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ABSTRACT

This guide is intended to assist vocational educators in providing job-relevant, performance-oriented training for students seeking to become house electricians. The introductory section reviews procedures for using the guide. Provided next are instructional units dealing with the following topics: computing service loads; installing electrical environmental control components, lighting fixtures, service entrances, and switch and outlet boxes; maintaining existing wiring; operating a business; roughing in feeders, branch circuit cables, and circuits; and trimming out (finishing) electrical devices and appliances. Each unit consists of a series of duty sheets and a final performance checklist and test. Duty sheets contain some or all of the following: duty title; performance objective (broken down into a task, task performance standard, source of the standard, and task performance conditions); enabling objectives; recommended resources; suggested teaching activities; a criterion-referenced measure with answers; a practical application; a method of evaluating the practical application; and a performance guide. Appendixes to the guide include a list of duties and tasks; definitions of relevant terms; an equipment list; and bibliographies of the sources of the standards included in the duty sheets, pertinent state-of-the-art literature, and recommended materials. (MN)

V-TECS GUIDE

FOR

HOUSE ELECTRICIAN

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INTRODUCTION

V-TECS guides are an extension or continuation of the V-TECS catalogs. While the V-TECS catalog is a composition of duties, tasks, performance objectives, and performance guides, it deals only with the psychomotor aspect of an occupation. It is a blueprint of an occupation. It deals only with the identification of the "hands on" aspect of the occupation. It does not take into consideration such things as the background information surrounding a task, how to make inferences, generalizations and decisions from a body of knowledge, nor does it deal with attitudes, job seeking skills, safety or energy conservation practices. V-TECS guides take these aspects of teaching and learning into consideration.

Experience has shown that the art of learning can also be taught while teaching subject matter. People need to learn how to learn. V-TECS guides take into consideration how students learn and are an efficient way for instructors to assist them to learn.

V-TECS guides are centered around all three domains of learning: psychomotor, cognitive, and effective. The following is a brief explanation of each.

Psychomotor

Any manipulative skill such as tightening a nut, replacing a hubcap, sharpening a pencil, machining a key slot in a steel shaft, or replacing a SCR in a solid state control panel are examples of manipulative or psychomotor skills. Tasks such as these are identified in V-TECS catalogs. V-TECS catalogs also group tasks by duties and objectives. Each performance objective has a performance standard which must be met to prove student proficiency in the manipulative aspect of the task. The V-TECS catalog, however, does not include any suggestions as to how to learn to do these tasks.

V-TECS guides are developed around psychomotor tasks which are worker oriented.

Cognitive

To perform psychomotor tasks, students must think. To tighten a nut they must know which way to turn it and when to stop turning it so that they won't strip the threads or shear the bolt off. If replacing a hubcap, there is a certain technique that may vary from one car to another. For example, start the hubcap by placing the cap in a tilted position and tapping it all the way around until it is properly seated. On a different model, it may be necessary to position the hubcap and snap it all at once. At any rate, students must think about what is being done. This is cognition or a mental activity. Cognition is what goes on in the mind about any job being done. V-TECS guides provide both the collateral knowledge and the impetus to apply cognition to psychomotor tasks.

Students gain cognition through both real and vicarious experiences. They may read, view tapes, memorize or practice a process or procedure until they are certain of it. To test their knowledge, students may be required to decide the proper procedure, method or sequence for performance. This decision making process or cognitive activity provides the basis for higher thinking skills.

Cognition, then, is that process by which information is stored and used. That voice that warns one of potential dangers is cognition. Anything that goes on in the mind is cognition. Students may become the best workers in their job; but if they fail to think a process through and apply their experience, they may become just one more statistic. It is cognition that tells them to lock and tag out the power supply to an electrical apparatus before starting to repair it. However, cognition does not apply only to safety. Good cognition or thinking can help employees do a job better and quicker. V-TECS guides provide for the cognitive aspects of learning.

Affective

Curriculum writers, supervisors, and instructors often fail to assist students in acquiring a positive attitude toward themselves, their jobs, their school, or their fellow students. V-TECS guides seek to provide assistance to the instructor in achieving this. It is difficult for the instructor to identify little bits and pieces of desirable behavior for every unit and often harder yet to teach them. In this area, students might be judged as to how well they clean up their work area, whether they show up to do the job on time, or whether they must be told several times to do something. Potential employers are interested in student attitude because persons angry at themselves or uncertain of themselves are often poor workers.

A student's ability to succeed on the first job and every job thereafter depends largely on attitude. If, for example, students have the attitude of "let someone else do it," they could be in trouble. Students using V-TECS guides will have activities dealing with how to get along with other students, supervisors, or staff members both in large and small groups.

USE OF V-TECS GUIDE

The guide is designed to provide job-relevant tasks, performance objectives, performance guides, resources, learning activities, evaluation standards and achievement testing in selected occupations.

A V-TECS guide is designed to be used with any teaching methods you may choose. If a lecture/demonstration method is best for you, you will find sufficient help to meet your needs. If you prefer to use discussions or other methods that require student participation, you will find ample help. Regardless of which method is successful for you, a V-TECS guide can save preparation time and offer innovative methods and procedures. For example, students may work either alone or in teams while in class and learn skills in direct relation to what is actually done on the job. This work also takes into consideration student attitudes, thinking skills, and mathematical reading skills.

The use of small groups in teaching can be helpful in two ways: (1) many students may feel inadequate due to their lack of background information in mechanical things; and (2) some students may feel that they are physically incompetent or lack the necessary background experiences. A successful program (course) can provide students with a sense of security by reinforcing positive attitudes while improving skill and knowledge of the subject. By allowing students to interact on a personal level, this task/learner-centered approach can achieve this. As students gain confidence and discover that they are an essential part of a team engaged in the learning-teaching process, their confidence increases. Too, the student in this setting can learn to work without direct supervision. In addition, use of the small-group method permits the instructor to vary instructional routines away from lecture or other full-class methods to activities for single students, pairs of students or any number so desired.

You will find suggestions for specific classroom activities. The activities are not meant to restrict you or your students, but only to suggest a variety of learning activities for each task statement. Please do not feel that you must take your students through all the activities.

ORGANIZATION OF TASKS FOR INSTRUCTION

This addendum provides a recommended sequence of the tasks which comprise the performance-based curriculum for a unit of instruction for House Electrician in South Carolina. The organization of these tasks was accomplished by a committee whose membership included the following electricity instructors: Johnny R. Fort, Bonneau Vocational Center, and Reginald S. Cross, Dorchester County Career Training Center.

Several tasks which fell below the 90% level were considered essential to the curriculum in South Carolina and have been included in the list. The tasks which were considered to be beyond the secondary level capabilities have been listed below the "cut-off" point.

Using this list as the foundation for the performance-based curriculum, an instructional unit can be developed for each task. The data provided in the form of performance objectives and performance guides, for the majority of tasks, will prove to be invaluable during the preparation of the instructional units. Please note, however, that the lesson themselves are placed in the Teacher's Guide in an alphabetical manner.

Instructional Sequence	Task
1.0	Computing Service Loads
1.1	Balance the total load per phase
1.2	Calculate individual circuit load
1.3	Calculate the load in watts and load current in amps for the entire residence
1.4	Compute the size of service entrance conductors
1.5	Design electrical systems
1.6	Determine how many convenience and appliance outlets should be on each separate circuit
1.7	Determine ground fault circuits required
1.8	Determine cost and practicality of underground service via overhead; also whether CT numbers should be used
1.9	Determine location of inside panels and boxes
2.0	Roughing in Feeders, Branch Circuit Cables, and Circuits
2.1	Rough in 120- or 240-volt circuits to distribution panel using non-metallic sheathed cable (N.M.C.)
2.2	Connect 240-volt circuits to circuit breaker panel using non- metallic sheathed cable
2.3	Rough in armored cable to outlet box
2.4	Rough in cable between an existing box and newly installed box
2.5	Install cable between an existing box horizontally along an existing wall in a channel behind a baseboard
2.6	Rough in cable or conduit for branch circuits
2.7	Install de-icing equipment
2.8	Rough in the circuit for a device controlled by two three way switches with feed to the switch box
2.9	Rough in the circuit for a device controlled by two three way switches with feed to the device outlet box
2.10	Rough in the circuit for a device controlled by two three way switches and one four way switch (with feed to a three way switch)

2.11 Rough in the circuit for a device controlled by two three way switches and one four way switch with feed to the device
2.12 Rough in the circuit for a device controlled by two three way switches and two four way switches with feed to a three way switch
2.13 Rough in the circuit for door chime system
2.14 Rough in the circuit for intercom system
2.15 Rough in line voltage thermostat wiring
2.16 Rough in low voltage thermostat wiring
2.17 Rough in non metallic cable in outlet boxes
2.18 Install pressure switch in existing wall
2.19 Rough in duplex receptacles circuit with two three way switches controlling one-half of each of two duplex receptacles
2.20 Rough in cables for single pole switch controlling one or more lights or devices with feed to a switch box
2.21 Rough in cables for single pole switch controlling one or more lights/devices with a feed to the light/device box
2.22 Rough in the circuit for a single pole switch controlling three lights/devices with feed to the end light device box
2.23 Rough in the circuit for a split circuit duplex receptacle
2.24 Rough in the circuit for two three way switches controlling one device using conduit and 4" square boxes with plaster rings
2.25 Install conduit underground
2.26 Rough in direct burial cable
2.27 Make fixture splice (Note: Consensus of writing team to move to Duty 1)
2.28 Make joint using crimp type connectors (splices)
2.29 Make pigtail splice (joint)
2.30 Make splices using mechanical- type connectors (split bolt connectors, lugs, and wire nuts)
2.31 Make up branch circuit wires to panels
2.32 Make western union splice (joint)
2.33 Rough in a single pole switch circuit
2.34 Run feeder cable from main service panel to auxiliary panel

3.0 Installing Switch Boxes and Outlet Boxes
3.1 Install (bar hanger) mounted box
3.2 Install flush mount junction box
3.3 Install flush mount switch and outlet box in a drywall, lath or plaster wall, or paneled wall
3.4 Install flush mount switch and outlet box in a lath and plaster wall
3.5 Install flush mount switch and outlet box in a paneled wall
3.6 Install flush mount switch in a masonry wall
3.7 Install gangable boxes
3.8 Install octagon outlet box
3.9 Install outlet boxes for receptacles and switches in existing wall
3.10 Install recessed fixture housing in ceiling
3.11 Install surface mount junction box
3.12 Install underground, water tight, cast iron box

4.0 Installing Lighting Fixtures
4.1 Connect delayed switch controlling one light with feed to switch
4.2 Install/connect fan controlled by switch
4.3 Connect/install flood lights
4.4 Connect/install lighting dimmer system
4.5 Install/connect heat-a-vent light

4.6 Connect incandescent lighting (fixture dimmer)
4.7 Connect/install light fixture
4.8 Install/connect photo-electric control on a light
4.9 Connect/install post lights
4.10 Install/connect power failure lighting
4.11 Install an incandescent lighting fixture dimmer
4.12 Install delayed switch controlling one light with feed to the switch
4.13 Install flood lights
4.14 Install fluorescent lighting fixture dimmer
4.15 Install low-voltage lighting controls
4.16 Install/connect moisture resistant fixtures
4.17 Install/connect pilot light to show when appliance is on
4.18 Install post lights
4.19 Install power failure lighting
4.20 Determine and install single pole light circuits, three way light switches, and four way light switches

