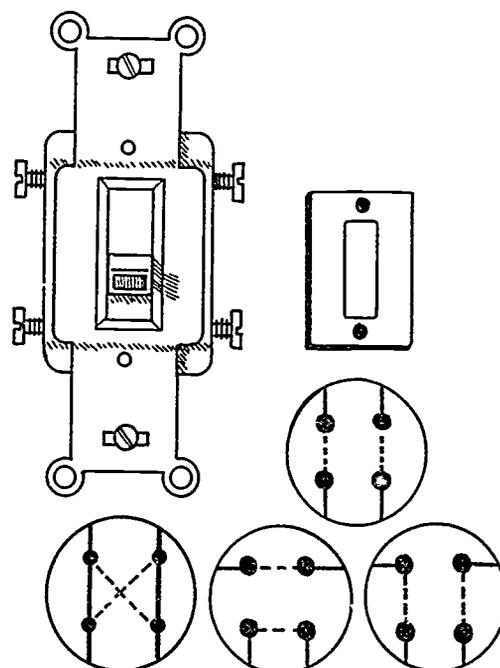


# INFORMATION SHEET

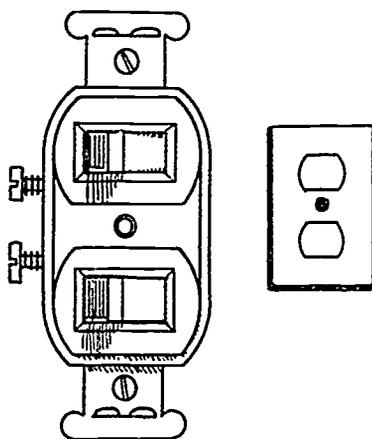
C. Three way



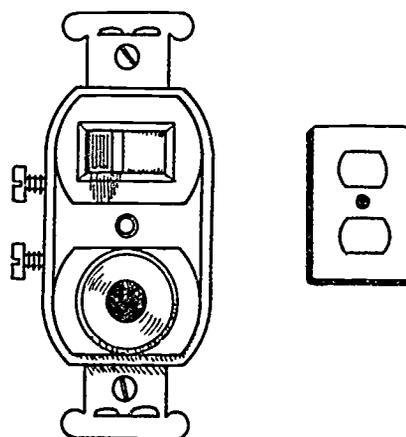
D. Four way



E. Duplex switches

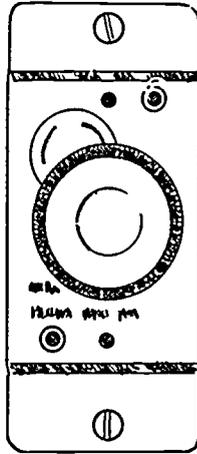


F. Switch and pilot light

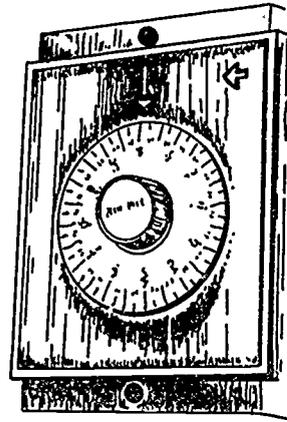


# INFORMATION SHEET

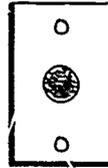
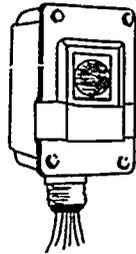
G. Dimmer



H. Timer switch



I. Photo cell

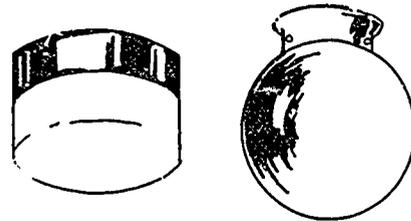


## IV. Common residential fixture locations and their types

A. Recessed fixtures and trims

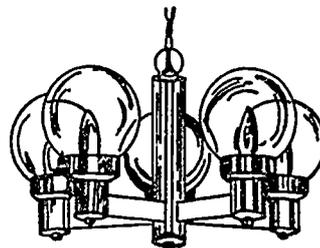
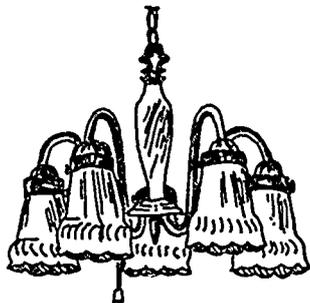


B. Bedroom or hall

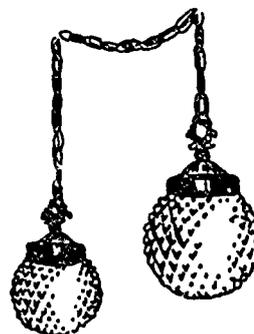


# INFORMATION SHEET

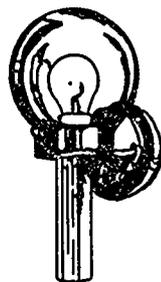
## C. Dining room



## D. Bathroom

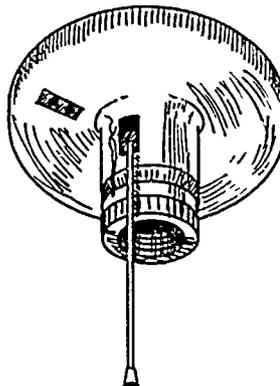
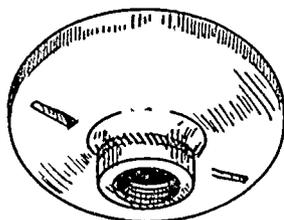


## E. Outdoor entry



## INFORMATION SHEET

### F. Walk-in closet



(NOTE: While the particular location and type of fixture is the choice of the customer, these examples are intended to be typical.)

### V. Appliance classifications

(NOTE: NEC Art: 422 pertains to regulations for appliances.)

- A. Fixed — A current consuming device which is permanently installed such as water heaters, built-in cook tops or ovens, and electric furnaces
- B. Stationary — A current consuming device not permanently attached, but not ordinarily moved such as clothes dryers, washing machines, and free-standing ranges
- C. Portable — A current consuming device which is commonly moved such as blenders, mixers, toasters, and radios
- D. Located on a separate circuit — A branch circuit that supplies only one (1) utilization equipment such as a range, dryer, or washing machine
- E. Cord and plug connected — Connected to a branch circuit with a pigtail plug inserted into a receptacle such as portable appliances, but may include stationary or fixed-in-place appliances

(NOTE: To comply with NEC requirements for cord-and-plug connections for appliances, the receptacles must be readily accessible.)

- F. Permanently connected — Connected to the branch circuit by solid connection not readily disconnected

## INFORMATION SHEET

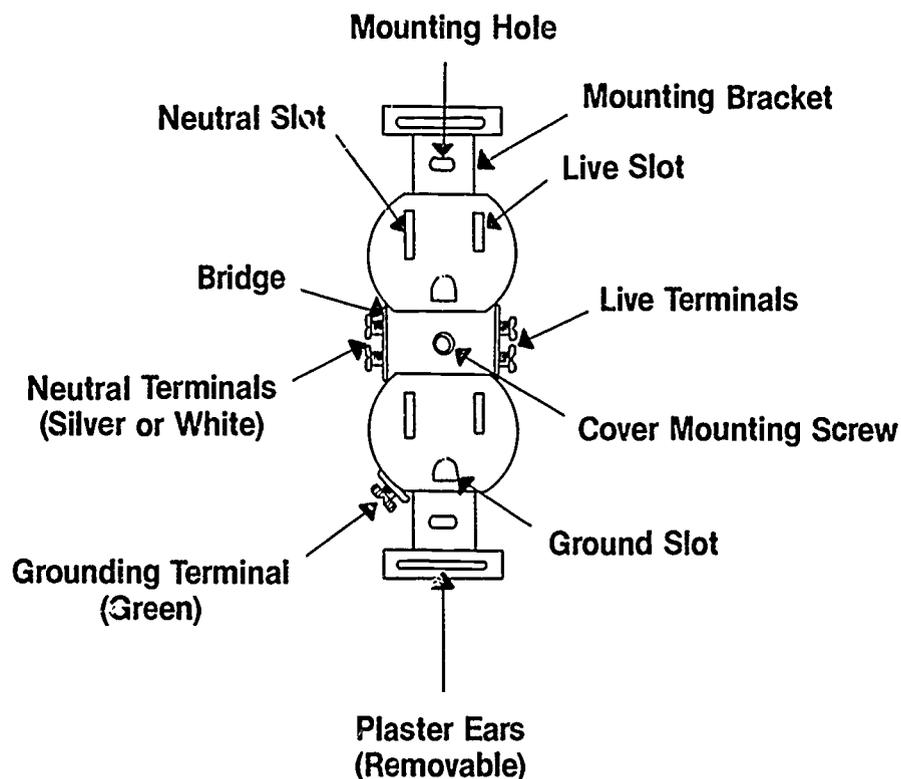
### VI. Requirements for appliance disconnect means

- A. Cord and plug connected appliances — An accessible plug and receptacle shall be permitted to serve as the disconnect means
- B. Permanently connected — The branch circuit breaker shall be permitted to serve as the disconnecting means where readily accessible to the user of the appliance

### VII. Grounding requirement for appliances — Appliances with exposed noncurrent-carrying metal parts of equipment likely to become energized shall be grounded

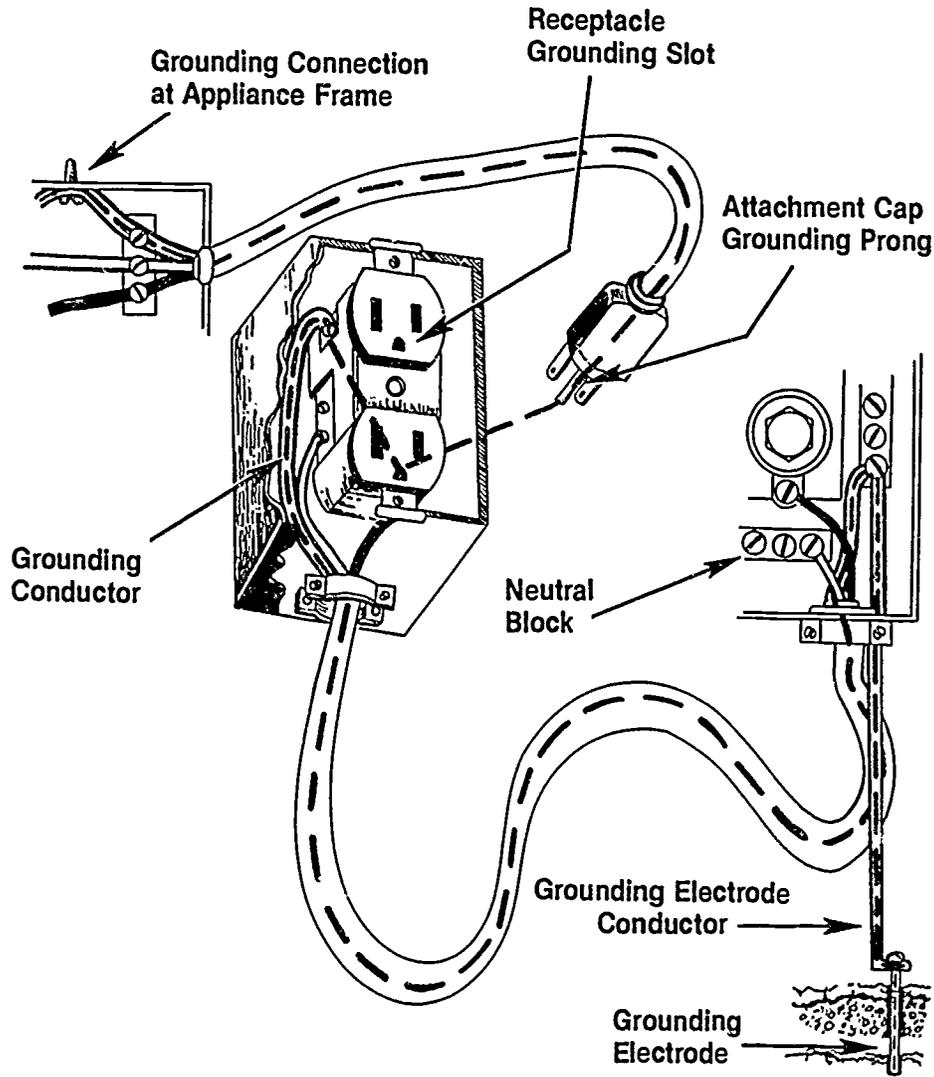
(NOTE: The exceptions are listed appliances protected by a system of double insulation or its equivalent where distinctively marked. See Sections 250-42, 250-43, 250-45, 250-57, and 250-60 of the NEC for specific equipment grounding methods.)

### VIII. Parts of a duplex grounding type receptacle



# INFORMATION SHEET

## IX. Parts of an equipment grounding system



## INFORMATION SHEET

### X. Steps for panel trim out

- A. Connect the grounding (bare) conductors (Ref NEC Art. 250-K) to their panel location. All grounding conductors attach to the grounding bar or lug (point at which grounding electrode conductor attaches).

(NOTE: With all conductor installation and connections inside the panel, neat and orderly forming of conductors is called for. Before conductors are routed inside the panel to a connection point, they should be straightened and preformed in the direction of travel.)

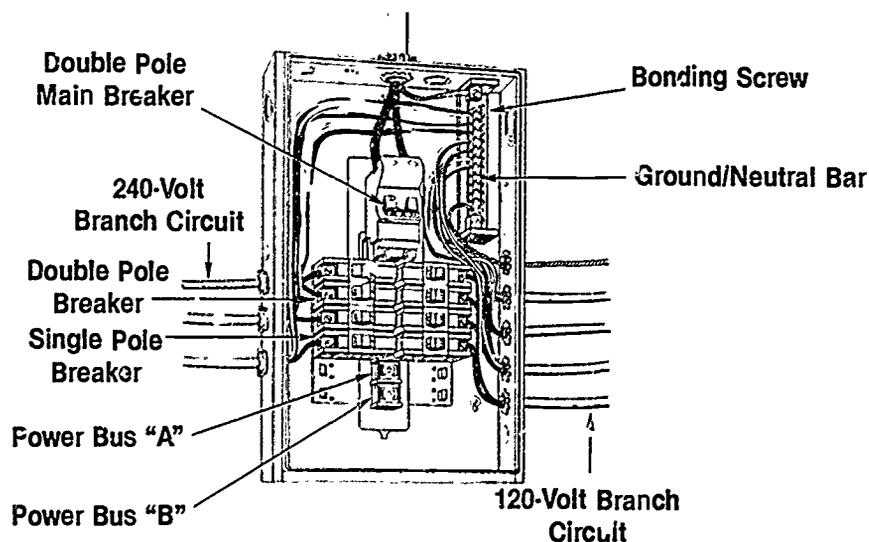
- B. Connect grounded (neutral) conductors (Ref NEC Art. 250) to the panel neutral bar.

(NOTE: The grounded conductor is normally white but may be another color if identified. In most residential panels the grounding and grounded bar are one in the same. However, for neatness and ease of tracing conductors, these different conductors should be installed in separated positions on the bar.)

- C. Connect ungrounded (hot) conductors (Ref NEC Art. 230-81) to their overcurrent protection devices (fuse holders or circuit breakers).

(CAUTION: With all multiwire circuits [both "hot" wires share the same neutral] care must be taken to insure that the ungrounded conductors are connected to different bus bar phases. This will prevent neutral overload.)

(NOTE: The ungrounded conductors of a multiwire circuit must be simultaneously opened at the panel. This may be secured by connection to a 2-pole circuit breaker or two single-pole circuit breakers with a handle tie. Where fuses are used, a two-pole disconnect switch is required.)



## INFORMATION SHEET

- D. Label panel in the form of a directory. This directory for circuit breaker location should be of a permanent type.

(NOTE: Most panels provide a space for the directory inside panel cover door.)

- E. Energize the system with temporary power after all other circuit trim out is completed. At this time a complete check out of job should be performed.

(NOTE: Check all circuits for proper operation, correct voltage output, and correct identification through directory.)

### XI. Troubleshooting procedures

- A. Determine symptoms of problem causing system. Consult owner about operation of system before, during, and after problem occurred.

(NOTE: A great deal of information can be gained in this questioning—did it flicker, hum, or explode? Was anything unusual going on at the time of problem, lightning, unusual load, too many appliances plugged in, has it happened before?)

- B. Inspect the system.

(NOTE: The panel is the place to start since the overcurrent protection device will identify the problem circuit.)

1. Trace system from panel by
  - a. Color of conductor
  - b. Number of conductor
  - c. Using an ohmmeter

(CAUTION: Always disconnect supply power from circuit to be tested before using ohmmeter. Line voltages will damage meter.)

2. Check conductor's condition.
  - a. Conductor discolored from overheating
  - b. Conductor insulation damaged or nicked
  - c. Loose conductor connection at devices or splice points

**INFORMATION SHEET**

3. Check devices or fixtures.
  - a. Device worn or overheated
  - b. Fixture worn or overheated
  - c. Reversed outlet polarity which may cause neutral overload

(NOTE: Fixtures with bulbs larger than their rating may have internal damage.)

- C. Locate problem causing area.
  1. Bad device or fixture
  2. Broken conductor
  3. Circuit overload
- D. Repair or replace cause of problem.
  1. Install new device or fixture
  2. Rewire circuit
  3. Install extra circuit to compensate for overload

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### JOB SHEET #1 — INSTALL A DUPLEX GROUNDING TYPE RECEPTACLE

#### A. Equipment and materials needed

1. Lineman's pliers
2. Long nose pliers
3. Flat blade screwdriver
4. Pocket knife
5. Wire strippers
6. Electrician's hammer
7. 12-2 or 14-2 G NM cable
8. Device box
9. Electrical supply
10. Staples
11.  $\frac{3}{8}$ " cable connector
12. Stud wall or work board
13. Tool pouch
14. Folding rule with sliding scale or tape
15. Safety glasses
16. Drill motor or brace
17.  $\frac{1}{2}$ " or larger wood bit

(NOTE: Holes should be large enough to accommodate cables safely.)

18. Extension cord
19. Duplex grounding type receptacle
20. Neon test light or voltmeter
21. GFI

## JOB SHEET #1

## B. Procedure

1. Gather equipment and materials and put on safety glasses.
2. Mount box.

(NOTE: Remember that your box set-out depends on the thickness of the wall covering to be installed.)

3. Remove a half inch knockout from the panel.

(NOTE: Lineman's pliers may be needed to finish removing the raised knockout.)

4. Install cable connector.

5. Bore holes for cable.

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

(CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident. Be sure and use GFI protection.)

6. Run cable.

(NOTE: Leave at least 8" extending past the surface of device box, and enough to reach the top of panel plus half the width.)

7. Staple cable within 12" of metal boxes, 6" of nonmetallic boxes.

8. Secure all cable clamps and connectors.

(CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

9. Strip cable insulation at device box and panel.

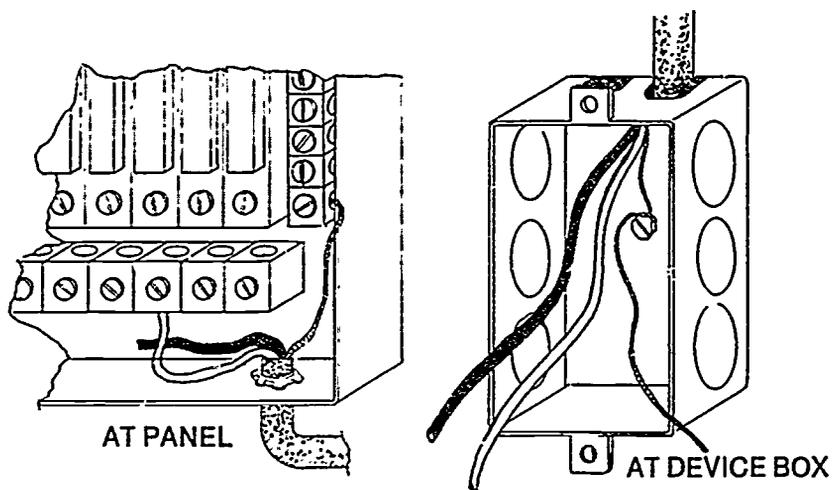
(NOTE: Trim the cable covering to within 1/4" of its point of entry.)

(CAUTION: Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.)

## JOB SHEET #1

10. Connect equipment grounding conductors and circuit neutral. (Figure 1)

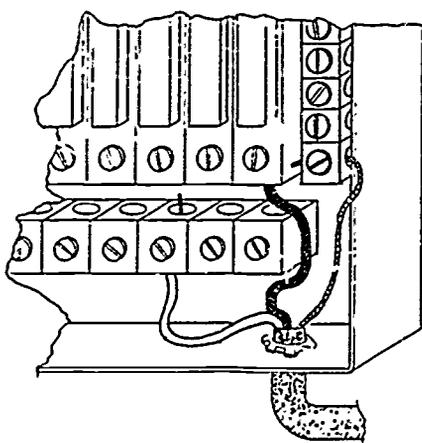
FIGURE 1



(NOTE: In a residence, all circuit neutrals and equipment grounding conductors would be connected at one time; the procedure is called panel make-up.)

11. Install receptacle.  
 i2. Connect ungrounded conductor to appropriate overcurrent device. (Figure 2)

FIGURE 2



(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

## JOB SHEET #1

13. Turn breaker on or screw fuse in.

**(CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.)**

14. Test receptacle with neon test light or voltmeter.
15. Have instructor evaluate this project.
16. Turn off breaker.
17. Clean work area and put away all equipment and materials.

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### JOB SHEET #2 — INSTALL A RANGE OR DRYER RECEPTACLE

#### A. Equipment and materials needed

1. Lineman's pliers
2. Long nose pliers
3. Screwdriver
4. Pocket knife
5. Wire strippers
6. Electrician's hammer
7. 10-3-G or 8-3G NM cable
8. Box

(NOTE: Check NEC Art: 370-18 for box requirements.)

9. Electrical supply
10. Staples
11. 1/2" or 3/4" cable connector
12. Stud wall or work board
13. Tool pouch
14. Folding rule with sliding scale or tape
15. Safety glasses
16. Drill motor or brace
17. 1/2" or larger wood bit
18. Extension cord
19. 125/250 volt, 30 or 50 amp receptacle
20. GFI

**JOB SHEET #2****B. Procedure**

1. Gather equipment and materials and put on safety glasses.
2. Mount box.

(NOTE: Remember that your box set-out depends on the thickness of the wall covering to be installed. Be sure your box is rated for your conductors.)

3. Remove appropriate size knockout from the panel.

(NOTE: Lineman's pliers may be needed to finish removing the raised knockout.)

4. Install cable connector.

5. Bore holes for cable.

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

**(CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident. Be sure and use GFI protection.)**

6. Run cable.

(NOTE: Leave at least 8" extending past the surface of device box, and enough to reach the top of panel plus half the width.)

7. Staple cable within 12" of metal boxes, 6" of all nonmetallic boxes.

8. Secure all cable clamps and connectors.

**(CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)**

9. Strip cable insulation at device box and panel.

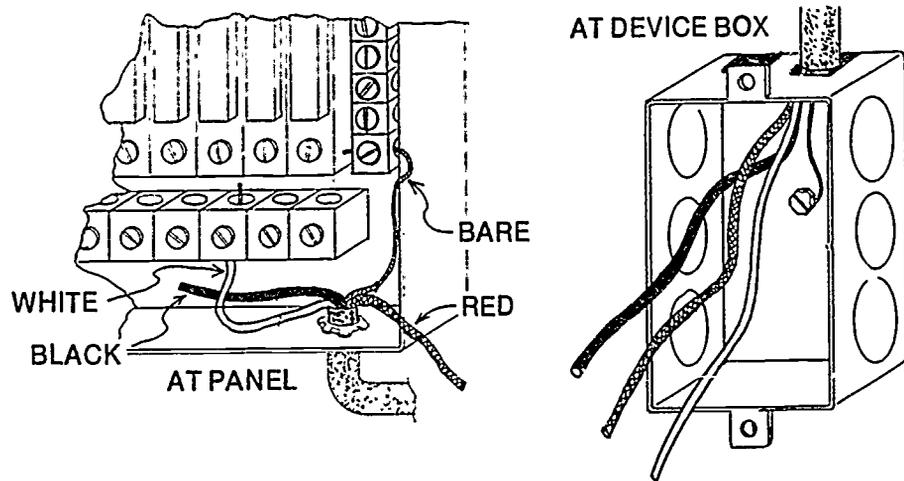
(NOTE: Trim the cable covering to within 1/4" of its point of entry.)

**(CAUTION: Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.)**

## JOB SHEET #2

10. Connect neutral and equipment grounding conductors. (Figure 1)

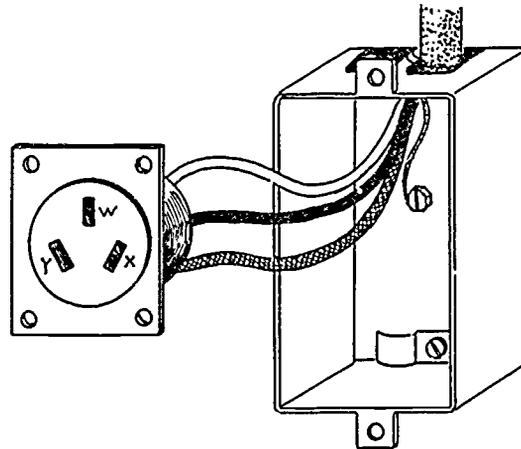
FIGURE 1



(NOTE: You are allowed to use the grounded circuit conductor as the equipment grounding conductor for the frames of ranges and dryers if specific conditions in Article 250 are met.)

11. Install your device. (Figure 2)

FIGURE 2

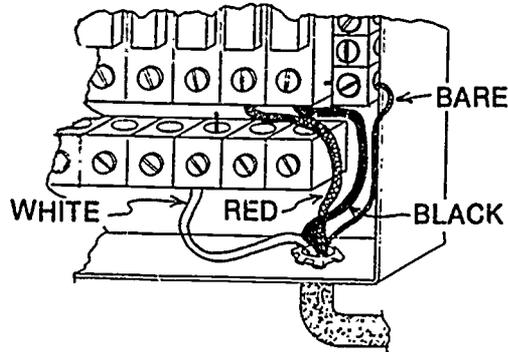


(NOTE: White conductor goes to terminal labeled "W" or Gr. The red and black connect to other terminals.)