5.0 <u>Installing Service Entrance</u>
5.1 Ground service entrance equipment
5.2 Install circuit breakers in panel
5.3 Install main service panel
5.4 Install mast type (through the roof) service entrance
5.5 Install main service disconnect
5.6 Install/connect mobile home service
5.7 Install service entrance cable to service drop
5.8 Install temporary service entrance
5.9 Install underground service entrance

6.0 <u>Trimming Out (Finishing) Electrical Devices and Appliances</u>
6.1 Install/connect automatic garage door operator
6.2 Connect convenience outlets
6.3 Connect de-icing equipment
6.4 Connect door chime system
6.5 Connect/install duplex receptacle outlets
6.6 Connect/install electric fence charger
6.7 Connect/install emergency warning system -- burgler or fire
6.8 Connect/install four-wire 220- volt receptacles
6.9 Install/connect ground fault interrupting device
6.10 Install/connect hot water heater
6.11 Connect/install humidity control device
6.12 Connect intercom system
6.13 Connect low-voltage lighting control
6.14 Connect mobile home service
6.15 Connect moisture resistant receptacle
6.16 Install/connect photo-electric cell control
6.17 Connect pilot light
6.18 Connect pressure switch in existing wall
6.19 Connect recessed fixture box in ceiling
6.20 Connect single pole switch
6.21 Connect/install single pole switch with pilot light
6.22 Connect split circuit duplex receptacle
6.23 Connect/install three wire 220- volt receptacle
6.24 Connect/install delayed action or time switch
6.25 Connect water pump motor

6.26 Connect wires from junction box to appliance
6.27 Connect/install three way switches
6.28 Connect/install four way switches
6.29 Install automatic garage door operator
6.30 Install electric fence charger
6.31 Install emergency warning system (burglar or fire)
6.32 Install four wire 220-volt receptacles
6.33 Install ground fault interrupting device
6.34 Install hot water heater
6.35 Install humidity control device
6.36 Install photo-electric control
6.37 Install single pole switch with pilot light
6.38 Install surface raceway
6.39 Install water pump motor
6.40 Connect 120/240-circuits to circuit breaker panel using non-metallic cable
6.41 Install 240-volt circuits to circuit breaker panel using non-metallic sheathed cable
6.42 Make fixture splice

7.0 Maintaining Existing Wiring
7.1 Repair automatic control equipment
7.2 Repair fire alarm stations
7.3 Diagnose/repair fluorescent fixture
7.4 Repair heating system controls
7.5 Diagnose and repair/replace lights
7.6 Repair/replace relays and timers
7.7 Repair solenoids in door chimes
7.8 Repair stoker controls
7.9 Repair thermostat
7.10 Repair water heater
7.11 Install and maintain emergency lighting
7.12 Repair or replace frayed service cords
7.13 Repair/replace power failure (lighting)
7.14 Replace existing interior load center
7.15 Replace blower motor
7.16 Replace cable
7.17 Replace circuit breakers
7.18 Replace duct heating element
7.19 Replace electric space heating equipment
7.20 Replace existing receptacle or switch
7.21 Replace float switches
7.22 Replace furnace motors
7.23 Replace fuses
7.24 Replace grounding electrode conductor
7.25 Replace heat cable in soil or concrete
7.26 Replace links in fuses
7.27 Replace pilot light bulb
7.28 Replace pump motors for a well
7.29 Replace service entrance
7.30 Replace transformer
7.31 Service electric motors
7.32 Test for correct voltage
7.33 Troubleshoot a branch circuit
7.34 Loading truck

CUT-OFF

Connect/install basement heat unit
Connect ceiling heat cable to thermostat
Connect central electric heat
Connect furnace motor
Connect/install gas or oil fired heating unit
Connect individual space heaters
Connect line voltage thermostat
Connect low voltage thermostat
Connect oil fired heating unit
Connect/install wall heater
Connect wiring for boiler control system
Install baseboard heat unit
Install ceiling heat cable
Install central electric heat
Install furnace motors
Install individual space heaters
Install wall heater
Calculate and record monthly/yearly operating expenses
Develop budgets
Develop employee work schedules
Develop/maintain accounting system
Develop/maintain filing system
Develop/maintain payroll system
Establish and record pay scale and benefits for employees
Estimate cost of job
Terminate employee
Hire employee
Maintain time records
Negotiate credit
Obtain insurance
Order materials
Prepare payroll records
Raise capital
Take inventory of materials and tools
Write work orders
Make out materials list used on each job
Complete work orders

COMPUTING SERVICE LOADS

DUTY: COMPUTING SERVICE LOADS

PERFORMANCE OBJECTIVE V-TECS 01

TASK: Balance the total load per phase.

STANDARD OF PERFORMANCE OF TASK: Balance the total load per phase.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A floor plan showing the basic wiring system.
2. A copy of the National Electrical Code.
3. A copy of the requirements from the authority having jurisdiction.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Richter. **Practical Electrical Wiring.** p. 211.
Kubala. **Electricity 2.,** Unit 11.

TEACHING ACTIVITIES:
1. Explain the various uses for 115-volt and 230-volt circuits.
2. Explain the procedure for determining circuit amperage using the circuit wattage.
3. Have the students calculate sample problems involving wattage to determine circuit amperage.
4. Demonstrate the procedure for determining phase loads.
5. Have the students calculate sample problems in loading each phase equally.

CRITERION REFERENCED MEASURE:
Questions:
1. The circuit voltage between each hot conductor and the grounded neutral bus shall be:
   a. 24-volts
   b. 115-volts
   c. 236-volts
   d. 460-volts.
2. Branch circuits must be divided equally between the two hot conductors so as to:
   a. Balance load in service panel.
   b. Assure enough voltage to each circuit.
   c. Be sure wires do not overheat.
   d. Make sure the power panel is not overloaded.
3. What is the unit load per square foot for the general lighting load of a residence?
   a. 3 watts per square foot
   b. 5 watts per square foot
   c. 6 watts per square foot
   d. 7 watts per square foot.

PERFORMANCE OBJECTIVE V-TECS 01 (Continued)

Answers

1. b
2. a
3. a

PERFORMANCE GUIDE:

1. Omit all 240 volt circuits from this calculation; i.e., range, water heater, central heat, and air.
2. Make a list of all 120 volt circuits; i.e., lighting, small appliance, dishwasher, etc.
3. Determine the wattage of all appliances being used or to be installed from the manufacturer's data plate.
4. Calculate the wattage total per circuit.
5. Divide the total wattage per circuit by the voltage of the circuit to get the ampere per circuit. (National Electrical Code, Chapter 9 -- examples and tables).
6. Load each phase with an equal number of 120 volt circuits based on amperage.
7. Total each phase.
8. Compare totals to determine degree of balance.
9. If they do not balance, redistribute 120 volt loads on phases until approximate balance is reached.

DUTY: COMPUTING SERVICE LOADS

PERFORMANCE OBJECTIVE V-TECS 02

TASK: Calculate individual circuit load.

STANDARD OF PERFORMANCE OF TASK: The circuit load must not total more than the allowed overcurrent device ratings or the current carrying capacity of the conductors. The calculations of the individual circuit load must meet the requirements as outlined by the National Electrical Code (Chapter 9, Example 1) and the local authority having jurisdiction.

SOURCES OF STANDARD:
Tennessee Writing Team.
National Electrical Code. pp. 644-646

CONDITIONS FOR PERFORMANCE OF TASK:
1. A floor plan showing the basic wiring system.
2. A copy of the National Electrical Code.
3. A copy of the requirements from the authority having jurisdiction.
4. Unit data plate ratings of items of equipment.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local code requirements.
4. Read and interpret manufacturer's data plate information.

RESOURCES:
Mullin. **Electrical Wiring, Residential,** Unit 3.
Kubala. **Electricity 2,** Unit 11.
National Electrical Code, 1981, Section 220.

TEACHING ACTIVITIES:
1. Discuss the branch circuit rating when the load is to be continuous. (National Electrical Code, Section 220)
2. Explain how to use the manufacturer's data to determine circuit amperage.
3. Demonstrate the procedure for determining general lighting loads per square foot of floor area.
4. Have the students calculate sample problems in which circuit wattage is used to determine the number of circuits needed.
5. Explain the alternate method for calculating how many general lighting and convenience outlet circuits are required.

CRITERION REFERENCED MEASURE:
Questions:
1. What is the unit load per square foot of floor area for a residence?
   a. 3 watts
   b. 4 watts
   c. 5 watts
   d. 6 watts

PERFORMANCE OBJECTIVE V-TECS 02 (Continued)

2. The total lighting load in amperes is determined by dividing the wattage by:
    a. The circuit voltage
    b. The voltage rating of the lights
    c. The maximum allowable lamp voltage
    d. The Code circuit voltage.
3. The Code states that receptacle outlets must be installed so that no point along the floor line in any space is more than X feet, measured horizontally, from an outlet in that space.
    a. 4
    b. 5
    c. 6
    d. 8

Answers:
1. a
2. a
3. c

PERFORMANCE GUIDE:
1. Make a list of all possible equipment that is used at one time on an individual circuit.
2. Determine the wattage of all appliances being used or to be installed from the manufacturer's data plate.
3. Total the wattage on that line.
4. Divide the total wattage by the applied voltage to get the total amperage for the circuit load.
5. For light and convenience outlets not calculated as above, allow 1½ amps per outlet.

DUTY: COMPUTING SERVICE LOADS

PERFORMANCE OBJECTIVE V-TECS 03

TASK: Compute the size of service entrance conductors.

STANDARD OF PERFORMANCE OF TASK: The total calculated load must include all circuits to be installed. The calculation of the size of the service entrance conductors must meet the requirements as outlined by the National Electrical Code (Article 220 and tables in Chapter 9) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A floor plan showing the basic wiring system.
2. A copy of the National Electrical Code.
3. A copy of the requirements of the authority having jurisdiction.
4. The unit data plate ratings.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.
4. Read and interpret manufacturer's specification.

RESOURCES:
Richter. **Practical Electrical Wiring,** Chapter 13.
Mullin. **Electrical Wiring, Residential,** Unit 28.

TEACHING ACTIVITIES:
1. Explain the computation of the general lighting load using the unit load per square foot.
2. Explain the procedure used to determine the minimum number of branch circuits required for general lighting, small appliance and laundry loads.
3. Demonstrate the procedure for calculating the major appliance loads.
4. Explain the procedure for determining the minimum size feeders required for the total computed load.
5. Discuss how to determine the minimum size service neutral using the derating factor in the Code.
6. Have the students calculate sample problems in determining feeder and service neutral sizes.

CRITERION REFERENCED MEASURE:
Questions:
1. Small appliance branch circuits shall be rated at:
   a. 15-amperes
   b. 20-amperes
   c. 25-amperes
   d. 30-amperes.

PERFORMANCE OBJECTIVE V-TECS 03 (Continued)

2. The Code requires a minimum of ___ small appliance circuits.
   a. 2
   b. 2, plus one 20-ampere laundry circuit
   c. 3
   d. 2 split circuits
3. An electric range has a rating of 12 kw, the computed load would be:
   a. 12 kw.
   b. 10 kw.
   c. 8 kw.
   d. 80% of rated kw.

Answers
1. b
2. b
3. c

PERFORMANCE GUIDE
1. Calculate the general lighting load.
2. Calculate the number of branch circuits required and their load.
3. Calculate the small appliance load.
4. Calculate the laundry load.
5. Calculate the total circuit load without major appliances.
6. Calculate the circuit loads of the major appliances (range, central heat, and air conditioner).
7. Total all circuit wattage load for the total wattage of the house.
8. Divide the total wattage by the applied voltage to get the total amperes. Derate according to Chapter 9, National Electrical Code.
9. After determining the total amperes for the load, use the appropriate table from the National Electrical Code to determine entrance cable size.

DUTY: COMPUTING SERVICE LOADS

PERFORMANCE OBJECTIVE V-TECS 04

TASK: Determine how many convenience and appliance outlets should be on each separate circuit.

STANDARD OF PERFORMANCE OF TASK: In all installations the number of circuits must be sufficient to supply the load served. The number of convenience and appliance outlets must meet the requirements as outlined by the National Electrical Code (Article 220, Example 1, Chapter 9) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 40-52, 644-646

CONDITIONS FOR PERFORMANCE OF TASK:
A floor plan showing the basic wiring system.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Mullin. **Electrical Wiring, Residential.** Unit 3.
Richter. **Practical Electrical Wiring,** pp. 204-211.

TEACHING ACTIVITIES:
1. Explain the derating of each branch circuit to insure safety.
2. Have the students calculate the rating of each required branch circuit using a sample floor plan.
3. Demonstrate the procedure for determining the number of convenience outlets per circuit using 1.5-amperes per outlet.
4. Explain the Code requirement for small appliance circuits and their uses.
5. Have the students identify the 120-volt branch circuits required by the Code.
6. Have the students list the 120-volt circuits using a sample residential floor plan.

CRITERION REFERENCED MEASURE:
Questions:
1. The Code requires at least ____ small appliance circuit(s) in each residence.
   a. 2, 10-amperes
   b. 3, 15-amperes
   c. 2, 15-amperes split circuits
   d. 1, 20-amperes

2. Appliance outlets installed in a dwelling unit for laundry equipment, shall be installed within ______ feet of intended location of the laundry equipment.
    a. 4
    b. 6
    c. 8
    d. 12
3. A dwelling having a living area of 2000 square feet, would require a minimum of ______, 15-ampere lighting circuits.
    a. 3
    b. 4
    c. 5
    d. 6

Answers:
1. a
2. b
3. d

PERFORMANCE GUIDE:
1. Allocate a minimum number of appliance circuits according to the National Electrical Code.
2. Choose each circuit and follow the procedure below for determining the number of receptacle outlets required:
    a. Determine the individual branch circuit amperages.
    b. Take 80% of total branch circuit amperages.
    c. Divide the answer in step b by 1.5 to determine the number of outlets per circuit.
3. Identify required convenience/appliance outlets per circuit.
   NOTE: Refer to National Electrical Code Article 220-2c (5).

INSTALLING ELECTRICAL ENVIRONMENTAL
CONTROL COMPONENTS

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 05

TASK: Connect/install baseboard heat unit.

STANDARD OF PERFORMANCE OF TASK: The installed baseboard unit must be level, without damage to unit and surrounding structures. The connection of baseboard heat units must meet the requirements as outlined by the National Electrical Code (Article 300 and 424) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122, 290-302.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Electric baseboard heat unit
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials

ENABLING OBJECTIVE(S):
1. Identify the terminology used with baseboard electric heat units.
2. Read and interpret information given in the National Electrical Code.

RESOURCES:
Alerich, **Electrical Construction Wiring,** pp. 215-219.
Mullin, **Electrical Wiring Residential,** pp. 197-199.
National Electrical Code, 1981, Articles 424.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 215-219, **Electrical Wiring Residential,** pp. 197-199, and **National Electrical Code,** Article 424.
2. Discuss the different types of baseboard units.
3. Identify the different types of wall texture.
4. Demonstrate the use of a stud finder.
5. Have the student practice finding the stud.
6. Explain the reasons for securing the mounting screws into the stud.

CRITERION REFERENCED MEASURE:
Questions:
1. The electrical baseboard heat unit should be installed:
   a. On an inside wall
   b. Below receptacle outlets
   c. On an outside wall
   d. Supported with strapping.

PERFORMANCE OBJECTIVE V-TECS 05 (Continued)

2. What type of insulated wire is used to connect baseboard heaters?
   a. TW
   b. TFN
   c. THHN
   d. THWN.
3. What is the average recommended watts per square foot in heating calculations?
   a. 1.5
   b. 10-12
   c. 3
   d. 15

Answers:
1. c
2. a
3. b

PRACTICAL APPLICATION:
Install and secure a baseboard heater. The heater should be level and firmly secured to the wall studs. The heater must operate satisfactorily through a complete heat cycle.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Performance Guide Checklist Objective 05 to determine if the assignment was completed with at least 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read the manufacturer's installation instructions.
5. Remove heat unit from housing, if required.
6. Attach wiring to housing.
7. Place temporary spacer approximately one inch thick under each end of heater to allow for later installation of floor covering.
8. Attach housing to wall. Use a level to verify that unit is level.
9. Remove spacer.
10. Replace heat unit in housing, if unit was removed.
11. Identify conductors, make connections including equipment ground.
12. Check circuit to see if it is free of grounds using an ohmmeter.
13. Install junction box cover and all trim hardware.
14. Turn power on.
15. Assure required current draw using an ammeter.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 05 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF BASEBOARD HEATER

Student's Name ________________________________ **Date** __________

DIRECTIONS TO STUDENT: Install and secure an electric baseboard heater. Console must be level and have sufficient clearance for the carpet.

DIRECTIONS TO EVALUATOR: Instructor will observe the student using proper safety techniques. The task will be completed within reasonable amount of time and a score of 90 percent is required for competency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected the proper materials.	______	______
2.	The student observed safety precautions.	______	______
*3.	The student demonstrated correct methods for finding the wall studs.	______	______
*4.	The student secured the heater housing to the wall.	______	______
*5.	The student made necessary electrical connections.	______	______
6.	The student allowed ample time for a complete operational check.	______	______
7.	The student completed the task within a reasonable time.	______	______
8.	The student returned tools and materials to their proper locations.	______	______
9.	The student cleaned the work area upon completion.	______	______

*Required for Competency

APPROVED: YES ______ NO ______

Evaluator's Signature ________________________________ **Date** __________

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 06

TASK: Connect ceiling heat cable to thermostat.

STANDARD OF PERFORMANCE OF TASK: The current flow, as checked by an ammeter, must equal the nameplate wattage divided by the voltage. The connections of the ceiling heat cable must meet the requirements as outlined by the National Electrical Code (Article 424, Part E) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 295-298.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Power source
2. A room that has had ceiling heat cable installed.
3. The basic tool kit
4. Installation/electrical materials

ENABLING OBJECTIVE(S):
1. Identify the terminology used with line voltage thermostats.
2. Use proper tools and materials.
3. Read and interpret information given in the National Electrical Code.

RESOURCES:
Alerich, **Electrical Construction Wiring,** pp. 220-225.
National Electrical Code, 1981, Article 424, Part E.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 229-230 and **National Electrical Code,** 1981, pp. 295-298.
2. Discuss the different types of thermostats.
3. Identify the nonheating leads of the heat cable.
4. Demonstrate the locations for installing the thermostat.
5. Explain the reasons for mounting the thermostat with a receptacle box.
6. Explain the use of armored cable and other types of raceways.

CRITERION REFERENCED MEASURE:
Questions:
1. The thermostat should be located ___ ft. above the floor.
   a. 8--10
   b. 6--7
   c. 5--6
   d. 2--3

PERFORMANCE OBJECTIVE V-TECS 06 (Continued)

2. The thermostat should be mounted on or near:
   a. Outside wall
   b. Large windows
   c. Cooking appliances
   d. Inside wall.
3. What are the wiring clearances above heated ceilings and within thermal insulation?
   a. 2"
   b. 6"
   c. 8"
   d. 12"

Answers:
1. c
2. d
3. a

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Pull ends of heat cable out of wall box for thermostat.
6. Determine wattage (size) of heat cable by looking at label near end of cable.
7. Connect cable leads and power leads to thermostat.
8. Turn circuit on and using clamp on type ammeter, verify that circuit is drawing correct amount of power.
9. Complete installation of thermostat on to wall box.

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 07

TASK: Connect central electric heat.

STANDARD OF PERFORMANCE OF TASK: Disconnecting means must be type and rating designated by unit data plate. All connections must be tight. The connecting of central electric heat must meet the requirements as outlined by the National Electrical Code (Article 424 and tables in Article 312) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 290-302.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A central electric heat unit
2. A power source
3. Previously roughed in wiring
4. The basic tool kit
5. Necessary materials.

ENABLING OBJECTIVES:
1. Identify the terminology used with central electric heat.
2. Use proper test equipment and tools.
3. Read and interpret manufacturer's specifications.
4. Read and interpret information given in the National Electrical Code.

RESOURCES:
Alerich, **Electrical Construction Wiring**, pp. 209-211.
National Electrical Code, 1981, Article 424, part A.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring**, pp. 209-212, and **National Electrical Code, 1981,** pp. 290-294.
2. Discuss the different types of central electric units.
3. Explain the purpose of using a disconnect device.
4. Explain the reasons for using the low voltage thermostat.
5. Discuss the location of the disconnect.

CRITERION REFERENCED MEASURE:
Questions:
1. The branch circuit conductors supplying a resistance heater rated at 16 amperes must have a capacity of:
   a. 16 amperes
   b. 20 amperes
   c. 32 amperes.

PERFORMANCE OBJECTIVE V-TECS 07 (Continued)

2. If the conductors for a 16-ampere heater are run above a heated ceiling, the smallest type R.H. conductor permitted is:
   a. 12
   b. 10
   c. 8.
3. The disconnect means must be visible from the unit location and must not be further than:
   a. 25 ft.
   b. 75 ft.
   c. 50 ft.

Answers:
1. b
2. b
3. c

PRACTICAL APPLICATION:
Install and secure the disconnect, wire the heating unit into the disconnect. Check for proper operation through a complete heating cycle.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Performance Guide for Objective 07 to determine if the assignment was completed with at least 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions and unit data plate.
5. Identify conductors.
6. Connect cable for supply conductors to disconnect switches.
7. Connect supply conductors to line side of disconnect switch.
8. Run conduit from disconnect switch to heat unit.
9. Pull conductor of correct size and type through conduit from disconnect switch to heat unit control box.
10. Connect conductor to terminals provided inside of heat unit.
11. Connect equipment grounding conductor.
12. Connect wiring from thermostat control cable to terminals provided in electric heat unit.
13. Install cover plates on junction boxes to cover exposed wiring.
14. Check connections for shorts and grounds with ohmmeter. (Operation is usually checked by heating and air contractor).
    CAUTION: Power source disconnected when using ohmmeter.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 07 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF CENTRAL ELECTRIC HEAT

Student's Name **Date**

DIRECTIONS TO STUDENT: Install the heat unit. The unit must be installed as per manufacturer's instructions. Electrical connections should be made as per the instructions.