## JOB SHEET #2

12. Connect ungrounded conductors to appropriate overcurrent device. (Figure 3)

FIGURE 3



(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

13. Turn breaker on.

(CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.)

14. Test receptacle with neon test light or voltmeter.
15. Have instructor evaluate this project.
16. Turn off breaker.
17. Clean work area and put away all equipment and materials.

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### JOB SHEET #3 — INSTALL A MULTI-CIRCUIT SPLIT-WIRED DUPLEX GROUNDING TYPE RECEPTACLE

#### A. Equipment and materials needed

1. Lineman's pliers
2. Long nose pliers
3. Flat blade screwdriver
4. Pocket knife
5. Wire strippers
6. Electrician's hammer
7. 12-3 or 14-2G NM cable
8. Device box
9. Electrical supply
10. Staples
11.  $\frac{3}{8}$ " cable connector
12. Stud wall or work board
13. Tool pouch
14. Folding rule with sliding scale or tape
15. Safety glasses
16. Drill motor or brace
17.  $\frac{1}{2}$ " or larger wood bit
18. Extension cord
19. Circuit tester

#### B. Procedure

1. Gather equipment and materials and put on safety glasses.
2. Mount box.

(NOTE: Remember that your box set-out depends on the thickness of the wall covering to be installed.)

### JOB SHEET #3

3. Remove a half inch knockout from the panel.

(NOTE: Lineman's pliers may be needed to finish removing the raised knockout.)

4. Install cable connector.

5. Bore holes for cable.

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

(CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident. Be sure and use GFI protection.)

6. Run cable.

(NOTE: Leave at least 8" extending past the surface of device box, and enough to reach the top of panel plus half the width.)

7. Staple cable within 12" of the box.

8. Secure all cable clamps and connectors.

(CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

9. Strip cable insulation at device box and panel.

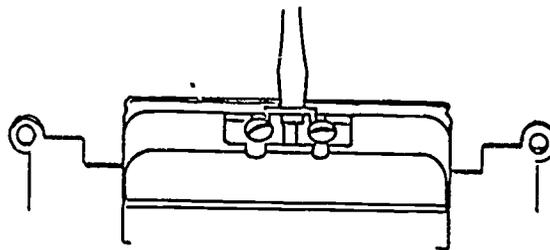
(CAUTION: Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.)

10. Connect equipment grounding conductors and panel neutral.

(NOTE: In a residence, all circuit neutrals and equipment grounding conductors would be connected at one time; the procedure is called panel make-up.)

11. Break connecting fin from ungrounded side of receptacle. (Figure 1)

FIGURE 1

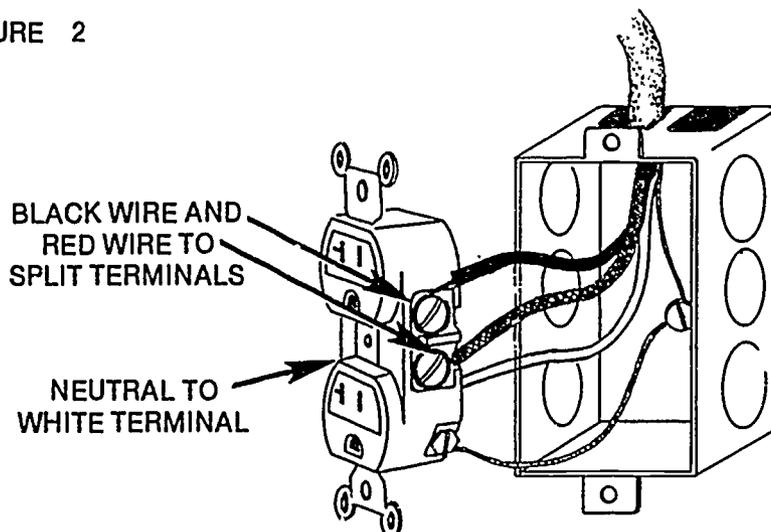


(NOTE: Repeated bending motions will probably be needed to remove the connecting fin.)

## JOB SHEET #3

12. Install receptacle. (Figure 2)

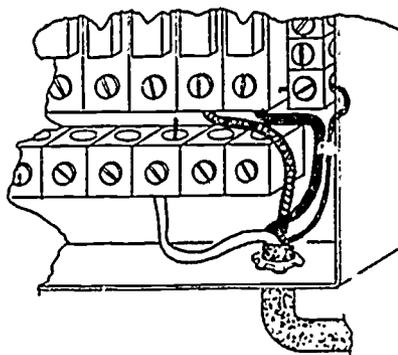
FIGURE 2



(NOTE: A common neutral is allowed on multi-wire branch circuits where there is a dual voltage potential difference between ungrounded conductors.)

13. Connect ungrounded conductor to appropriate overcurrent devices. (Figure 3)

FIGURE 3



(NOTE: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.)

14. Turn breaker on or screw fuse in.

(CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.)

**JOB SHEET #3**

15. Test receptacle with circuit tester or voltmeter.
16. Have instructor evaluate this project.
17. Turn off breaker.
18. Clean work area and put away all equipment and materials.

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### JOB SHEET #4 — WIRE A RECEPTACLE FED FROM A LIGHTING OUTLET THROUGH A SINGLE POLE SWITCH

A. Equipment and materials needed

1. 12-2-G or 14-2-G NM cable
2. 12-3-G or 14-3-G NM cable
3. Two device boxes
4. Octagon box and bar hanger
5. Light socket
6. 120 volt bulb
7. Staples
8. Single pole switch
9. Duplex grounding type receptacle
10. Stud wall or work board
11. 120v supply  
  
(NOTE: The overcurrent protection on this supply should not exceed the conductors NEC ampacity rating.)
12. Wire connectors
13. Four 16 penny nails or other fasteners as needed to secure the boxes
14. Electrician's hammer
15. Plain tip screwdriver
16. Lineman's pliers
17. Long nose pliers
18. Pocket knife
19. Wire strippers

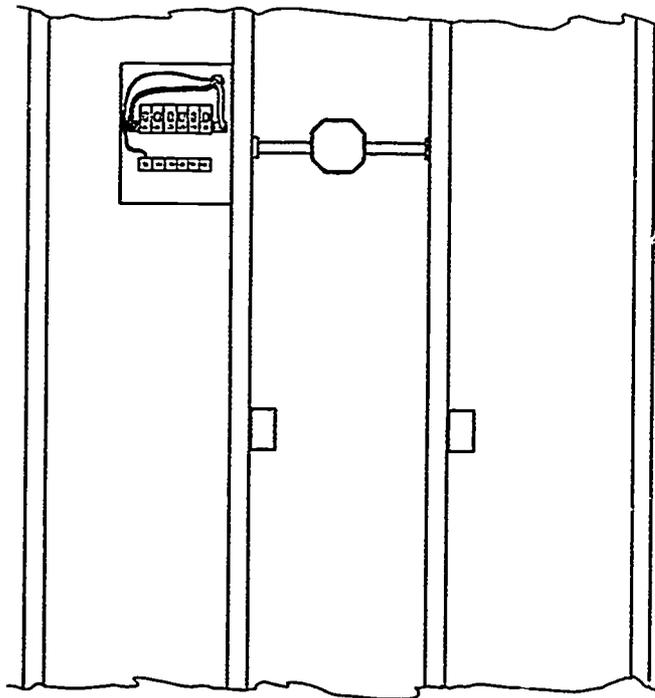
## JOB SHEET #4

20. Tool pouch
21. Drill motor or brace
22.  $\frac{1}{2}$ " or larger wood bit
23. Extension cord
24. Safety glasses
25. GFI

## B. Procedure

1. Gather equipment and materials and put on safety glasses.
2. Mount boxes. (Figure 1)

FIGURE 1



3. Remove a half inch knockout from the panel.
4. Install cable connector.

## JOB SHEET #4

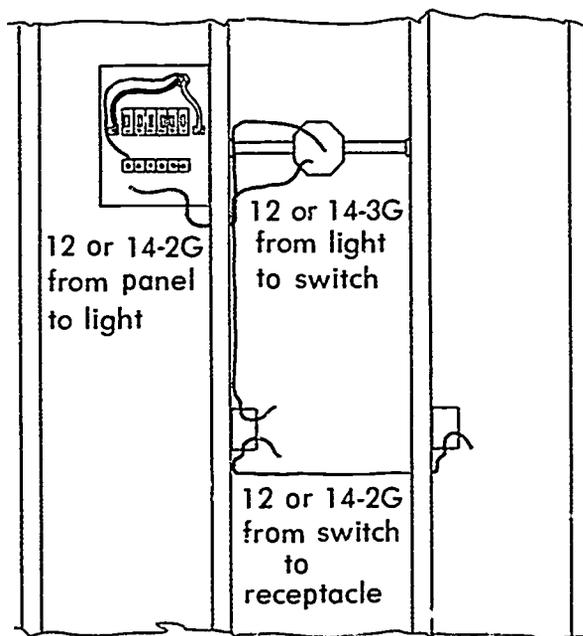
5. Bore holes for cable.

(NOTE: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.)

(CAUTION: Be sure and use a GFI protection.)

6. Run cable between boxes and to panel. (Figure 2)

FIGURE 2



(NOTE: Leave at least 8" extending past the surface of device box, and enough to reach the top of panel plus half the width.)

7. Staple cable within 12" of metal boxes, 6" of nonmetallic boxes.
8. Secure all cable clamps and connectors.

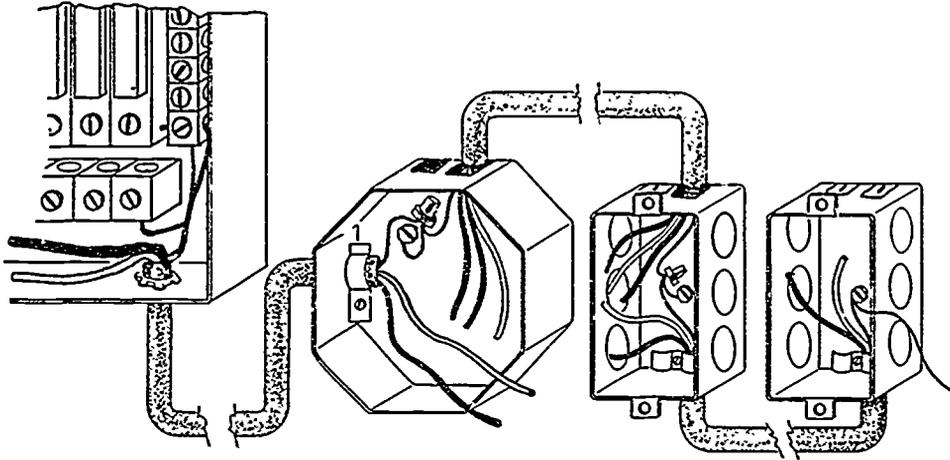
(CAUTION: Tighten them until the cable will not slip in the box; overtightening can cause an electrical short.)

9. Strip cable insulation at device box and panel.

### JOB SHEET #4

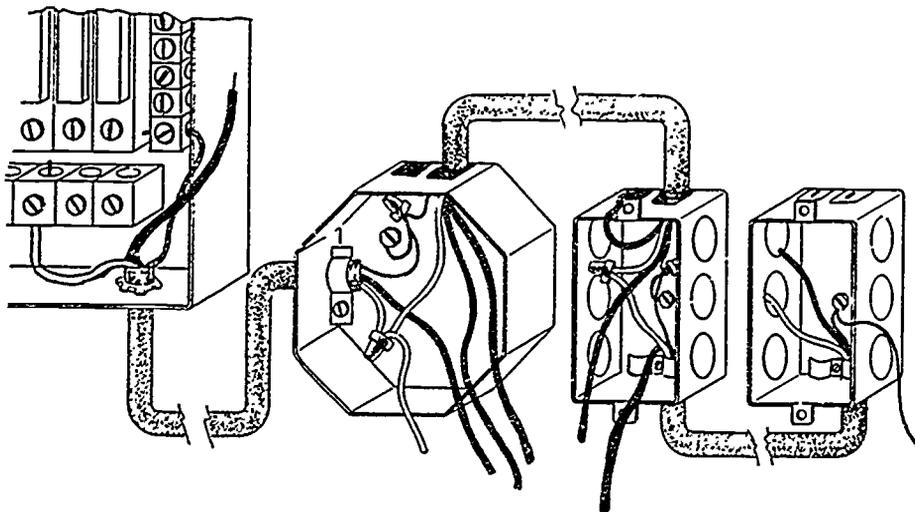
10. Connect equipment grounding conductors. (Figure 3)