DIRECTIONS TO EVALUATOR: The instructor will observe student using proper safety techniques. The student is to complete the task within a reasonable time limit at a 90 percent proficiency level.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for installing the heat unit.	______	______
*4.	The student secured the heat unit.	______	______
*5.	The student secured electrical connections.	______	______
*6	The student found the proper location for mounting the heating unit.	______	______
*7.	The student mounted the heat unit and made tight electrical connections.	______	______
8.	The student finished the task within a reasonable amount of time.	______	______
9.	The student completed the task in a workmanship like manner.	______	______
10.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: YES ______ No ______

Evaluator's Signature **Date**

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 08

TASK: Connect furnace motor.

STANDARD OF PERFORMANCE OF TASK: All connections must be tight. The motor must be grounded. The connections must be in accordance with the motor manufacturer's wiring diagram and materials. The furnace motor connections must meet the requirements as outlined by the National Electrical Code (Article 110) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A furnace motor
2. A power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify types of motors used in heating units.
2. Read and interpret schematic diagrams.
3. Use proper test equipment, hand tools and materials.
4. Read and interpret the National Electrical Code.

RESOURCES:
Alerich, **Electrical Construction Wiring,** pp. 224-227.
National Electrical Code 1981, Article 110, Part A.

TEACHING ACTIVITIES:
1. Instruct the student to read **National Electrical Code,** pp. 16-24 and **Electrical Construction Wiring,** pp. 224-227.
2. Discuss the different types of motors.
3. Explain the purpose of using the disconnect device or motor controller.
4. Show how to calculate the current flow and size of controller required.
5. Demonstrate the correct rotation of the installed motor.

CRITERION REFERENCED MEASURE:
Questions:
1. What size fuse protection should a furnace motor system require that draws 6 amperes of 240 volts?
   a. 20A
   b. 30A
   c. 15A
   d. 12A

PERFORMANCE OBJECTIVE V-TECS 08 (Continued)

2. A 20-ampere AC snap switch may disconnect a 2-horsepower motor with a maximum full load current of:
   a. 16A
   b. 10A
   c. 20A.
3. Live parts of motors must be guarded if they operate at over:
   a. 150V
   b. 50V
   c. 100V.

Answers:
1. c
2. a
3. b

PRACTICAL APPLICATION:
Install and secure the motor connect to proper relay or contactor. Determine the proper rotation of the motor. Wire contactor to the disconnect. Connect supply terminals to the disconnect and prepare the unit for an operational check.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Performance Guide, Objective 08 to determine if the assignment was completed with at least 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Identify conductors and determine connections for voltage supplied.
6. Attach power cable or conduit to motor controller.
7. Connect supply conductor to terminals provided on motor controller.
8. Run conduit, cable, or wire from motor controller to furnace motor.
9. Connect conductors at motor and at motor controller using approved connectors.
10. Install cover plates on junction boxes to cover exposed wiring.
11. Turn power on.
12. Turn motor controller on.
13. Check motor rotation.
14. Check motor amps with ammeter. Amperage must be within limits set on motor data plate.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 08 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF A FURNACE MOTOR

Student's Name **Date**

DIRECTIONS TO STUDENT: Install the blower unit into the furnace. Make proper electrical connections observing correct polarity.

DIRECTIONS TO EVALUATOR: The instructor will observe for proper safety procedures. The student will complete the task in a reasonable time limit with a 90 percent proficiency level.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected proper materials.	________	________
2. The student used safety precautions.	________	________
3. The student demonstrated two methods for locating and installing blower unit.	________	________
*4. The student secured blower unit.	________	________
*5. The student secured electrical connections.	________	________
*6. The student found the proper location for mounting a blower unit.	________	________
*7. The student mounted the blower unit and completed electrical connections to motor.	________	________
8. The student finished the task within a reasonable amount of time.	________	________
9. The student completed the task in a workmanship like manner.	________	________
10. The student dismantled the project and returned the materials to their proper places.	________	________

*Required for competency

APPROVED: YES ______ NO ______

Evaluator's Signature **Date**

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 09

TASK: Connect/install gas or oil fired heating unit.

STANDARD OF PERFORMANCE OF TASK: The connections must be tight and at designated points using approved connectors to meet appropriate codes. The heater must provide heat equal to its rated capacity as evidenced by thermostat control unit. The disconnecting means must be the type and rating designated by the unit data plate and readily accessible. The connections and installation of the gas or oil fired heating units must meet the requirements as outlined by the National Electrical Code (Article 110, 300, and 310) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 113-122, 124-161.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A gas or oil fired heating unit
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the terminology used with central heat units.
2. Use hand tools, test instruments and materials.
3. Read and interpret the National Electrical Code.

RESOURCES:
Alerich, **Electrical Construction Wiring,** pp. 244-253.
Mullins, **Electrical Wiring Residential,** pp. 202-205.
National Electrical Code, 1981, pp. 16-24, 113-122, 124-161.

TEACHING ACTIVITIES:
1. Instruct the students to read **Electrical Wiring Residential,** pp. 202-205, **Electrical Construction Wiring,** pp. 244-253, **National Electrical Code,** 1981, pp. 16-24 , 113-122, 124-161.
2. Discuss the different types of heating units and controls.
3. Identify the controls to be installed and connected.
4. Explain how to calculate the size of disconnect required.
5. Explain how to calculate the correct size wiring required.
6. Demonstrate procedures for connecting the thermostat to the unit.

CRITERION REFERENCED MEASURE:
Questions:
1. What voltage is used customarily for control units of an automatic draft-damper installation?
   a. 240V
   b. 24V
   c. 120V
   d. 12V

PERFORMANCE OBJECTIVE V-TECS 09 (Continued)

2. What is the smallest size of conductor that should be used for wiring 120 Volt Controls?
   a. 14 AWG
   b. 12 AWG
   c. 18 AWG
   d. 10 AWG
3. What is the smallest size conductor suitable for wiring 24-volt controls?
   a. 18 AWG
   b. 16 AWG
   c. 14 AWG
   d. 12 AWG

Answers:
1. b
2. a
3. a

PRACTICAL APPLICATION:

Install an oil fired furnace, connecting all controls. Wire furnace to disconnect, making all connections and prepare the furnace for operational check.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use Performance Guide, Objective 09 to determine if all requirements were met within 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Identify conductors.
6. Attach supply conductor cable or conduit to local unit disconnect switch.
7. Connect supply conductors to terminals provided in local disconnect switch.
8. Run appropriate conduit, wire, cable, etc., from local disconnect switch to gas heat unit.
9. Make wiring connections at local unit disconnect switch and at heat unit using ohmmeter. Check wiring to see if it is clear of grounds and shorts.
10. Make wiring connections required for thermostat control of unit.
11. Turn fuel valve off on heating unit.
12. Turn power on for heating unit.
13. Follow unit directions for lighting pilot light.
14. After amount of time specified by manufacturer, turn fuel valve on for heat unit.
15. Set thermostat to bring heat on.
16. Let the unit run for a few minutes.
17. Set thermostat to below normal setting.
18. Unit should cut off.
19. Install cover plates on junction boxes to cover exposed wiring.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 09 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF A GAS FIRED HEAT UNIT

Student's Name **Date**

DIRECTIONS TO STUDENT: Install the heating unit as per the manufacturer's instructions and make electrical connections as per manufacturer's instructions.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety precautions. The student is to complete task within reasonable amount of time at a 90 percent proficiency level.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected proper materials.	______	______
2. The student used safety precautions.	______	______
3. The student demonstrated two methods for mounting and installing the unit.	______	______
*4. The student secured the heat unit.	______	______
*5. The student secured electrical connections.	______	______
*6. The student found the proper location for mounting the heat unit.	______	______
*7. The student mounted the heat unit and made tight electrical connections.	______	______
8. The student finished the task within a reasonable amount of time.	______	______
9. The student completed the task in a workmanship like manner.	______	______
10. The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: YES ______ NO ______

Evaluator's Signature **Date**

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 10

TASK: Connect line voltage thermostat.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using approved connectors. Thermostat must control the unit it is attached to as evidenced by cycling on and off at its set point. The thermostat must have an amperage rating equal to or higher than the connecting load.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A line voltage thermostat
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the terminology associated with thermostats.
2. Use schematic diagrams furnished with thermostat.
3. Use hand tools test instruments and materials.
4. Read and interpret the National Electrical Code.

RESOURCES:
Alerich, **Electrical Construction Wiring,** pp. 223-224.
Mullin, **Electrical Wiring Residential,** p. 196.
National Electrical Code, 1981, Article 424.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 223-224. **Electrical Wiring Residential,** p. 196. **National Electrical Code,** Article 424.
2. Discuss the different types of thermostats.
3. Explain how to determine the position of installation.
4. Explain how to calculate the current draw.
5. Demonstrate the correct procedures for connecting the thermostat.

CRITERION REFERENCED MEASURE:
Questions:
1. The line voltage thermostat is mounted:
   a. Flush
   b. In a receptacle
   c. With #18 AWG.
2. Which thermostat must pass full current of the connected heater?
   a Line voltage
   b. Low voltage
   c. Heat/cool.

PERFORMANCE OBJECTIVE V-TECS 10 (Continued)

3. If a thermostat is rated at 5000 watts, 240 volts, the current is:
   a. 21.8A
   b. 41.7A
   c. 20.8A
   d. 10.4A.

Answers:
1. b
2. a
3. c

PRACTICAL APPLICATION:
Install a line thermostat, connecting thermostat leads to furnace and supply conductor to the thermostat. Prepare the unit to operational check.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Performance Guide, Objective 10 to determine if all requirements were met with 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Attach supply cable or conduit to box for thermostat.
6. Identify conductors.
7. Connect supply conductors to line terminals of thermostat.
8. Connect load conductors to load side of thermostat.
9. Attach thermostat to box provided for it.
10. Turn power on.
11. Set thermostat to the desired temperature.
12. Observe operation through at least one cycle.
13. Turn power off or leave thermostat set for normal operation of equipment as per instruction of owner.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 10 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF LINE VOLTAGE THERMOSTAT

Student's Name ______________________ **Date**

DIRECTIONS TO STUDENT: The student will mount a junction box. The box must be flush with finished wall. The electrical connections must be neat and tight.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety techniques. The student should complete task within reasonable time limit at a 90 percent proficiency level.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected proper materials.	______	______
2. The student used safety precautions.	______	______
3. The student demonstrated two methods for finding proper location for junction box.	______	______
*4. The student secured junction box.	______	______
*5. The student secured electrical connections.	______	______
*6. The student found the proper location in mounting a junction box.	______	______
*7. The student mounted the thermostat.	______	______
8. The student finished the task within a reasonable amount of time.	______	______
9. The student completed the task in a workmanship like manner.	______	______
10. The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: YES _____ NO ______

Evaluator's Signature ______________________ **Date**

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 11

TASK: Connect low voltage thermostat.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using methods and connectors suitable for conditions encountered. The thermostat must be mounted so that it is level and plumb. The heat anticipator adjustment must be set to match current rating of device being controlled.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Low voltage thermostat
2. Power source
3. Previously roughed in low voltage wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the difference between line and low voltage thermostats.
2. Use a schematic to wire low voltage thermostat.
3. Determine the position and location of installation.

RESOURCES:
Alerich, **Electrical Construction Wiring,** pp. 220-223.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 220-223.
2. Demonstrate the method of connecting the conductors.
3. Identify the proper conductors to be used.
4. Explain how to calculate the circuit current draw.
5. Demonstrate the procedures for mounting the thermostat.

CRITERION REFERENCED MEASURE:
Questions:
1. The low voltage thermostat is installed above the floor:
   a. 60 inches
   b. 48 inches
   c. 6 inches
   d. In the heater.
2. The low voltage operates on:
   a. 120 volts
   b. 12 volts
   c. 24 volts
   d. 240 volts.
3. The low voltage thermostat is connected with:
   a. 12 AWG
   b. 20 AWG
   c. 14 AWG
   d. 18 AWG.

PERFORMANCE OBJECTIVE V-TECS 11 (Continued)

Answers:
1. a
2. c
3. d

PRACTICAL APPLICATION:
Install a low voltage thermostat making necessary connections, using proper color code.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Performance Guide, Objective 11 to determine if all requirements were met with 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Remove thermostat from shipping carton.
5. Read manufacturer's installation instructions.
6. Remove approximately 3/4-inch insulation from each conductor.
7. Connect conductors to thermostat using methods and connectors suitable for conditions encountered, also observing color coding of wiring.
8. Attach thermostat to structure or designated point on equipment.
9. Determine that thermostat has been installed level and plumb.
10. Set heat anticipator adjustment to match current rating of device being controlled.
11. Install all trim and cover plates.
12. Turn power on.
13. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 11 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF LOW VOLTAGE THERMOSTAT

Student's Name _______________ Date _______________

DIRECTIONS TO STUDENT: Install and secure the thermostat. The thermostat must be 60" from the floor and level.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety procedures. The student will complete the task within reasonable time limit at a 90 percent proficiency limit.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for locating proper location to install thermostat.	______	______
*4.	The student secured electrical connections.	______	______
*5.	The student secured and leveled thermostat.	______	______
*6.	The student found the proper location for mounting the thermostat.	______	______
*7.	The student mounted the low voltage thermostat.	______	______
8.	The student finished the task within a reasonable amount of time.	______	______
9.	The student completed the task in a workmanship like manner.	______	______
10.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: YES _____ NO _____

Evaluator's Signature _______________ Date _______________

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 12

TASK: Connect/install wall heater.

STANDARD OF PERFORMANCE OF TASK: The connections must be made using approved connectors. The heater must be installed at specified location and grounded. The heater must provide heat equal to its capacity. The installation of the wall heater must meet the requirements as outlined by the National Electrical Code (Article 110, 300, and 310) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 113-122, 124-161.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A wall heater
2. A power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the different types of wall heaters.
2. Use hand tools and materials.
3. Read and interpret a schematic and instructions furnished with the heater.
4. Read and interpret the National Electrical Code.
5. Determine the proper location to install the unit.

RESOURCES:
Alerich, **Electrical Construction Wiring,** p. 214.
National Electrical Code, 1981, Article 110, 300 and 310

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** p. 214. **National Electrical Code, 1981,** Article 424.
2. Discuss the types of wall units.
3. Demonstrate the method for finding the wall studs.
4. Explain how to determine the position for the installation.
5. Demonstrate the correct procedures for connecting the conductors to the wall unit.

CRITERION REFERENCED MEASURE:
Questions:
1. The bottom of the box should be located approximately ___ inches from the floor.
   a. 60
   b. 12
   c. 48
   d. 10

2. The heater is controlled by _____ _____ thermostats and limit switches.
   a. Built-in
   b. Circuit breakers
   c. Fuse links
   d. Plug-in.
3. Wall heaters are most often supplied by:
   a. Wall receptacle
   b. Individual circuits
   c. From the lighting circuit.

Answers:
1. d
2. a
3. b

PRACTICAL APPLICATION:
Install and secure a wall heater. Unit must be between wall studs and flush with finished dry wall.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Checklist Performance Objective 12 to determine if the assignment was completed with at least 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Remove heating coils from housing.
6. Attach cable to housing.
7. Attach housing to structure.
8. Identify conductors.
9. Remove only sufficient insulation to accept connector.
10. Connect heater leads to power source.
11. Connect ground to grounding terminal.
12. Install heater in housing.
13. Install trim.
14. Turn power on.
15. Observe heater coils to see if they turn red or test heater performance with ammeter.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 12 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF THE WALL HEATER

Student's Name ____________________ Date ________

DIRECTIONS TO STUDENT: Install and secure a wall heater. Heater housing must be flush with the finished wall. Electrical connections must be tight.

DIRECTIONS TO EVALUATOR: Instructor will observe the student using proper safety procedures. The student is to complete task within reasonable time limit at a 90 percent proficiency level.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for locating proper location.	______	______
*4.	The student secured heater housing.	______	______
*5.	The student secured electrical connections.	______	______
*6.	The student found the proper location for mounting heating unit.	______	______
*7.	The student mounted the heat unit and made tight electrical connections.	______	______
8.	The student finished the task within a reasonable amount of time.	______	______
9.	The student completed the task in a workmanship like manner.	______	______
10.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: YES _____ NO _____

Evaluator's Signature ____________________ Date ________

DUTY: INSTALLING ELECTRICAL ENVIRONMENTAL CONTROL COMPONENTS

PERFORMANCE OBJECTIVE V-TECS 13

TASK: Install ceiling heat cable.

STANDARD OF PERFORMANCE OF TASK: Cable installations must be inspected and approved by authority having jurisdiction before being covered. Cables must not be closer than 8" to any metal object, box, pipe, vent, etc. Non-heating leads must be routed back to thermostat location a minimum of six inches to be left in box. The non-heating loads must not be cut or shortened. The installation of ceiling heat cable must meet the requirements as outlined by the National Electrical Code (Article 424) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 290-302.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A ceiling heat cable
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the terminology associated with ceiling heat cables.
2. Use instruction and schematics furnished with the heat cable.
3. Use hand tool and materials.
4. Read and interpret the National Electrical Code.

RESOURCES:
Alerich, **Electrical Construction Wiring,** pp. 229-239.
National Electrical Code, 1981, pp. 290-302.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 229-239 and **National Electrical Code,** 1981, pp. 290-302.
2. Explain how to determine the area of the location for installation of heat cable.
3. Determine how to prepare the ceiling for installing heat cables.
4. Show how to prepare the wall for the thermostat installation.
5. Demonstrate the method of routing the non-heat conductors.
6. Demonstrate continuity testing in the checking of the cable.

CRITERION REFERENCED MEASURE:
Questions:
1. Nonheating leads of 240-volts heating cable are:
   a. Yellow
   b. Blue
   c. Red
   d. White.

PERFORMANCE OBJECTIVE V-TECS 13 (Continued)

2. The separation between heating cables and an outlet box must be at least:
   a. 8 inches
   b. 2 inches
   c. 6 inches
   d. 10 inches
3. The minimum length of nonheating leads furnished for a heating panel is:
   a. 7 ft.
   b. 8 in.
   c. 3 ft.
   d. 6 in.

Answers:
1. c
2. a
3. a

PRACTICAL APPLICATION:
Install and secure a ceiling heat cable. The cable must be installed in accordance with the National Electrical Control and manufacturer's instructions.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Performance Guide Objective 13 to determine if the assignment was completed with at least 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read and be familiar with the requirements of Article 424 of the National Electrical Code.
5. Read manufacturer's installation instructions.
6. Determine from manufacturer's instructions or electrical floor plan that the cable supplied is the correct size for the rooms to be heated.
7. Determine the space (at least 1½") between cable runs.
8. Attach cable only to gypsum board, plaster lath, or other similar fire resistant non-conductive materials. Cable is to be strapped or otherwise secured a minimum of every 16 inches.
9. Run feeder cable from thermostat location through wall and/or floor partition back to distribution panel.
10. When all of cable has been attached to ceiling, notify authority having jurisdiction that installation is ready for inspection.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 13 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF A CEILING HEAT CABLE

Student's Name ______________________ **Date** __________

DIRECTIONS TO STUDENT: Install the heat cable as per manufacturer's instructions, spacing must be observed.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety procedures. The task must be completed within a reasonable time limit and at a 90 percent proficiency level.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for locating cable routing.	______	______
*4.	The student secured heat cable.	______	______
*5.	The student secured thermostat conductors.	______	______
*6.	The student found the proper location for mounting heat cable.	______	______
*7.	The student mounted the heat cable and connected thermostat.	______	______
8.	The student finished the task within a reasonable amount of time.	______	______
9.	The student completed the task in a workmanship like manner.	______	______
10.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: YES _____ NO _____

Evaluator's Signature ______________________ **Date** __________

INSTALLING LIGHTING FIXTURES

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 14

TASK: Install/connect fan controlled by switch.

STANDARD OF PERFORMANCE OF TASK: The connections must be made using methods and connectors suitable for conditions encountered. Connections must be tight. The switch must turn the fan off when in off position and on when in on position. The installation of the fan controlled by a switch must meet the requirements as outlined by the National Electrical Code (Articles 110, 300, and 310) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 113-122, 124-161.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Fan
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the various types of fans.
2. Read and interpret wiring diagrams and instructions furnished with the fan.
3. Use hand tools and materials.
4. Read and interpret the National Electrical Code.

RESOURCES:
Alerich, **Electrical Construction Wiring,** pp. 108-112.
Mullin, **Electrical Wiring Residential,** pp. 38-40.
National Electrical Code, 1981, pp. 16-24, 113-122, 124-161.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 108-112, **Electrical Wiring Residential,** pp. 38-40, **National Electrical Code,** pp. 16-24, 113-122, 124-161.
2. Discuss how to determine the location for installing the fan.
3. Discuss how to prepare the location for installation.
4. Demonstrate the method of routing and connecting the switch circuit.
5. Demonstrate correct procedure for connecting supply conductors.
6. Explain how to prepare the installation for an operational check.

CRITERION REFERENCED MEASURE:
Questions:
1. The switching circuit should always be in the _________ conductor.
   a. green
   b. white
   c. black

PERFORMANCE OBJECTIVE V-TECS 14 (Continued)

2. The hot conductor should always be:
   a. Black
   b. White
   c. Green.
3. The neutral conductor is:
   a. Green
   b. Black
   c. White.
4. The switch loop should be connected to the __________ conductor of the line and the fan.
   a. black
   b. green
   c. white

Answers:
1. c
2. a
3. c
4. a

PRACTICAL APPLICATION:

Remove the ceiling light and install the ceiling fan. The fan must be balanced and controlled by a wall switch.

METHOD OF EVALUATING THE PRACTICAL APPLICATION:

Use Performance Guide Objective 14 to determine if the assignment was completed with at least 90 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Remove approximately 3/4-inch insulation from each conductor.
6. Make wiring connections.
7. Fasten ground wire.
8. Attach fan to mounting brackets.
9. Turn power on.
10. Check fan for correct operation.
11. Assure required current drain.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 14 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF A CEILING FAN AND CONTROL

Student's Name ______________________________ **Date** __________

DIRECTIONS TO STUDENT: Install and secure mounting boxes. Make electrical connections to switch and fan. Secure switch and fan.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety procedures. The task must be completed at a 90 percent proficiency and within a reasonable time limit.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for finding the center of the room.	______	______
*4.	The student secured fan and switch boxes.	______	______
*5.	The student secured electrical connections.	______	______
*6.	The student found the proper location for mounting fan and switch boxes.	______	______
*7.	The student mounted the fan and switch making proper electrical connections.	______	______
8.	The student finished the task within a reasonable amount of time.	______	______
9.	The student completed the task in a workmanship like manner.	______	______
10.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: YES _____ NO _____

Evaluator's Signature ______________________________ **Date** __________

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 15

TASK: Connect/install flood lights.