FIGURE 3



11. Make up neutral through the system. (Figure 4)

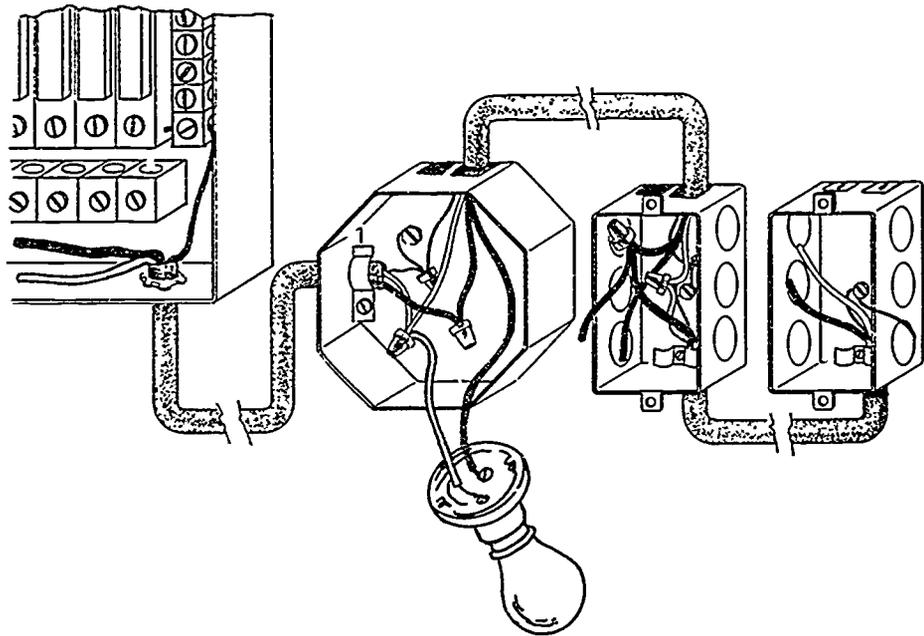
FIGURE 4



## JOB SHEET #4

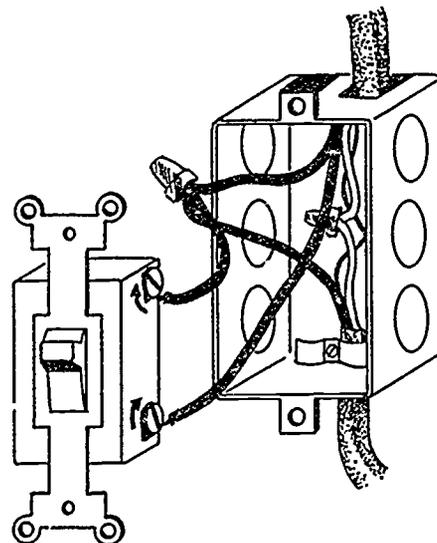
12. Make up switch, return, feed through conductors, and install light fixture. (Figure 5)

FIGURE 5



13. Install switch. (Figure 6)

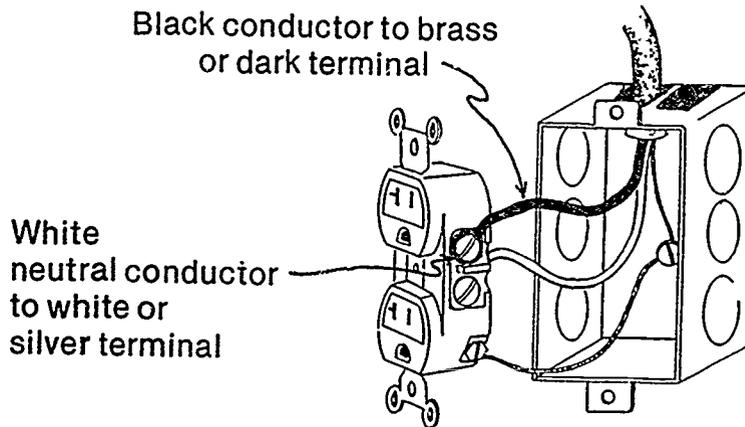
FIGURE 6



## JOB SHEET #4

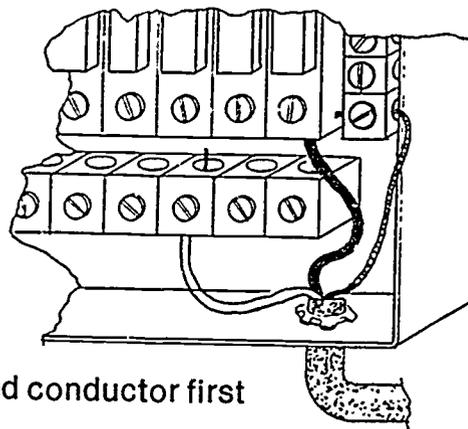
14. Install receptacle. (Figure 7)

FIGURE 7



15. Connect return leg and neutral to light socket.
16. Connect ungrounded conductor. (Figure 8)

FIGURE 8



(NOTE: Be sure the breaker is off or the fuse is screwed out before connecting this conductor. Always be safety conscious.)

17. Turn on breaker or screw in fuse.
18. Turn on switch.

(NOTE: Light should burn.)

**JOB SHEET #4**

19. Test receptacle with test light or V.O.M..
20. Have your instructor evaluate this project.
21. Turn off breaker.
22. Clean work area and put away all equipment and materials.

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### JOB SHEET #5 -- CONNECT A SUPPLY CORD TO A FREE STANDING RANGE

#### A. Equipment and materials needed

1. Screwdriver
2. Appropriate appliance cord

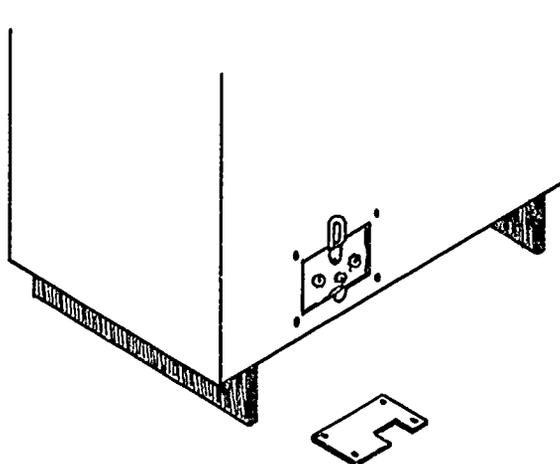
(NOTE: Cord must be acceptable to the NEC and local code enforcing agent.)

3. Free standing range
4. Nut driver set
5. Safety glasses

#### B. Procedure

1. Gather equipment and materials and put on safety glasses.
2. Position range in best possible working position.
3. Remove appliance terminal cover plate. (Figure 1)

FIGURE 1



4. Install cord securing equipment.

(NOTE: Most range cord sets have a clamp included with the cord.)

5. Connect ungrounded conductors to appropriate terminals.

**JOB SHEET #5**

6. Connect equipment grounding conductor.

(NOTE: The frame of the range may be grounded to the grounded circuit conductor, providing it is not smaller than a No. 10 copper.)

7. Check cord conductors.

(NOTE: Conductors should be arranged so that a pull on the cord will put tension on the cord connector, not the appliance terminals.)

8. Replace cover plate.

9. Plug in appliance.

10. Check appliance for correct operation.

(NOTE: Be sure and remove all tape and packing from the oven before testing. Level the oven before you leave.)

11. Clean work area and put away all equipment and materials.

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### JOB SHEET #6 — INSTALL A FIXED APPLIANCE EQUIPPED WITH A PIGTAIL TO A BRANCH CIRCUIT

#### A. Equipment and materials needed

1. Box and cover

(NOTE: Be sure box has a capacity rating to accommodate the conductors being used.)

2. Fixed appliance with pigtail

(NOTE: Pigtail should consist of flexible metal conduit (greenfield) with proper sized conductors for the appliance being connected.)

3. Connectors

(NOTE: The pigtail may have a greenfield connector already on it. A cable connector will probably be needed if not internal with the box.)

4. Two #12 × 1" MTS screws

5. Wire connectors

(NOTE: Wire nuts, crimp sleeves, and tape or any other code approved method area acceptable.)

6. Screwdriver

7. Pocket knife

8. Wire strippers

9. Safety glasses

#### B. Procedure

(NOTE: Be sure that the branch circuit you are working around is not hot.)

1. Gather equipment and materials and put on safety glasses.
2. Determine box location.

(NOTE: Be sure and place the box in a location close enough to make the connection to the appliance pigtail.)

## JOB SHEET #6

3. Mount the box.

(NOTE: Be sure the box will not interfere with the installation of the appliance.)

4. Install branch circuit conductors in the box.
5. Position the appliance so the pigtail will reach the box.
6. Connect appliance pigtail to box. (Figures 1 and 2)

FIGURE 1

Connecting Counter Top Cooking Unit

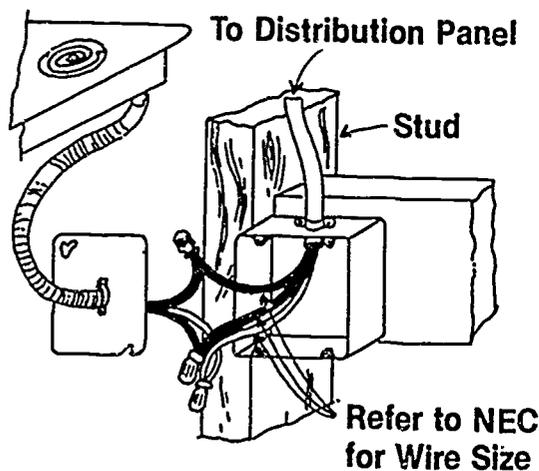
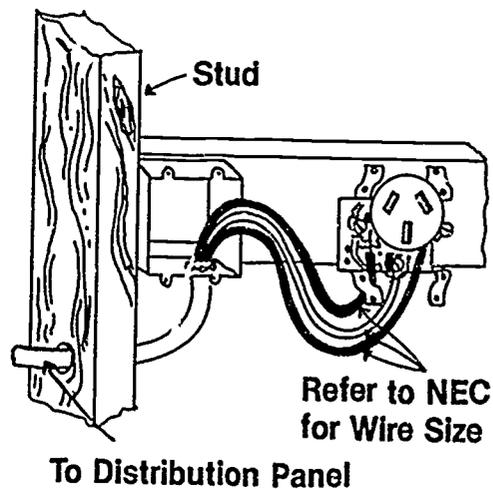


FIGURE 2

Connecting Range and Receptacle



7. Splice appliance supply conductors to branch circuit conductors.  
(NOTE: Be sure and make mechanically secure connections.)
8. Install cover plate on box.
9. Position appliance for securing.
10. Activate circuit and check appliance.
11. Rest appliance in its correct position.  
(NOTE: Make sure the pigtail is not in a bind.)
12. Secure and level appliance.
13. Clean work area and put away all equipment and materials.

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### JOB SHEET #7 — INSTALL A FUSIBLE SAFETY SWITCH FOR AN AIR-CONDITIONING CONDENSER

(NOTE: This job sheet deals only with the mounting of the disconnect. The supply line to the unit is sometimes installed by the air-conditioning installer and sometimes by the electrician.)

#### A. Equipment and materials needed

1. Pouch tools
2. Raintight fusible safety switch

(NOTE: Size of the switch will be determined by the full load or running amperage of the unit.)

3. Connecting equipment for switch

(NOTE: If this is a new house, a rigid metal conduit or EMT nipple should have been installed during the rough-in and should be extending just beyond the surface of the exterior wall.)

4. Fasteners

(NOTE: Anchors and screws will be required for brick or concrete; wood screws will work on wood siding.)

5. Safety glasses
6. Pencil
7. Drill motor and appropriate bit
8. GFI

#### B. Procedure

(NOTE: Check to be sure the circuit is not live.)

1. Gather equipment and materials and put on safety glasses.
2. Mark mounting holes for switch.

(NOTE: Remember the switch must be within sight of the unit and readily accessible. Check the applicable code requirements of NEC Art: 440-14 and 110-16.)

**JOB SHEET #7**

3. Connect supply raceway or connector to switch.

(NOTE: A,b, and c are three possible rough-in techniques that could be encountered.)

- a. Cable only visible

- 1) Situate cable so not in a bind.
- 2) Install a seal tight clamp on the cable.
- 3) Connect cable to box.

(NOTE: You may have to chisel around the cable to allow the connector freedom.)

- b. Rigid conduit with threads

- 1) Adjust conduit so appropriate amount extends inside the box.

(NOTE: There should be enough to install a locknut and a bushing.)

- 2) Install back up locknut.
- 3) Install interior locknut and bushing.

- c. EMT

- 1) Put a raintight connector on EMT.
- 2) Adjust conduit so switch fits flat against wall.

4. Secure switch to the wall.

(NOTE: If holes need to be drilled be sure and use GFI.)

5. Connect grounded conductor.

(NOTE: If a bar or lug is not supplied you can mount on a lug.)

6. Connect ungrounded conductors.

7. Activate circuit.

8. Test across and between line lugs.

9. Close cover.

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### JOB SHEET #8 — TROUBLESHOOT AN ELECTRICAL SYSTEM PROBLEM

(NOTE: This is a general job sheet designed to provide practice in using sound troubleshooting procedures.)

**A. Equipment and materials needed**

1. Pouch tools
2. Volt-ohm-ammeter
3. Safety glasses
4. Auxiliary lighting

**B. Procedure**

1. Familiarize yourself with the system.
  - a. Locate supply panel and any subpanels or disconnects.
  - b. Know system voltage and other data.
  - c. Trace circuits out mentally and physically if possible.
2. Ask the owner about the problem.
  - a. Ask about performance prior to the problem.
  - b. Ask about problem symptoms.
  - c. Inquire about maintenance procedures.
  - d. Ask if this problem has happened before.
3. Inspect the system.
  - a. Look for discolorations on equipment.
  - b. Smell for unusual odors.
  - c. Look for frayed cords.
  - d. Watch for improperly installed or connected appliances.

**JOB SHEET #8**

4. Operate the system if safely possible.

- a. Turn off switches.
- b. Unplug appliances.
- c. Check voltages.

5. List possible problem causes.

(NOTE: Use your knowledge of the system plus information received from the troubleshooting techniques used to this point.)

6. Formulate a conclusion.

- a. Review list of probable causes.
- b. Select cause.