STANDARD OF PERFORMANCE OF TASK: Lights must burn when switch is turned on. Flood lights must be controlled by at least one switch. Outlet box must be mounted securely. The installation of flood lights must meet the requirements as outlined by the National Electrical Code (Articles 110, 300, and 310) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code. pp. 16-24, 113-122, 124-161.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Flood lights
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify electrical terminology for outdoor lighting.
2. Determine the proper tools and materials to be used.
3. Read and interpret blue prints.
4. Read and interpret the National Electrical Code.

RESOURCES:
Mullin. **Electrical Wiring Residential,** pp. 72-76.
The National Electrical Code, Article 310.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Wiring Residential,** pp. 72-76 and **National Electrical Code,** Article 310.
2. Discuss the different uses of weather proof lighting systems.
3. Identify the different types of flood lights.
4. Identify the different locations of flood lights.
5. Demonstrate procedures for installing flood lights.
6. Have student discuss why proper installation is important.

CRITERION REFERENCED MEASURE:
Questions:
1. Flood lights are used for:
   a. Security
   b. Decorative
   c. Both a and b
   d. Neither a nor b.

PERFORMANCE OBJECTIVE V-TECS 15 (Continued)

2. Shrub and tree lights should operate from:
   a. 24V
   b. 12V
   c. 120V
   d. 240V.
3. The flood lamps in your reference assignment are ________ watt PHR reflectors.
   a. 150
   b. 75
   c. 100
   d. 300

Answers:
1. c
2. b
3. a

PRACTICAL APPLICATION:
Install a decorative lighting system from the materials furnished. Calculate total amperes required and connect to proper transformer and circuit breaker.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Checklist Performance Objective 15 to determine that the objective was met with 90 percent proficiency.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Unfold conductors from box.
5. Remove approximately 3/4-inch insulation from each conductor.
6. Read manufacturer's installation instructions for flood lights.
7. Connect white wires from flood lights to white wires extending from wiring device with approved connectors.
8. Attach black wires of fixture to the switch leg. Complete other circuit connections as required.
9. Connect ground wire to ground terminal.
10. Attach flood light to box using supplied screws.
11. Install lamps.
12. Turn power on.
13. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 15 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF FLOOD LIGHTS

Student's Name _______________ **Date** _______________

DIRECTIONS TO STUDENT: Install three flood lights to decorate shrubs. Use correct transformer, lamps and circuit breaker.

DIRECTIONS TO EVALUATOR: The instructor will observe for safety and proper material usage. The task should be complete within a reasonable time limit with 90 percent proficiency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected proper materials.	____	____
2. The student used safety precautions.	____	____
3. The student demonstrated two methods for finding proper installation location.	____	____
*4. The student secured the transformer.	____	____
*5. The student secured the lamp fixtures.	____	____
*6. The student found the proper location for mounting lamp fixtures.	____	____
*7. The student mounted the transformer, fixtures and made necessary electrical connections.	____	____
8. The student finished the task within a reasonable amount of time.	____	____
9. The student completed the task in a work-manship like manner.	____	____
10. The student dismantled the project and re-turned the materials to their proper places.	____	____

*Required for competency

APPROVED: YES _____ NO _____

Evaluator's Signature _______________ **Date** _______________

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 16

TASK: Connect/install lighting dimmer system.

STANDARD OF PERFORMANCE OF TASK: The dimmer system must be installed at the specified location and must operate within predetermined tolerances. Connections must be tight. The installation of a lighting dimmer system must meet the requirements as outlined by the National Electrical Code (Article 380) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 238-241.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A lighting dimmer system
2. Power Source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the rotary dimmer switch.
2. Determine tools and materials to be used.
3. Identify the techniques for installation points.

RESOURCES:
Mullin, **Electrical Wiring Residential,** pp. 97-99.
Alerich, **Electrical Construction Wiring,** pp. 126-127.
National Electrical Code, 1981, Article 520-25, pp. 70-463.

TEACHING ACTIVITIES:
1. Instruct the students to read **Residential Wiring,** pp. 97-99. **Electrical Construction Wiring,** pp. 126-127. **National Electrical Code,** Article 520- 25.
2. Discuss different uses for dimmers.
3. Identify different types of dimmers.
4. Demonstrate procedures used to find installation points.
5. Have students practice finding the center points in given areas.
6. Have students discuss why proper installation is important.

CRITERION REFERENCED MEASURE:
Questions:
1. How are modern residential light dimming circuits controlled?
   a. Step switch
   b. Rheostat
   c. SCR.

PERFORMANCE OBJECTIVE V-TECS 16 (Continued)

2. How many wires must be installed between an incandescent lamp and its dimmer control?
   a. 2
   b. 3/Ground
   c. 3
   d. 2/Ground
3. What type dimmer switch is used with a 3-way switch?
   a. SPST
   b. SPDT
   c. DPDT
   d. 3-way Dimmer.

Answers:
1. c
2. b
3. d

PRACTICAL APPLICATION:

Install and secure a dimmer switch. Dimmer must control the light from brilliance to off.

METHODS OF EVALUATING PRACTICAL APPLICATION:

Use Checklist Performance Objective 16 to determine if the assignment was completed to the task standard of 90 percent proficiency.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Examine the dimmer to be sure it is the proper type and size for the application (fluorescent or incandescent).
6. Examine the mounting boxes and circuit conductors to be sure they are correct.
7. Make the wiring connections: circuit and grounding.
8. Install the switches and dimmers with the mounting hardware.
9. Turn power on.
10. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 16 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF A LIGHT DIMMING SYSTEM

Student's Name ____________________ **Date** __________

DIRECTIONS TO STUDENT: Install and secure a rotary dimmer. The dimmer must be installed as per manufacturer's instructions.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety procedures. The task must be completed within reasonable time limit with 90 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.		
2.	The student used safety precautions.		
3.	The student demonstrated two methods for locating position to mount dimmer.		
*4.	The student secured the electrical connections.		
*5.	The student secured the dimmer control.		
*6.	The student found the proper location for mounting the dimmer.		
*7.	The student mounted the dimmer making proper electrical connections.		
8.	The student finished the task within a reasonable amount of time.		
9.	The student completed the task in a workmanship like manner.		
10.	The student dismantled the project and returned the materials to their proper places.		

*Required for competency

APPROVED: YES _____ NO _____

Evaluator's Signature ____________________ **Date** __________

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 17

TASK: Install/connect heat-a-vent light.

STANDARD OF PERFORMANCE OF TASK: The unit must be installed with clearance from frame work as recommended by the manufacturer. All connections must be tight and suitable for the purpose. The heat, vent, and light must be controlled by separate switch functions. Correct polarity must be maintained. The installation of the heat-a-vent light must meet the requirements as outlined by the National Electrical Code (Article 110, 300, and 310) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 113-122, 124-161.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Heat-a-vent light
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify heat-a-vent terminology.
2. Determine the proper tools and materials to be used.
3. Read and interpret information furnished by the manufacturer.
4. Read and interpret the National Electrical Code.
5. Recall the technique of locating the ceiling point.

RESOURCES:
Mullin. **Electrical Wiring Residential,** pp. 173-175.
National Electrical Code, 1981, Articles 110, 300 and 310.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Wiring Residential,** pp. 173-175, **The National Electrical Code,** Article 300-310.
2. Discuss different usage of heat-a-vents.
3. Identify different ceiling textures.
4. Demonstrate use of the stud finder.
5. Have student practice using stud finder.
6. Have student discuss importance of locating the studs.

CRITERION REFERENCED MEASURE:
Questions:
1. The heat-a-vent fan usually operates on a wattage of:
   a. 1500W
   b. 1000W
   c. 737W
   d. 1475W.

PERFORMANCE OBJECTIVE V-TECS 17 (Continued)

2. The heat-a-vent light is connected to ______ circuit.
   a. A23
   b. A15
   c. A25
   d. A30
3. How many and what size wires are used to control the heat-a-vent fan:
   a. 3-wire #10
   b. 2-wire #14
   c. 2-wire #12
   d. 3-wire #8.

Answers:
1. d
2. a
3. c

PRACTICAL APPLICATION:

Install and secure a heat-a-vent light. Unit must be centered between ceiling joist. The unit must be flush with ceiling finish.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist Performance Objective 17 to determine if the assignment was completed with at least 90 percent proficiency.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Install the housing per instructions.
6. Attach previously run wire from power source to the housing using a cable clamp and the appropriate knockout.
7. Remove approximately 3/4-inch of insulation from each conductor.
8. Identify all conductors.
9. Make all wiring connections observing polarity.
10. Connect the ground wire.
11. Install cover plates on junction boxes to cover exposed wiring.
12. Install trim.
13. Turn power on.
14. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 17 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF THE HEAT-A-VENT LIGHT

Student's Name **Date**

DIRECTIONS TO STUDENT: Install and secure a heat-a-vent light. The unit must be centered and flush with the ceiling finish.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety procedures. The task is to be completed within a reasonable time limit with 90 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	____	____
2.	The student used safety precautions.	____	____
3.	The student demonstrated two methods for finding the center of the area.	____	____
*4.	The student secured the heat-a-vent light.	____	____
*5.	The student secured the electrical connections.	____	____
*6.	The student found the proper location for mounting the heat-a-vent light.	____	____
*7.	The student mounted the heat-a-vent light making all electrical connections.	____	____
8.	The student finished the task within a reasonable amount of time.	____	____
9.	The student completed the task in a workmanship like manner.	____	____
10.	The student dismantled the project and returned the materials to their proper places.	____	____

*Required for competency

APPROVED: YES _____ No _____

Evaluator's Signature **Date**

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DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 18

TASK: Connect/install light fixture.

STANDARD OF PERFORMANCE OF TASK: Light must burn when switch is on. Fixture must cover hole and present a finished appearance. Correct polarity must be maintained. The installation of the light fixture must meet the requirements as outlined by the National Electrical Code (Article 110, 300, 310, and 410) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 113-122, 124-161, 267-283.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Light fixture
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify electrical boxes by terminology.
2. Identify light fixture by terminology.
3. Determine the proper tools and materials to be used.
4. Read and interpret blue prints and schematics.
5. Recall the technique for locating the installation point.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 25-38.
Mullin. **Electrical Wiring Residential,** pp. 72-131.
Mix. **House Wiring Simplified,** pp. 76-77, 87-98.
The National Electrical Code, Article 410.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 25-38. **Electrical Wiring Residential,** pp. 72-131. **House Wiring Simplified,** pp. 76-77, 87-98. **The National Electrical Code,** Article 410.
2. Discuss different types of electrical light fixtures.
3. Identify different fixtures.
4. Identify different types of wall and ceiling materials.
5. Demonstrate procedures used to find installation point.
6. Have the students discuss why proper installation is important.