7. Test conclusion.

(NOTE: Test the conclusion you have reached before repairing the system if possible.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### PRACTICAL TEST JOB SHEET #1 — INSTALL A DUPLEX GROUNDING TYPE RECEPTACLE

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Box set out correct for wall covering thickness.	_____	_____
3. Holes drilled at proper height and depth.	_____	_____
4. Staples for cable spaced properly.	_____	_____
5. Care taken during stripping of outer sheath to protect insulation of conductors from nicks.	_____	_____
6. Conductor insulation stripped without nicking conductor.	_____	_____
7. Proper connection of conductors made at receptacle.	_____	_____
8. Proper connection of conductors made at panel.	_____	_____
9. Checked in/put away tools and materials.	_____	_____
10. Cleaned the work area.	_____	_____
11. Used proper tools correctly.	_____	_____
12. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
13. Practiced safety rules throughout procedure.	_____	_____
14. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

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## JOB SHEET #1 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Device installed securely	4	3	2	1
Device performs correctly when energized	4	3	2	1
Proper polarity maintained	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_  
 \_\_\_\_\_

PERFORMANCE EVALUATION KEY
4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### PRACTICAL TEST JOB SHEET #2 — INSTALL A RANGE OR DRYER RECEPTACLE

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:

YES      NO

- |                                                                                                |       |       |
|------------------------------------------------------------------------------------------------|-------|-------|
| 1. Checked out proper tools and materials.                                                     | _____ | _____ |
| 2. Box set out correct for wall covering.                                                      | _____ | _____ |
| 3. Holes drilled at proper height and depth.                                                   | _____ | _____ |
| 4. Staples for cable spaced properly.                                                          | _____ | _____ |
| 5. Care taken during stripping of outer sheath to protect insulation of conductors from nicks. | _____ | _____ |
| 6. Conductor insulation stripped without nicking conductor.                                    | _____ | _____ |
| 7. Proper connection of conductors made at receptacle.                                         | _____ | _____ |
| 8. Proper connection of conductors made at panel.                                              | _____ | _____ |
| 9. Checked in/put away tools and materials.                                                    | _____ | _____ |
| 10. Cleaned the work area.                                                                     | _____ | _____ |
| 11. Used proper tools correctly.                                                               | _____ | _____ |
| 12. Performed steps in a timely manner (____hrs ____min. ____sec.)                             | _____ | _____ |
| 13. Practiced safety rules throughout procedure.                                               | _____ | _____ |
| 14. Provided satisfactory responses to questions asked.                                        | _____ | _____ |

EVALUATOR'S COMMENTS: \_\_\_\_\_

## JOB SHEET #2 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Device installed securely	4	3	2	1
Device performs correctly when energized	4	3	2	1
Proper polarity maintained	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_  
 \_\_\_\_\_

PERFORMANCE EVALUATION KEY
4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### PRACTICAL TEST JOB SHEET #3 — INSTALL A MULTI-CIRCUIT SPLIT-WIRED DUPLEX GROUNDING TYPE RECEPTACLE

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Box set out correct for wall covering thickness.	_____	_____
3. Holes drilled at proper height and depth.	_____	_____
4. Staples for cable spaced properly.	_____	_____
5. Care taken during stripping of outer sheath to protect insulation of conductors from nicks.	_____	_____
6. Conductor insulation stripped without nicking conductor.	_____	_____
7. Proper connection of conductors made at receptacle.	_____	_____
8. Connecting fin removed from ungrounded side of receptacle only.	_____	_____
9. Proper connection of conductors made at panel.	_____	_____
10. Checked In/put away tools and materials.	_____	_____
11. Cleaned the work area.	_____	_____
12. Used proper tools correctly.	_____	_____
13. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
14. Practiced safety rules throughout procedure.	_____	_____
15. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

## JOB SHEET #3 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Device installed securely				
	4	3	2	1
Device performs correctly when energized				
	4	3	2	1
Correct polarity maintained				
	4	3	2	1
Workmanship				
	4	3	2	1
Compliance to NEC				

EVALUATOR'S COMMENT: \_\_\_\_\_  
 \_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### PRACTICAL TEST JOB SHEET #4 — WIRE A RECEPTACLE FED FROM A LIGHTING OUTLET THROUGH A SINGLE POLE SWITCH

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Box set out correct for wall covering thickness.	_____	_____
3. Fixture box mounted securely to bar hanger.	_____	_____
4. Holes drilled at proper height and depth.	_____	_____
5. Staples for cable spaced properly.	_____	_____
6. Cable stripped without nicking conductor insulation.	_____	_____
7. Conductor insulation stripped without nicking conductor.	_____	_____
8. Proper connection of conductors made at fixture.	_____	_____
9. Proper connection of conductors made at switch.	_____	_____
10. Proper connection of conductors made at receptacle.	_____	_____
11. Checked in/put away tools and materials.	_____	_____
12. Cleaned the work area.	_____	_____
13. Used proper tools correctly.	_____	_____
14. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
15. Practiced safety rules throughout procedure.	_____	_____
16. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #4 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

**Criteria:**

Devices installed securely	4	3	2	1
Fixture installed securely	4	3	2	1
Receptacle energized with breaker turn on	4	3	2	1
Correct polarity maintained	4	3	2	1
Fixture controlled by switch on/off	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_

PERFORMANCE EVALUATION KEY	
4	— Skilled — Can perform job with no additional training.
3	— Moderately skilled — Has performed job during training program; limited additional training may be required.
2	— Limited skill — Has performed job during training program; additional training is required to develop skill.
1	— Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### PRACTICAL TEST JOB SHEET #5 — CONNECT A SUPPLY CORD TO A FREE STANDING RANGE

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Cord selected matches appliance load specifications.	_____	_____
3. Cord conductor connections made to proper terminals.	_____	_____
4. Appliance grounded correctly.	_____	_____
5. Cord secured to appliance at connection point.	_____	_____
6. Checked in/put away tools and materials.	_____	_____
7. Cleaned the work area.	_____	_____
8. Used proper tools correctly.	_____	_____
9. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
10. Practiced safety rules throughout procedure.	_____	_____
11. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #5 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Appliance operates properly when energized				
Workmanship				
Compliance to NEC				

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### PRACTICAL TEST JOB SHEET #6 — INSTALL A FIXED APPLIANCE EQUIPPED WITH A PIGTAIL TO A BRANCH CIRCUIT

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:

YES      NO

- |                                                                     |       |       |
|---------------------------------------------------------------------|-------|-------|
| 1. Checked out proper tools and materials.                          | _____ | _____ |
| 2. Proper size box selected.                                        | _____ | _____ |
| 3. Pigtail equipment is sized properly.                             | _____ | _____ |
| 4. Connections of pigtail (greenfield) secure.                      | _____ | _____ |
| 5. Appliance is properly grounded.                                  | _____ | _____ |
| 6. Circuit and appliance conductors connected correctly.            | _____ | _____ |
| 7. Box cover installed.                                             | _____ | _____ |
| 8. Checked in/put away tools and materials.                         | _____ | _____ |
| 9. Cleaned the work area.                                           | _____ | _____ |
| 10. Used proper tools correctly.                                    | _____ | _____ |
| 11. Performed steps in a timely manner (____hrs. ____min. ____sec.) | _____ | _____ |
| 12. Practiced safety rules throughout procedure.                    | _____ | _____ |
| 13. Provided satisfactory responses to questions asked.             | _____ | _____ |

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #6 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Appliance operates properly when energized	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### PRACTICAL TEST JOB SHEET #7 — INSTALL A FUSIBLE SAFETY SWITCH FOR AN AIR-CONDITIONING CONDENSER

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Supply raceway connected properly to disconnect switch.	_____	_____
3. Switch mounted securely to wall surface.	_____	_____
4. Supply conductors connected to correct terminals (supply should always attach to top terminals).	_____	_____
5. Ungrounded conductors connected correctly.	_____	_____
6. Grounded conductors connected correctly.	_____	_____
7. Grounding conductors connected correctly.	_____	_____
8. Checked in/put away tools and materials.	_____	_____
9. Cleaned the work area.	_____	_____
10. Used proper tools correctly.	_____	_____
11. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
12. Practiced safety rules throughout procedure.	_____	_____
13. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

## JOB SHEET #7 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Disconnect switch mounted correctly	4	3	2	1
Correct voltage available when circuit energized	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### PRACTICAL TEST JOB SHEET #8 — TROUBLESHOOT AN ELECTRICAL SYSTEM PROBLEM

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:

YES

NO

- |                                                                                                               |       |       |
|---------------------------------------------------------------------------------------------------------------|-------|-------|
| 1. Checked out proper tools and materials.                                                                    | _____ | _____ |
| 2. Followed step by step procedure to trace out circuit.                                                      | _____ | _____ |
| 3. Followed step by step questioning procedure as to circuit performance or characteristics prior to problem. | _____ | _____ |
| 4. Checked circuit conductor for insulation breakdown.                                                        | _____ | _____ |
| 5. Checked circuit equipment for malfunction.                                                                 | _____ | _____ |
| 6. Prepared list of probable causes.                                                                          | _____ | _____ |
| 7. Determined action to correct problem.                                                                      | _____ | _____ |
| 8. Completed repair or replacement action.                                                                    | _____ | _____ |
| 9. Checked in/put away tools and materials.                                                                   | _____ | _____ |
| 10. Cleaned the work area.                                                                                    | _____ | _____ |
| 11. Used proper tools correctly.                                                                              | _____ | _____ |
| 12. Performed steps in a timely manner.(____hrs. ____min. ____sec.)                                           | _____ | _____ |
| 13. Practiced safety rules throughout procedure.                                                              | _____ | _____ |
| 14. Provided satisfactory responses to questions asked.                                                       | _____ | _____ |

EVALUATOR'S COMMENTS: \_\_\_\_\_

## JOB SHEET #8 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Source of problem located	4	3	2	1
Circuit returned to normal	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### TEST

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

## 1. Match the terms on the right with their correct definitions.

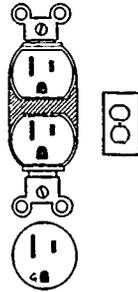
- |         |                                                                                                                                                                                                                                                          |                                |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| _____a. | Conductor that carries electrical energy from the switch to the load                                                                                                                                                                                     | 1. Appliance                   |
| _____b. | The use of a box for splicing or rerouting conductors to get to another location                                                                                                                                                                         | 2. Appliance branch circuit    |
| _____c. | Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, or deep frying | 3. Cable clamp                 |
| _____d. | A single device with two or more receptacles                                                                                                                                                                                                             | 4. Device                      |
| _____e. | The systematic diagnosis of a malfunction                                                                                                                                                                                                                | 5. Disconnecting means         |
| _____f. | Conductors between light and switch when supply enters the light                                                                                                                                                                                         | 6. Duplex grounding receptacle |
| _____g. | A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply                                                                                                                       | 7. Feed through                |
| _____h. | Point of attachment for conductors                                                                                                                                                                                                                       | 8. Individual branch circuit   |
| _____i. | Metal strip containing one or more devices                                                                                                                                                                                                               | 9. Multiple receptacle         |
| _____j. | A single device with two grounding type receptacles                                                                                                                                                                                                      | 10. Pigtail                    |
| _____k. | Transfer conductors in a switching situation; they are used between 3-ways and 4-ways                                                                                                                                                                    | 11. Poles                      |
| _____l. | Receptacle that has had a connecting fin removed for remote control or separate circuit connections                                                                                                                                                      | 12. Receptacle connecting fin  |
|         |                                                                                                                                                                                                                                                          | 13. Line leg                   |
|         |                                                                                                                                                                                                                                                          | 14. Single receptacle          |
|         |                                                                                                                                                                                                                                                          | 15. Split-wired receptacle     |

## TEST

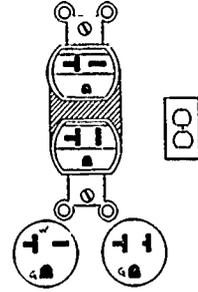
- |         |                                                                                                                                                      |                     |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| _____m. | Voltage multiplied times amperage                                                                                                                    | 16. Strap or yoke   |
| _____n. | Unit of an electrical system which is intended to carry but not utilize electrical energy                                                            | 17. Switch          |
| _____o. | Detachable design feature that makes terminals common connections                                                                                    | 18. Switch leg      |
| _____p. | Conductor that supplies electrical energy to a switch                                                                                                | 19. Switch loop     |
| _____q. | Current carrying conductors, both grounded and ungrounded, on a receptacle                                                                           | 20. Terminal        |
| _____r. | Branch circuit that supplies only one piece of utilization equipment                                                                                 | 21. Traveler        |
| _____s. | A branch circuit supplying energy to one or more outlets to which appliances are to be connected                                                     | 22. Trim out        |
| _____t. | Splicing technique that leaves an accessible conductor for termination at a device, load, or grounding terminal                                      | 23. Troubleshooting |
| _____u. | Device used to open or transfer circuit direction                                                                                                    | 24. Volt ampere     |
| _____v. | Piece of equipment used to secure cables                                                                                                             | 25. Wires           |
| _____w. | Final stage in a residential wiring project; involves devices and plates, connecting and securing equipment, hanging fixture, and testing the system |                     |
| _____x. | Current carrying conductors and grounding conductors                                                                                                 |                     |
| _____y. | A single contact device with no other contact device on the same yoke                                                                                |                     |

# TEST

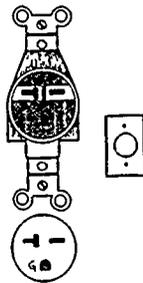
2. Identify common residential receptacle types and cover plates shown below.



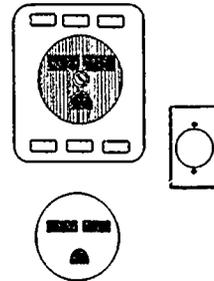
a. \_\_\_\_\_



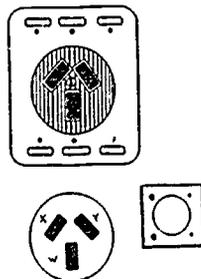
b. \_\_\_\_\_



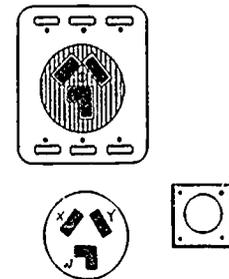
c. \_\_\_\_\_



d. \_\_\_\_\_

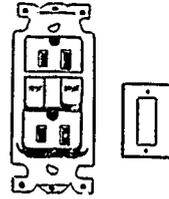
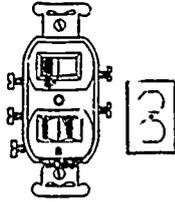


e. \_\_\_\_\_



f. \_\_\_\_\_

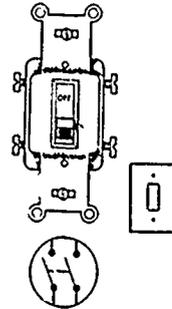
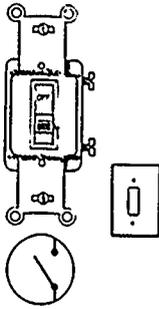
TEST



g. \_\_\_\_\_

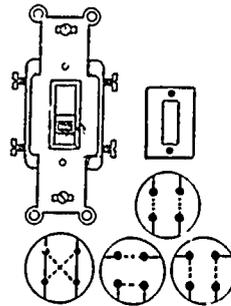
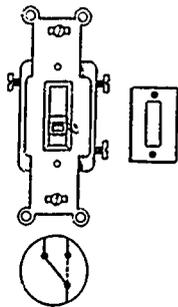
h. \_\_\_\_\_

3. Identify common residential switch types and cover plates shown below.



a. \_\_\_\_\_

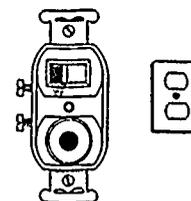
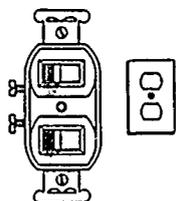
b. \_\_\_\_\_



c. \_\_\_\_\_

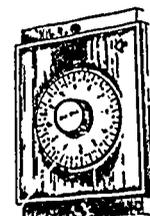
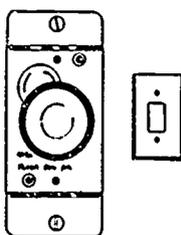
d. \_\_\_\_\_

TEST



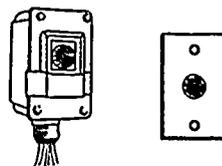
e. \_\_\_\_\_

f. \_\_\_\_\_



g. \_\_\_\_\_

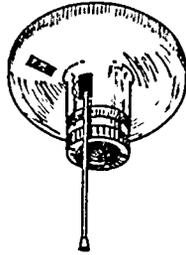
h. \_\_\_\_\_



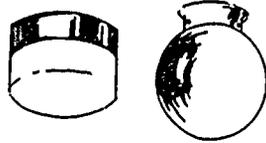
i. \_\_\_\_\_

TEST

4. Match common residential fixture locations on the right with their correct types.



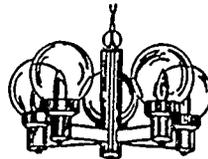
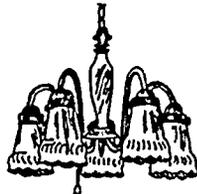
\_\_\_ a.



\_\_\_ b.



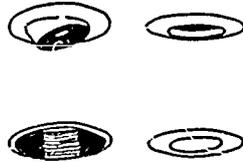
\_\_\_ c.



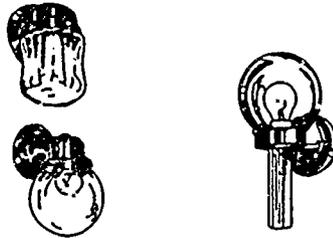
\_\_\_ d.

1. Dining room
2. Bedroom or hall
3. Recessed fixtures and trims
4. Bathroom
5. Closet
6. Outdoor entry

## TEST



\_\_\_\_\_ e.



\_\_\_\_\_ f.

5. Complete the following statements related to appliance classifications by circling the word which best completes each statement.
- a. Fixed — A current consuming device which is (**permanently, temporarily**) installed such as water heaters, built-in cook-tops or ovens, and electric furnaces.
  - b. Stationary — A current consuming device not permanently (**moved, attached**) but, not ordinarily moved such as clothes dryers, washing machines, and free standing ranges.
  - c. Portable — A current (**carrying, consuming**) device which is commonly moved such as blenders, mixers, toasters, and radios.
  - d. Located on a separate circuit — A branch circuit that supplies only one (1) (**utilization, refrigeration**) equipment such as a range, dryer, or washing machine.
  - e. Cord-and-plug connected — Connected to a branch circuit with a (**piglet, pigtail**) plug inserted into a receptacle such as portable appliances, but may include stationary or fixed-in-place appliances.

TEST

6. Distinguish between requirements for appliance disconnect means by placing an "X" for permanently connected appliances next to the correct requirement.

\_\_\_a. An accessible plug and receptacle shall be permitted to serve as the disconnect means.

\_\_\_b. The branch circuit breaker shall be permitted to serve as the disconnecting means where readily accessible to the user of the appliance.

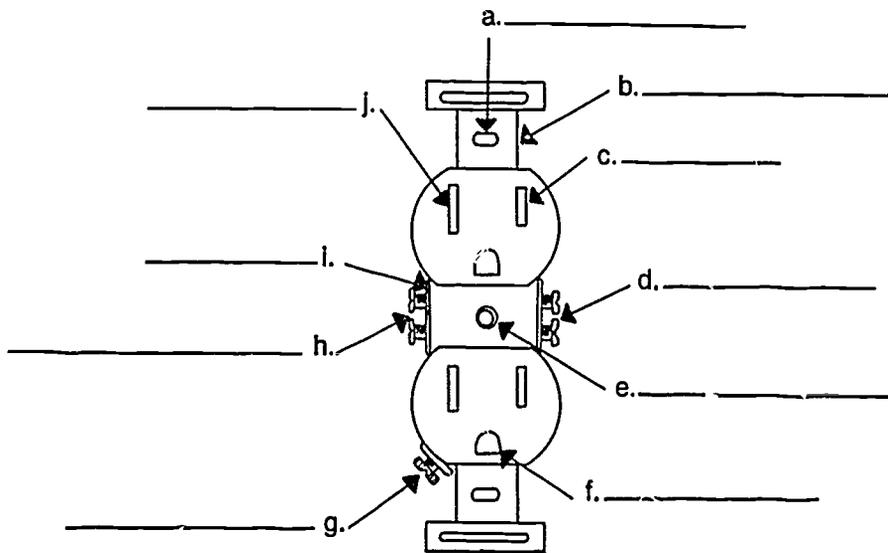
7. State the grounding requirement for appliances.

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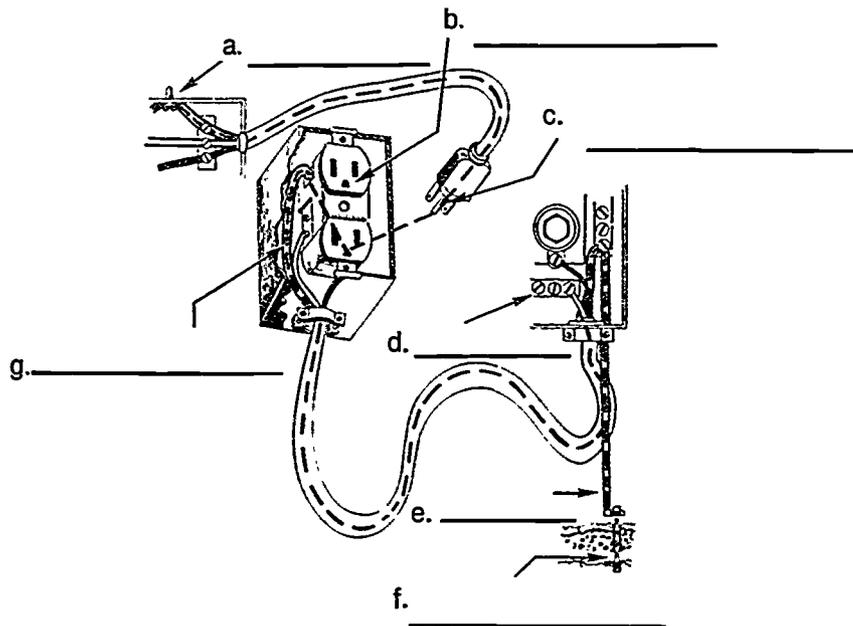
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8. Identify the parts of a duplex grounding type receptacle.



## TEST

9. Identify the parts of an equipment grounding system.



10. Arrange in order the steps for panel trim out by placing a "1" for the first step, a "2" for the second step and so on in the blanks preceding the steps.

- \_\_\_\_a. Connect ungrounded conductors to their overcurrent protection devices.
- \_\_\_\_b. Label panel in the form of a directory.
- \_\_\_\_c. Connect the grounding conductors to their panel location.
- \_\_\_\_d. Energize the system with temporary power.
- \_\_\_\_e. Connect grounded conductors to the panel neutral bar.

**TEST**

11. Select true statements concerning troubleshooting procedures by placing an "X" in the blanks preceding the true statements.

- \_\_\_\_\_a. Consulting the owner about the operation of a system may help to determine symptoms of a problem causing system.
- \_\_\_\_\_b. Locate the problem solving area by turning on the power and waiting for smoke to indicate where the problem is.
- \_\_\_\_\_c. Check the conductor to see if it is discolored from overheating or if the insulation is damaged or nicked.
- \_\_\_\_\_d. Replace fuse or circuit breaker with a larger size to eliminate breaker trip.
- \_\_\_\_\_e. Check devices and fixtures for worn or overheated parts.
- \_\_\_\_\_f. Repair or replace cause of problem.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

12. Demonstrate the ability to:

- a. Install a duplex grounding type receptacle. (Job Sheet #1)
- b. Install a range or dryer receptacle. (Job Sheet #2)
- c. Install a multi-circuit split-wired duplex grounding type receptacle. (Job Sheet #3)
- d. Wire a receptacle fed from a lighting outlet through a single pole switch. (Job Sheet #4)
- e. Connect a supply cord to a free standing range. (Job Sheet #5)
- f. Install a fixed appliance equipped with a pigtail to a branch circuit. (Job Sheet #6)
- g. Install a fusible safety switch for an air-conditioning condenser. (Job Sheet #7)
- h. Troubleshoot an electrical system problem. (Job Sheet #8)

## TRIM OUT AND TROUBLESHOOTING UNIT IV

### ANSWERS TO TEST

1.
 

a.	18	f.	19	k.	21	p.	13	u.	17
b.	7	g.	5	l.	15	q.	11	v.	3
c.	1	h.	20	m.	24	r.	8	w.	22
d.	9	i.	16	n.	4	s.	2	x.	25
e.	23	j.	6	o.	12	t.	10	y.	14
  
2.
 

a.	Duplex grounding receptacle	e.	Range receptacle
b.	Dual voltage receptacle	f.	Dryer receptacle
c.	Air conditioner receptacle, 20 amp	g.	Switch and receptacle
d.	Air conditioner receptacle, 30 amp	e.	Ground fault receptacle
  
3.
 

a.	Single pole	f.	Switch and pilot light
b.	Double pole	g.	Dimmer
c.	Three way	h.	Timer switch
d.	Four way	i.	Photo cell
e.	Duplex switch		
  
4.
 

a.	5
b.	2
c.	4
d.	1
e.	3
f.	6
  
5.
 

a.	Permanently
b.	Attached
c.	Consuming
d.	Utilization
e.	Pigtail
  
6. b
  
7. Appliances with exposed noncurrent carrying metal parts likely to become energized shall be grounded.

## ANSWERS TO TEST

8. a. Mounting hole  
b. Mounting bracket  
c. Live slot  
d. Live terminals  
e. Cover mounting screw
- f. Ground slot  
g. Grounding terminal  
h. Neutral terminals  
i. Bridge  
j. Neutral slot
9. a. Grounding connection at frame  
b. Receptacle grounding slot  
c. Attachment cap grounding prong  
d. Neutral block  
e. Grounding electrode conductor  
f. Grounding electrode  
g. Grounding conductor
10. a. 3  
b. 4  
c. 1  
d. 5  
e. 2
11. a, c, e, f
12. Performance skills evaluated to the satisfaction of the instructor

# LOAD CENTER CHANGES

## UNIT V

### UNIT OBJECTIVE

After completion of this unit, the student should be able to change out existing load centers or add supplemental load centers to existing panels. Competencies will be demonstrated by completing the job sheets and the unit tests with a minimum score of 85 percent.

### SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to load center changes with their correct definitions.
2. Describe the three basic types of load centers.
3. Match reasons for load center changes with their correct causes.
4. List possible ways to increase service size on an existing dwelling.
5. Select true statements concerning procedures for changing existing service.
6. Demonstrate the ability to:
  - a. Replace an existing interior flush mount load center. (Job Sheet #1)
  - b. Install a rainproof load center to supplement an existing interior load center. (Job Sheet #2)

## LOAD CENTER CHANGES UNIT V

### SUGGESTED ACTIVITIES

- A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

- B. Provide students with objective sheet.
- C. Discuss unit and specific objectives.
- D. Provide students with information sheet.
- E. Discuss information sheet.
- F. Provide students with job sheets.
- G. Discuss and demonstrate the procedures outlined in the job sheets.
- H. Integrate the following activities throughout the teaching of this unit:
1. Contact local utility company representative to visit class to discuss requirements for electricians disconnecting or reconnecting service drop conductors.
  2. Contact local code enforcement representative to visit class to discuss local regulations regarding inspection requirements for service change outs.
  3. Construct trainer boards to simulate existing service riser and panel installations to be changed out in these job sheets.
  4. Contact local contractor to arrange job site visit for class to witness a live work change out.
  5. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.
- I. Give test.
- J. Evaluate test.
- K. Reteach if necessary.

## REFERENCES USED WRITING THIS UNIT

- A. Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.
- B. *National Electrical Code, 1987*. Quincy, MA: National Fire Protection Association, 1986.

## SUGGESTED SUPPLEMENTAL MATERIAL

Text — Holzman, Harvey W. *Modern Residential Wiring*. South Holland, IL: Goodheart-Wilcox Co., Inc., 1986. 123 W. Taft Dr. South Holland, IL 60473.

(NOTE: This text may be obtained by writing to Goodheart-Wilcox Co., Inc., 123 W. Taft Dr., South Holland, IL 60473.)

# LOAD CENTER CHANGES UNIT V

## INFORMATION SHEET

### I. Terms and definitions

A. Air-conditioning condenser — Refrigeration equipment that sits outside a residential dwelling and is used to remove heat from refrigerant; usually contains a hermetically sealed compressor

B. Full load amps (F.L.A.) — Amperage at which equipment is designed to operate

(NOTE: This information can usually be found on the equipment nameplate.)

C. Life sustaining medical equipment — Equipment necessary to keep patients alive

(NOTE: This could be an iron lung, kidney machine or any other machine used to replace or sustain a bodily function.)

D. Load center — A factory assembled metal cabinet consisting of fuses or circuit breakers for overcurrent protection of electrical wiring

E. Outage — Period during which no current is available to circuits in a residential dwelling

F. Premises wiring — The interior and exterior wiring including power, lighting, control and signal circuits together with associated hardware, fittings, and wiring devices

### II. Basic types of load centers

A. Flush interior — Mounted behind wall covering with opening flush with the wall covering

B. Surface interior — Mounted on the surface of the wall covering inside the dwelling

C. Surface exterior — Mounted on the surface of the wall covering outside the dwelling

## INFORMATION SHEET

### III. Reasons for load center changes

#### A. Load center changes with no structural changes

1. Addition of window air conditioner unit or central air conditioning unit.
2. Addition of increased laundry load (electric clothes dryer)
3. Addition of increased kitchen loads (microwave oven, garbage disposal, etc.)
4. Change out worn out antiquated load center

#### B. Load center changes with structural changes

1. Room additions to existing dwellings (extra bedroom, utility room, den, or family center)
2. Remodel existing dwelling (new kitchen, wall removal, or refurbish interior walls)
3. Addition of a deck area for swimming pool or hot tub

(NOTE: Any change made to existing dwelling exceeding 50% remodel will require that the premises wiring be brought up to existing code standards.)

### IV. Possible ways to increase existing service size

- #### A. Install larger service entrance conductors in existing raceway, and increase load center main breaker size accordingly.

(NOTE: This method will only work if the raceway is large enough, the load center bus is rated for increased size, and the main breaker is interchangeable and the panel has sufficient space for additional circuit breakers.)

- #### B. Increase service conductor size and set a new exterior load center with main breaker sized to supply new and existing loads.

(NOTE: Raceway must be changed if it is not rated for increased conductor size. A separate breaker must be installed in the new exterior panel to feed the old panel as a subpanel.)

- #### C. Make a complete service change out.

(NOTE: This the most extensive change and must include all new equipment (service raceway and conductor and load center.)

## INFORMATION SHEET

### V. Procedures for changing an existing service

(NOTE: Always check with local utility company and code enforcement authority before starting.)

A. Calculate new service size needed.

(NOTE: It is possible to use Unit I, Blueprint Reading and Load Calculations, for sizing the new service.)

B. Estimate materials and labor needed.

(NOTE: This involves exact calculation of material cost [plus mark-up] and estimated labor cost to install the materials. Do not forget to include in estimate any permit or inspection fees for local code enforcement compliance.)

C. Consult with customer about best possible time to do the work.

(NOTE: Be sure no life sustaining medical equipment is involved in the outage. In extreme summer heat, this may include air conditioning units.)

D. Contact utility company and local code enforcement authority about the project.

(NOTE: The utility company may require inspection by the local code enforcement officer before reconnecting the service conductors to the service drop conductors. They may even need to increase their service drop conductors size.)

E. Start and complete load center and service change out.

(NOTE: Be prepared to finish this project once you start unless the dwelling is unoccupied.)

## LOAD CENTER CHANGES UNIT V

### JOB SHEET #1 — REPLACE AN EXISTING INTERIOR FLUSH MOUNT LOAD CENTER

(NOTE: This job sheet is intended to provide instruction on removing an inadequate or defective load center and replacing it with an appropriate new one. Riser, meter base, and other service equipment will not be dealt with due to the number of variables involved.)

**(CAUTION: This job should be done on a trainer board, not on a live job site.)**

#### A. Equipment and materials needed

1. Pouch tools
2. Keyhole saw
3. Hacksaw blade or nail saw
4. Load center with flush cover

(NOTE: If you are increasing the size of the load center use Example No. 1, 1[a], 1[b], or 1[c], from the tables and examples in the back of the NEC to compute the size needed.)

5. Drop cloth
6. Knockout cutter set

(NOTE: If the load center you are changing is fed through a nipple from the meter base and it can be aligned with existing KO's in the new load center you will not need this equipment.)

7. Safety glasses
8. Voltmeter
9. Metal tapping screws or pan head wood screws

(NOTE: The length of these screws will be determined by the distance between the panel and the stud. Shims may be needed.)

10. Portable GFI

## JOB SHEET #1

## B. Procedure

(NOTE: This project must be completed once started. Check with the customer to find when it would be of least inconvenience to have the electricity off for this operation. Be sure there is not any life sustaining medical equipment involved in this outage. Have emergency lighting available.)

1. Gather equipment and materials.

(NOTE: Check to be sure you have every possible item needed to finish the job once you start. Contact utility company. They may want to remove the meter.)

2. Put on safety glasses.
3. Remove load center cover screws.

4. Remove load center cover.

(NOTE: Place the cover out of your working area.)

5. Turn off or pull existing main.

(NOTE: Notify the customer that there will be an outage before disconnecting power.)

6. Pull the meter.

(NOTE: Turning off the main(s) eliminates an arc during this process.)

7. Remove fasteners securing load center to studs.

(CAUTION: If it is secured by screws, use extreme care when working around load center interior.)

(NOTE: Use hacksaw blade with tape for a handle or a nail saw to cut nails between load center and stud.)

8. Trace outline for new load center.

- a. Hold new load center over existing one.

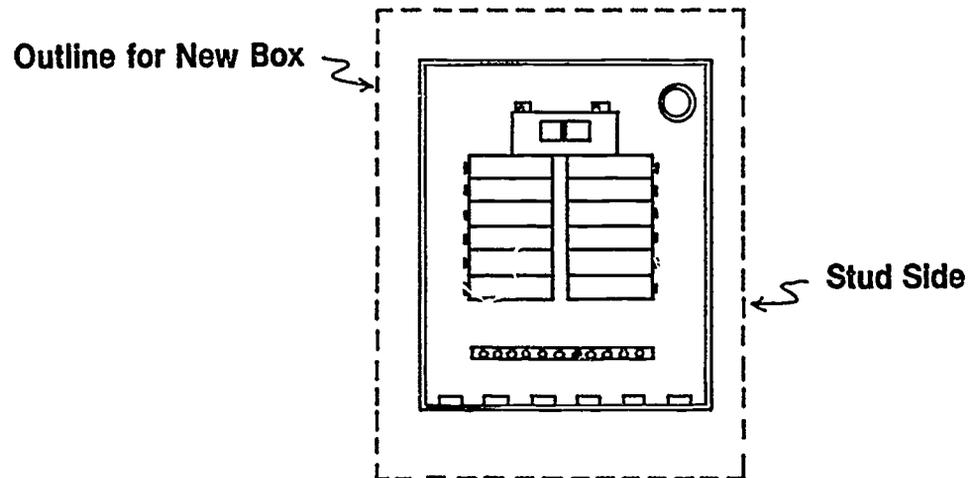
(NOTE: Match up knockouts so your panel will fit over existing feeder raceway. You may have to cut an opening.)

## JOB SHEET #1

- b. Draw around load center once it is in place. (Figure 1)

(NOTE: Make opening about 1/4" large on top and bottom of the panel.)

FIGURE 1



9. Cut opening for new load center.
  - a. Cut lightly along line with knife.
  - b. Repeat cuts until cut is over one half way through plasterboard.
 

(NOTE: Do not use a saw until it is evident there are no wires that could be cut.)
  - c. Break out plasterboard.
 

(NOTE: Dress the opening with the keyhole saw.)
10. Disconnect the service entrance conductors from the load center line lugs.
11. Disconnect the grounded conductor.
 

(NOTE: Grounded conductors are always last off and first back on for safety purposes.)
12. Disconnect all wires from branch circuit breakers.
 

(NOTE: Label all circuits so you can update new circuit directory.)
13. Disconnect all grounded and grounding wires from block.
14. Remove all locknuts and bushings.

**JOB SHEET #1**

15. Slip all branch circuit cables out of load center.

(NOTE: This may not be possible until you start pulling the panel from the opening.)

16. Pull load center out of opening.

17. Lay old load center out of the way.

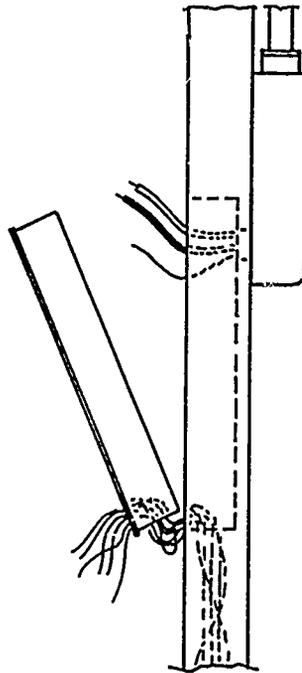
18. Punch out appropriate KO's for feeder and branch circuits.

19. Hold panel up to opening.

20. Start branch circuit cables into openings. (Figure 2)

(NOTE: Readjust cable connectors before starting cables into the panel.)

FIGURE 2



21. Feed cables in as you move the load center into place.

(NOTE: Proceed carefully so you do not damage any cables.)

22. Guide service entrance conductors into opening.

23. Move load center into place.

(NOTE: Some installations may require mat frame or trim.)

**JOB SHEET #1**

24. Replace locknut and bushing.  
(NOTE: Bond equipment according to the NEC and local codes.)
25. Secure load center.  
(NOTE: Screws are recommended for this job.)
26. Reconnect service neutral.
27. Reconnect ungrounded service entrance conductors.  
(NOTE: If these conductors are not long enough, replace them.)
28. Reconnect branch circuits.  
(NOTE: Be sure and hook conductors to appropriate size breaker.)
29. Turn all disconnects off.
30. Replace meter.
31. Turn on main(s).
32. Turn on branch circuit.
33. Check circuits.
34. Put all covers and trims in place.
35. Clean work area and put away all equipment and materials.

## LOAD CENTER CHANGES UNIT V

### JOB SHEET #2 — INSTALL A RAINPROOF LOAD CENTER TO SUPPLEMENT AN EXISTING INTERIOR LOAD CENTER

(NOTE: There are many variables involved in this project. It is highly possible that you could do ten jobs like this and have all of them be different. This is only one application; keep in mind there could be many more. This job sheet is an example of one way to increase circuit capacity for a service when the load calculations show the amperage rating will accept your additional circuits.)

**(CAUTION: This job sheet should be accomplished on a trainer board, not on a live job site.)**

#### A. Equipment and materials needed

1. Pouch tools
2. Rainproof load center

(NOTE: The number of circuits needed and type of disconnect already employed will determine whether this load center needs to have a main.)

3. Feeder wire

(NOTE: Size will be determined by service ampacity and use of the load center.)

4. Raceway to connect load center

(NOTE: If the connection is made with conduit you will need fittings; if made with rigid metal conduit you will need locknuts and bushings.)

5. Fasteners

(NOTE: Screws and anchors should be used on concrete or bricks; metal tapping or wood screws will work on wood.)

6. Safety glasses
7. Pencil
8. Leather gloves
9. Voltmeter
10. Auxiliary light
11. Portable GFI

**JOB SHEET #2**

12. Drill motor and masonry bit

13. Leather gloves

14. Wooden ladder

15. Service connectors

(NOTE: If the utility company disconnects the drop, these will not be needed.)