CRITERION REFERENCED MEASURE:
Questions:
1. What is the ampere rating of the kitchen lighting circuit?
   a. 30A
   b. 10A
   c. 20A
   d. 15A

PERFORMANCE OBJECTIVE V-TECS 18 (Continued)

2. Who is to select the lighting fixtures?
   a. Home owner
   b. Architect
   c. Electrician
3. What type of light fixtures are installed on workshop ceilings?
   a. 41 AMP fluorescent
   b. Incandescent
   c. 2 lamp fluorescent

Answers:
1. d
2. a
3. c

PRACTICAL APPLICATION:

Install and secure a light fixture. Calculate proper ampere and connect to proper circuit breaker. Check for correct operation.

METHODS OF EVALUATING PRACTICAL APPLICATION:

Use Checklist Performance Objective 18 to determine if the assignment was completed with 90 percent proficiency.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Connect fixture wire to power supply observing polarity.
6. Connect ground wire.
7. Attach fixture base to box with screws supplied.
8. Install lamps.
9. Turn power on.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 18 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF A LIGHT FIXTURE

Student's Name **Date**

DIRECTIONS TO STUDENT: Install and secure a light fixture. Work must be neat and light should work from switch locations.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety procedures. The task is to be completed within a reasonable time limit with 90 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for finding installation point.	______	______
*4.	The student secured a receptacle box.	______	______
*5.	The student secured the light fixture.	______	______
*6.	The student found the proper location for mounting a receptacle box.	______	______
*7.	The student mounted the light fixture and made necessary electrical connections.	______	______
8.	The student finished the task within a reasonable amount of time.	______	______
9.	The student completed the task in a workmanship like manner.	______	______
10.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: YES _____ NO _____

Evaluator's Signature **Date**

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 19

TASK: Install/connect photo-electric control on a light.

STANDARD OF PERFORMANCE OF TASK: The light must burn at dusk and turn off at dawn or when conditions are simulated. The installation of a photo- electric control on a light must meet the requirements as outlined by the National Electrical Code (Article 410) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 267-283.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Photo-electric control
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify terminology associated with photo-electric controls.
2. Determine the proper tools and materials to be used.
3. Recall techniques of locating installation point.
4. Read and interpret the National Electrical Code.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 128-129.
The National Electrical Code, 1981, Article 410.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 128-129, and **National Electrical Code,** Article 410.
2. Discuss the usage of photo-electric cells.
3. Identify different types of photo-electric cells.
4. Identify areas where photo-electric should be mounted.
5. Demonstrate procedures necessary to install photo-electric cell.
6. Have students discuss why proper location is important.

CRITERION REFERENCED MEASURE:
Questions:
1. One of the common uses of photo-electric cells is:
   a. Hallway light
   b. Time delays
   c. Dimmer switch
   d. Security light.

PERFORMANCE OBJECTIVE V-TECS 19 (Continued)

2. The photo-electric cell at supermarkets is used to:
   a. Open doors
   b. Operate lights
   c. Security
   d. Decorative.
3. The photo-electric cell is a ________ wire device.
   a. one
   b. two
   c. three
   d. four

Answers:
1. d
2. a
3. c

PRACTICAL APPLICATION:
Install a security light operated by a photo-electric cell. The light must operate when the cell is covered and extinguished when the cell is exposed to light.

METHODS OF EVALUATING PRACTICAL APPLICATION:
Use Checklist Performance Objective 19 to determine if the assignment was completed with a 90 percent proficiency.

PERFORMANCE GUIDE:
1. Locate light to receive photo-electric control.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Take light down.
6. Check light for a knockout that will accept the photo cell. If none exists, use drill or other means to make the desired hole.
7. Attach photo-electric control to light base.
8. Connect wire ends per manufacturer's installation instructions.
9. Hang light.
10. Turn power on.
11. Test according to manufacturer's installation instructions.
12. If instructions are not supplied:
    a. Place a dark covering over cell lens. Light should come on in approximately three minutes.
    b. Remove dark covering. Light should stop burning in approximately three minutes.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 19 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF A PHOTO-ELECTRIC CELL

Student's Name **Date**

DIRECTIONS TO STUDENT: Using the materials furnished, connect a photo-electric cell. The light must operate as per instructions.

DIRECTIONS TO EVALUATOR: Observe the student following safety procedures. The task must be completed within reasonable time limit with 90 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for installing the cell.	______	______
*4.	The student secured the photo-cell.	______	______
*5.	The student secured the lamp.	______	______
*6.	The student found the proper location for mounting photo-electric cell.	______	______
*7.	The student mounted the cell facing away from the lamp.	______	______
8.	The student finished the task within a reasonable amount of time.	______	______
9.	The student completed the task in a workmanship like manner.	______	______
10.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 20

TASK: Connect/install post lights.

STANDARD OF PERFORMANCE OF TASK: Light post must be securely anchored and vertically plumb in ground. Light must be controlled by a switch or a photo-cell or other approved means. Post lights must be grounded if metallic. Correct polarity must be maintained. The installation of post lights must meet the requirements as outlined by the National Electrical Code (Articles 110, 300, 310, and 410) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 113-122, 124-161, 267-283.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Post lights
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the terms associated with underground wiring.
2. Determine the proper tools and materials to be used.
3. Read and interpret information sheet furnished by the manufacturer.
4. Recall the techniques of locating the installation area.
5. Read and interpret the National Electrical Code.

RESOURCES:
Mullin. **Electrical Wiring Residential**, pp. 79-80.
The National Electrical Code, Articles 300 and 410.

TEACHING ACTIVITIES:
1. Instruct students to read **Electrical Wiring Residential**, pp. 79-80 and **National Electrical Code**, Articles 300-5 and 410-4.
2. Discuss the uses of conduit.
3. Explain how to determine the depth to bury the cable.
4. Demonstrate the method of installing the post.
5. Have student demonstrate the mounting and connecting of the light.
6. Have student discuss why weatherproof connections are important.

CRITERION REFERENCED MEASURE:
Questions:
1. What is the minimum depth UF cable can be buried direct?
   a. 12"
   b. 24"
   c. 18"
   d. 15"

PERFORMANCE OBJECTIVE V-TECS 20 (Continued)

2. What is the minimum depth UF cable with 2" concrete cover can be buried?
   a. 12"
   b. 18"
   c. 6"
   d. 2"
3. What sections of the code deals with grounding the post light?
   a. 410-4 (a)
   b. 300-5 (d)
   c. 250-45 (c)
   d. 250-42

Answers:
1. a
2. c
3. d

PRACTICAL APPLICATION:
Install and secure a post light, making all connections weather proof.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Checklist Performance Objective 20 to determine if the task was completed in a reasonable time limit with 90 percent proficiency.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Be sure post is well anchored.
3. Turn power off.
4. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
5. Read manufacturer's installation instructions.
6. Connect post light wire ends to power source observing polarity.
7. Connect ground wire.
8. Attach fixture to post.
9. Install lamps.
10. Turn power on.
11. Assure required operation of light.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 20 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF A POST LIGHT

Student's Name **Date**

DIRECTIONS TO STUDENT: Install and weatherproof the post light, making sure all electrical connections are secured.

DIRECTIONS TO EVALUATOR: Observe the student following safety procedures, the task should be completed within reasonable time limits and within 90 percent proficiency for minimum competency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for determining correct fixture.	______	______
*4.	The student secured the light fixture.	______	______
*5.	The student secured the electrical connections.	______	______
*6.	The student mounted the fixture and weatherproofed all connections.	______	______
7.	The student finished the task within a reasonable amount of time.	______	______
8.	The student completed the task in a workmanship like manner.	______	______
9.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 21

TASK: Install/connect power failure lighting.

STANDARD OF PERFORMANCE OF TASK: The power failure light must be located to give maximum light when activated. All connections must be tight. The light fixture must be securely fastened to structure and must burn when the power has been disrupted. The installation of the power failure lighting must meet the requirements as outlined by the National Electrical Code (Article 700) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 577-581.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Power failure lighting device
2. A power source
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the terminology used with emergency lighting systems.
2. Determine the proper tools and materials to be used.
3. Read and interpret information from blueprints and floor plans.
4. Recall technique of locating area for mounting system.
5. Read and interpret the National Electrical Code.

RESOURCES:
The National Electrical Code, 1981, Article 716.

TEACHING ACTIVITIES:
1. Instruct the student to read **The National Electrical Code,** Article 700 -- Section D, pp. 580-581.
2. Discuss the different usages of emergency lighting systems.
3. Identify the different types of systems.
4. Demonstrate procedures used to install emergency units.
5. Have students practice finding locations for installing units.
6. Have students discuss why proper installation is important.

CRITERION REFERENCED MEASURE:
Questions:
1. The emergency system controls __________ lights and all other systems for illumination.
   a. exit
   b. security
   c. hallway
   d. office

PERFORMANCE OBJECTIVE V-TECS 21 (Continued)

2. Circuits for emergency lighting must comply with the National Electrical Code Section:
    a. 700-18
    b. 700-20
    c. 700-12
    d. 700-22.
3. Items that may not be connected to the emergency system are:
    a. Furnace
    b. Appliances
    c. Random lights
    d. All of the above.

Answers:
1. a
2. c
3. d

PRACTICAL APPLICATION:
Install and secure an emergency lighting unit. The unit must be installed where maximum illumination will occur.

METHODS OF EVALUATING PRACTICAL APPLICATION:
Use Checklist Performance Objective 21 to determine that the task was completed with a 90 percent proficiency.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Attach the power failure light to the structure per manufacturer's instructions.
6. Fasten branch circuit, cable or conduit to the light.
7. Remove approximately 3/4-inch insulation from each conductor.
8. Make all electrical connections observing polarity.
9. Install all cover plates on junction boxes to cover exposed wiring.
10. Turn power on.
11. After power has been on for a time sufficient to charge the batteries, turn power off or push test switch.
12. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 21 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF POWER FAILURE LIGHTING SYSTEM

Student's Name ______________________ **Date** __________

DIRECTIONS TO STUDENT: Install an emergency lighting unit. The unit must be located near the top of the wall and must light exit signs in necessary areas.

DIRECTIONS TO EVALUATOR: Observe the student practicing safety procedures. The task must be completed in reasonable time limit with 90 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	________	________
2.	The student used safety precautions.	________	________
3.	The student demonstrated two methods for installing light failure system.	________	________
*4.	The student secured the light unit.	________	________
*5.	The student secured the electrical connections.	________	________
*6.	The student found the proper location for mounting the light failure unit.	________	________
*7.	The student mounted the emergency unit and checked for proper operation.	________	________
8.	The student finished the task within a reasonable amount of time.	________	________
9.	The student completed the task in a workmanship like manner.	________	________
10.	The student dismantled the project and returned the materials to their proper places.	________	________

*Required for competency

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ **Date** __________

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 22

TASK: Install/connect moisture resistant fixtures.

STANDARD OF PERFORMANCE OF TASK: Fixtures must be installed in the desired location. All gaskets, globes, and/or seals must be installed so the fixture will be moisture resistant. The fixture must be controlled by a switch or other means. All fixtures must be installed according to the fixture's design.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Moisture resistant fixtures
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify weatherproof fixtures by terminology.
2. Determine the proper tools and materials to be used.
3. Read and interpret manufacturer's instructions.
4. Recall technique of locating installation point.
5. Read and interpret the National Electrical Code.