16. Close nipple

(NOTE: The size of this equipment will be determined by the size of the conductors to be installed.)

17. Four locknuts to fit nipple

18. Two bushings to fit nipple

19. Feeder wire

(NOTE: This includes ungrounded and grounded; size will be determined by service size.)

**B. Procedure**

(NOTE: Contact the utility company before you start this project. They may want to disconnect the service drop from the service entrance conductors.)

1. Gather equipment and materials.

2. Put on safety glasses.

3. Notify customer that there will be a temporary outage.

(NOTE: Make sure you will not be disrupting the operation of any life sustaining equipment.)

4. Disconnect the service drop.

a. Work from a wooden ladder.

b. Wear gloves.

c. Disconnect one conductor at a time.

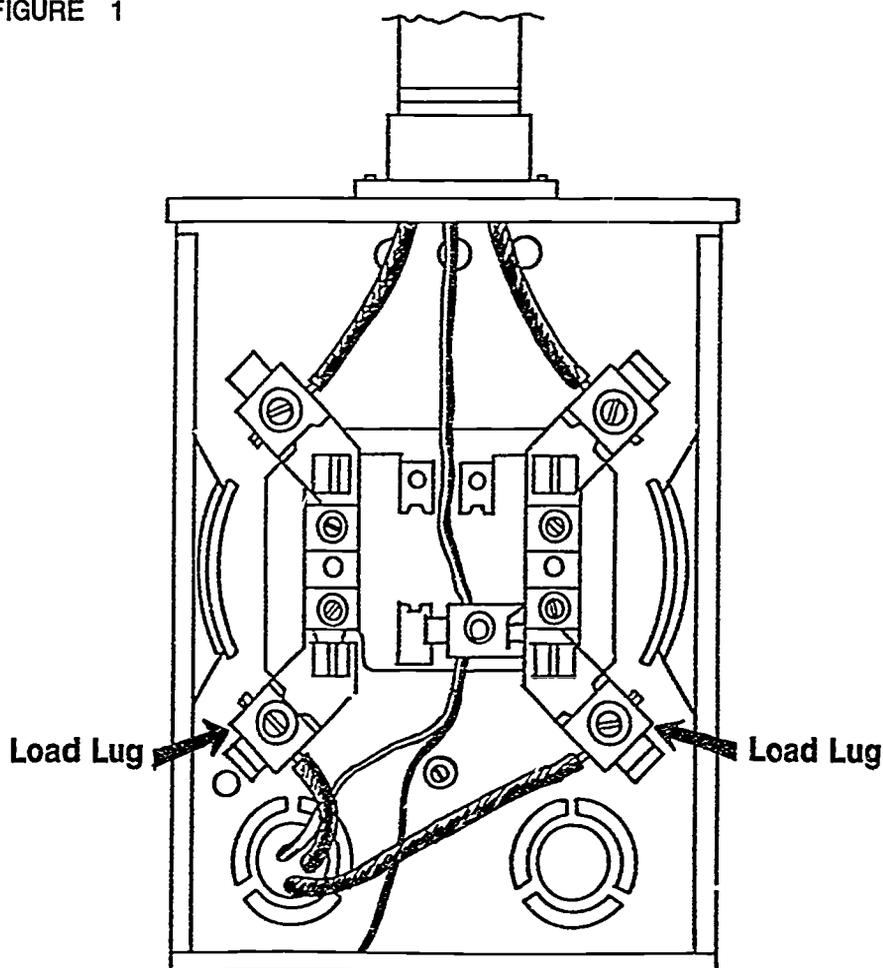
d. Tape conductors as you remove them.

e. Remove neutral last.

## JOB SHEET #2

5. Loosen straps connecting riser to structure.
6. Remove meter base cover.
7. Remove screws securing meter base.
8. Remove ungrounded conductors from load side. (Figure 1)

FIGURE 1



9. Remove grounded and grounding conductors.
10. Remove bushing and locknuts.
11. Straighten conductors.
12. Pull meter base straight out and over conductors.
13. Lift meter base out of way.

## JOB SHEET #2

14. Remove appropriate KO from load center.

(NOTE: If it is going to put the meter higher than the utility company will allow when you use a bottom KO use a top one instead. You may have to cut a new one.)

15. Put load center over conductors.

16. Mark securing screw locations.

17. Mount the load center.

(NOTE: Be sure and use GFI if holes are to be drilled.)

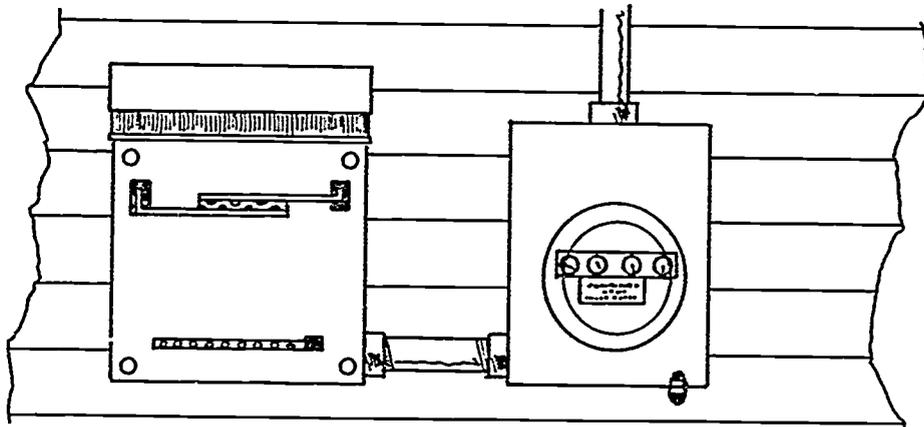
18. Install locknuts and bushings.

(NOTE: Check on bonding requirements with local utility company)

19. Install nipple between load center and meter base using backup locknuts on the outside of both enclosures.

(NOTE: It may be that you will have to mount the meter base to the side of your panel instead of above it. See Figure 2. Look the situation over carefully before you decide.)

FIGURE 2



20. Secure meter base.

21. Install interior locknuts and bushings.

(NOTE: Check with local utility company on bonding requirements.)

22. Install conductors between existing panel and new load center.

(NOTE: Size is determined by load and equipment calculations. Provide overcurrent protection for existing panel from new load center.)

**JOB SHEET #2**

23. Install conductors between meter load lugs and new load center line lugs.
24. Reconnect grounding electrode conductor.
25. Resecure service riser.
26. Reconnect service drop.

(NOTE: Consult your local utility company; they may want to do this. Always remember:

- a. Grounded conductor is last off and first back on.
  - b. Wear gloves.
  - c. Work one conductor at a time.
  - d. Tape conductor as it is connected.
  - e. Don't carry extra tools in your hands.
  - f. Work from a wooden ladder. )
27. Turn off main breaker(s).
  28. Install meter.
  29. Turn on breakers.
  30. Check circuits.
  31. Update circuit directory.
  32. Clean work area and put away all equipment and materials.

## LOAD CENTER CHANGES UNIT V

### PRACTICAL TEST JOB SHEET #1 — REPLACE AN EXISTING INTERIOR FLUSH MOUNT LOAD CENTER

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. All circuits turned off (including main).	_____	_____
3. Meter removed before beginning removal of panel.	_____	_____
4. Care taken to protect existing branch circuit conductors.	_____	_____
5. Care taken to protect existing service conductors.	_____	_____
6. All circuit conductors re-enter panel (none folded back).	_____	_____
7. Existing grounding conductor re-enter panel.	_____	_____
8. Service conductors attached proper lugs.	_____	_____
9. Branch circuit conductor attached to proper breakers and lugs (neutral).	_____	_____
10. Bonding accomplished between service and new load center.	_____	_____
11. Checked in/put away tools and materials.	_____	_____
12. Cleaned the work area.	_____	_____
13. Used proper tools correctly.	_____	_____
14. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
15. Practiced safety rules throughout procedure.	_____	_____
16. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

\_\_\_\_\_

## JOB SHEET #1 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
All circuits work when supply voltage turned on	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_

PERFORMANCE EVALUATION KEY	
4	— Skilled — Can perform job with no additional training.
3	— Moderately skilled — Has performed job during training program; limited additional training may be required.
2	— Limited skill — Has performed job during training program; additional training is required to develop skill.
1	— Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

## LOAD CENTER CHANGES UNIT V

### PRACTICAL TEST JOB SHEET #2 — INSTALL A RAINPROOF LOAD CENTER TO SUPPLEMENT AN EXISTING INTERIOR LOAD CENTER

STUDENT'S NAME \_\_\_\_\_

DATE \_\_\_\_\_

EVALUATOR'S NAME \_\_\_\_\_

ATTEMPT NO. \_\_\_\_\_

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

#### PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	_____	_____
2. Caution used to protect existing load conductor insulation.	_____	_____
3. Proper size and location K.O. removed.	_____	_____
4. Lock nut and bushing reconnected securely.	_____	_____
5. Proper size conductors installed between existing panel and new panel.	_____	_____
6. Proper size conductors installed between meter and new load center.	_____	_____
7. Proper size conductors installed in service raceway.	_____	_____
8. Service raceway and meter secured properly.	_____	_____
9. Checked in/put away tools and materials.	_____	_____
10. Cleaned the work area.	_____	_____
11. Used proper tools correctly.	_____	_____
12. Performed steps in a timely manner (____hrs. ____min. ____sec.)	_____	_____
13. Practiced safety rules throughout procedure.	_____	_____
14. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS: \_\_\_\_\_

## JOB SHEET #2 PRACTICAL TEST

### PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
All equipment connections made securely	4	3	2	1
All circuits work properly when energized	4	3	2	1
Workmanship	4	3	2	1
Compliance to NEC	4	3	2	1

EVALUATOR'S COMMENTS: \_\_\_\_\_  
 \_\_\_\_\_

#### PERFORMANCE EVALUATION KEY

- 4 — Skilled — Can perform job with no additional training.
- 3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
- 2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
- 1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

# LOAD CENTER CHANGES UNIT V

## TEST

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

1. Match the terms on the right with their correct definitions.

- |         |                                                                                                                                                                 |  |                                      |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------|
| _____a. | Refrigeration equipment that sits outside a residential dwelling and is used to remove heat from refrigerant; usually contains a hermetically sealed compressor |  | 1. Air conditioning condenser        |
| _____b. | A factory assembled metal cabinet consisting of fuses or circuit breakers for overcurrent protection of electrical wiring                                       |  | 2. Full load amps (F.L.A.)           |
| _____c. | Amperage at which equipment is designed to operate                                                                                                              |  | 3. Life sustaining medical equipment |
| _____d. | The interior and exterior wiring including power, lighting, control and signal circuits together with associated hardware, fittings, and wiring devices         |  | 4. Load center                       |
| _____e. | Equipment necessary to keep patients alive                                                                                                                      |  | 5. Outage                            |
| _____f. | Period during which no current is available to circuits in a residential dwelling                                                                               |  | 6. Premises wiring                   |

2. Describe the three basic types of load centers.

- a. Flush interior — \_\_\_\_\_  
\_\_\_\_\_
- b. Surface interior — \_\_\_\_\_  
\_\_\_\_\_
- c. Surface exterior — \_\_\_\_\_  
\_\_\_\_\_

## TEST

3. Match reasons for load center changes on the right with their correct causes of increased load.

- |         |                                                  |                                                  |
|---------|--------------------------------------------------|--------------------------------------------------|
| _____a. | Addition of window air conditioner               | 1. Load center changes with no structural change |
| _____b. | Increased kitchen loads (microwave and disposer) |                                                  |
| _____c. | Utility room addition                            | 2. Load center changes with structural change    |
| _____d. | Remodel kitchen                                  |                                                  |
| _____e. | Install electric clothes dryer                   |                                                  |
| _____f. | New deck with hot tubs                           |                                                  |

4. List three possible ways to increase service size on an existing dwelling.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_

5. Select true statements concerning procedures for changing an existing service by placing an "X" in the blanks preceding the true statements.

- \_\_\_\_\_a. Calculate new service size needed.
- \_\_\_\_\_b. Estimate materials and labor needed.
- \_\_\_\_\_c. Consult with customer about best possible time to do the work.
- \_\_\_\_\_d. Contact utility company and local code enforcement authority about the project.
- \_\_\_\_\_e. Start load center and service change out on occupied dwelling and complete at your convenience.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

6. Demonstrate the ability to:
- a. Replace an existing interior flush mount load center. (Job Sheet #1)
- b. Install a rainproof load center to supplement an existing interior load center. (Job Sheet #2)

## LOAD CENTER CHANGES UNIT V

### ANSWERS TO TEST

1. 

a.	1	d.	6
b.	4	e.	3
c.	2	f.	5
  
2.
  - a. Flush interior — Mounted behind wall covering with opening flush with the wall covering
  - b. Surface interior — Mounted on the surface of the wall covering inside the dwelling
  - c. Surface exterior — Mounted on the surface of the wall covering outside the dwelling
  
3. 

a.	1	d.	2
b.	1	e.	1
c.	2	f.	2
  
4.
  - a. Install larger service entrance conductors in existing raceway and increase load center main breaker size accordingly.
  - b. Increase service conductor size and set a new exterior load center with main breaker sized to supply new and existing loads.
  - c. Make a complete service change out.
  
5. a, b, c, d
  
6. Performance skills evaluated to the satisfaction of the instructor