RESOURCES:

Alerich. **Electrical Construction Wiring,** pp. 40-41.
Mullin. **Electrical Wiring Residential,** pp. 75, 80, 104-106, 113, 117 and 126.
National Electrical Code, 1981. Article 710.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 40-41. **Electrical Wiring Residential,** pp. 75, 80, 104-106, 113, 117 and 126. **National Electrical Code, 1981.** Article 710-8.
2. Discuss different uses of moisture fixtures.
3. Identify different moisture areas.
4. Demonstrate procedures for locating installation area.
5. Have student practice finding areas of moisture.
6. Have student discuss reason for using weatherproof fixtures in moisture laden areas.

CRITERION REFERENCED MEASURE:

Questions:
1. Outdoor fixtures must be marked suitable for:
   a. Damp locations
   b. Dry locations
   c. Wet locations.

PERFORMANCE OBJECTIVE V-TECS 22 (Continued)

2. What type of convenience outlets are found on the porch?
   a. 30A.
   b. 22OV.
   c. 20A. weather proof
   d. 24V.
3. What sections of the code cover the exterior of the garage fixtures?
   a. 210-15
   b. 210-7
   c. 210-8
   d. 210-7 and 210-8.

Answers:

1. a
2. c
3. d

PRACTICAL APPLICATION:

Install and secure porch light. The light must be a weather light located in the proper location.

METHODS OF EVALUATING PRACTICAL APPLICATION:

Use Checklist Performance Objective 22 to determine if the task is completed with a 90 percent proficiency.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Install box or fixture housing per manufacturer's installation instructions.
6. Make wiring connections observing polarity.
7. Attach lamp assembly to housing or outlet box. Make certain that all gaskets and seals are in place.
8. Turn power on.
9. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 22 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF MOISTURE RESISTANT FIXTURE

Student's Name **Date**

DIRECTIONS TO STUDENT: Install and secure a weather proof fixture. The fixture must be the correct height and properly sealed from moisture.

DIRECTIONS TO EVALUATOR: Observe the student using proper safety techniques. The student is to complete the task within reasonable amount of time with 90 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	______	______
2.	The student used safety precautions.	______	______
3.	The student demonstrated two methods for locating installation point.	______	______
*4.	The student secured a fixture.	______	______
*5.	The student secured an electrical connection.	______	______
*6.	The student found the proper location for mounting a weatherproof fixture.	______	______
*7.	The student mounted the moisture proof fixture and checked for operation.	______	______
8.	The student finished the task within a reasonable amount of time.	______	______
9.	The student completed the task in a workmanship like manner.	______	______
10.	The student dismantled the project and returned the materials to their proper places.	______	______

*Required for Competency

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: INSTALLING LIGHTING FIXTURES

PERFORMANCE OBJECTIVE V-TECS 23

TASK: Install/connect pilot light to show when appliance is on.

STANDARD OF PERFORMANCE OF TASK: Pilot light must be installed where it will be readily visible and must burn only when unit or appliance is in operation.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:

1. Pilot light
2. The unit
3. Appliance or equipment to receive the pilot light
4. Power source

   Previously roughed in wiring

6. The basic tool kit
7. Installation/electrical materials.

ENABLING OBJECTIVE(S):

1. Identify pilot light terminology.
2. Determine the proper tools and materials to be used.
3. Interpret written manufacturer's instructions furnished with pilot lamp.
4. Recall the techniques of connecting pilot light.

RESOURCES:

Mullin, **Electrical Wiring Residential,** p. 76.
Alerich, **Electrical Construction Wiring,** pp. 130-132.

TEACHING ACTIVITIES:

1. Instruct the student to read **Electrical Wiring Residential,** p. 76 and **Electrical Construction Wiring,** pp. 130-132.
2. Discuss uses for pilot lights.
3. Identify the types of pilot lights.
4. Demonstrate the methods of installing pilot lights.
5. Have students practice reading the wiring diagram.
6. Have student discuss why proper installation is important.

CRITERION REFERENCED MEASURE:

Questions:

1. Where are pilot light switches used?
   a. Living room
   b. Kitchen
   c. Bedroom
   d. Furnace room
2. What does the pilot light on the oven indicate?
   a. High
   b. Low
   c. On
   d. Broil

PERFORMANCE OBJECTIVE V-TECS 23 (Continued)

3. The switch light is illuminated when the switch is:
    a. On
    b. Off
    c. (a) and (b)
    d. (a) nor (b)

Answers:
1. d
2. a
3. b

PRACTICAL APPLICATION:
Install and secure a pilot light switch in the furnace room. The switch must illuminate when in the off position.

METHODS OF EVALUATING PRACTICAL APPLICATION:
Use Checklist for Performance Objective 23 to determine the task has been completed with a 90 percent proficiency.

PERFORMANCE GUIDE:
1. Locate appliance or equipment to receive the pilot light.
2. Locate installation point of pilot light.
3. Turn power off.
4. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
5. Read manufacturer's installation instructions.
6. Attach pilot light to appliance or equipment.
7. Run wire of correct size from load side of equipment terminals to the pilot light.
8. Connect wire ends of pilot light to wires run from load terminals.
9. Turn power on.
10. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 23 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF PILOT LIGHT SWITCH

Student's Name ______________________________ Date ____________

DIRECTIONS TO STUDENT: Install and secure a pilot switch. The switch must be installed in an area accessible from doorway.

DIRECTIONS TO EVALUATOR: Observe the student using proper safety procedures. The task must be complete within reasonable time limit with 90 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student selected proper materials.	________	________
2.	The student used safety precautions.	________	________
3.	The student demonstrated two methods for locating installation area.	________	________
*4.	The student secured the electrical connections.	________	________
*5.	The student secured the switch.	________	________
*6.	The student found the proper location for mounting the pilot switch.	________	________
*7.	The student mounted the switch and made necessary operational check.	________	________
8.	The student finished the task within a reasonable amount of time.	________	________
9.	The student completed the task in a workmanship like manner.	________	________
10.	The student dismantled the project and returned the materials to their proper places.	________	________

*Required for competency

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________________ Date ____________

INSTALLING SERVICE ENTRANCE

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 24

TASK: Ground service entrance equipment.

STANDARD OF PERFORMANCE OF TASK: Connections must be made at designated points and must be tight. The grounding of service entrance equipment must meet the requirements as outlined by the National Electrical Code (Article 250, Parts G, H, J, and K) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 97-107.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Identify and use service entrance grounding equipment.

RESOURCES:
Mullin. **Electrical Wiring, Residential,** pp. 227-231.
Richter. **Practical Electrical Wiring,** Chapter 9 and pp. 298-305.
National Electrical Code, 1981.

TEACHING ACTIVITIES:
1. Explain the purpose of the system grounding concept.
2. Illustrate what could happen if system is not grounded properly and a short-to-ground occurs.
3. Explain the National Electrical Code requirements for grounding electrode sizes and types.
4. Explain the National Electrical Code requirements for grounding electrode conductor sizes and types.
5. Have the students calculate grounding conductor sizes for various size residential services.

CRITERION REFERENCED MEASURE:
Questions:
1. Which of the following could NOT be used as a grounding electrode?
   a. 3/4-inch trade size galvanized pipe.
   b. 5/8-inch steel rod.
   c. 1/2-inch iron rod.
   d. 2 square foot metal plate, 1/2-inch thick.

PERFORMANCE OBJECTIVE V-TECS 24 (Continued)

2. What size copper grounding electrode conductor is required for a 200-ampere service entrance?
   a. AWG No. 2
   b. AWG No. 4
   c. AWG No. 6
   d. AWG No. 8
3. Which of the following copper grounding electrode conductors would require protection from physical abuse?
   a. AWG No. 2
   b. AWG No. 4
   c. AWG No. 6
   d. AWG No. 8

Answers:

1. c
2. b
3. d

PERFORMANCE GUIDE:

1. Remove meter base cover.
2. Locate all installation points.
3. Apply corrosive inhibitor if required by authority having jurisdiction.
4. Terminate grounding conductor at point designated by the authority having jurisdiction.
5. Drive ground rod or bury grounding electrode.
6. Fasten ground wire to grounding electrode with a clamp approved for direct burial.
7. Attach wire to surface of structure.
8. If a metal water system is installed, extend the grounding conductor to the water pipe.

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 25

TASK: Install circuit breakers in panel.

STANDARD OF PERFORMANCE OF TASK: Breaker must be qualified for panel and must be inserted so that they fully engage the busses and such that the load is distributed equally. The ampacity rating of the circuit breaker must not exceed that of the circuit conductors. The installation of the circuit breakers must meet the requirements as outlined by the National Electrical Code (Articles 240 and 384) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 74-83, 241-246.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Circuit breakers
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Identify and use circuit breakers by size and type.

RESOURCES:
Mullin. **Electrical Wiring, Residential,** pp. 234-236.
Richter. **Practical Electrical Wiring,** pp. 90-92.

TEACHING ACTIVITIES:
1. Explain the trip-free operation of a circuit breaker.
2. Explain the ambient temperature compensation for circuit breakers.
3. Have the students identify various circuit breakers by size and type of installation.
4. Demonstrate the procedure for installing various types of circuit breakers in the panels.
5. Demonstrate the procedure for continuity testing circuit breakers with a VOM.
6. Have the students install the various circuit breakers in the panels.
7. Have the students test the continuity of the various types of circuit breakers.

CRITERION REFERENCED MEASURE:
Questions:
1. The magnetic coil of a circuit breaker causes the breaker to trip:
   a. On an overload
   b. On a short circuit
   c. On an open circuit
   d. On high resistance.

PERFORMANCE OBJECTIVE V-TECS 25 (Continued)

2. An ambient temperature compensated circuit breaker has two elements. One element heats as a result of current passing through it and the other heats from.
   a. Eddy currents
   b. Reverse current
   c. Surrounding air only
   d. Spring tension.
3. Which of the following is NOT a standard size circuit breaker?
   a. 25 amperes
   b. 20 amperes
   c. 15 amperes
   d. 10 amperes.
4. What size circuit breaker would be used to protect a circuit wired with AWG No. 12 conductors?
   a. 20 amperes
   b. 25 amperes
   c. 30 amperes
   d. 35 amperes.

Answers:
1. a and b
2. c
3. a
4. a

PERFORMANCE GUIDE:
1. Check breaker size and type to insure that the breaker is suitable for use in panel.
2. Insert breaker in breaker box.
3. Assure continuity with VOM.

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 26

TASK: Install main service panel.

STANDARD OF PERFORMANCE OF TASK: The main service panel and installation must meet the requirements as outlined by the National Electrical Code (Articles 110, 230, 384) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 57-74, 241-246.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The main service panel with main breaker installed in panel
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Mullins. **Electrical Wiring, Residential,** pp. 221-222.
Richter. **Practical Electrical Wiring,** Chapter 17.

TEACHING ACTIVITIES:
1. Explain the importance of locating the main panel to prevent excessive voltage drop.
2. Demonstrate the procedure for installing the service panel on various wall surfaces, using different types of mounting hardware.
3. Demonstrate the procedure for installing raceways from entrance to the main service panel using different types of conduit.
4. Have the students list the parts needed to install the service panel on the different types of wall surfaces.
5. Have the students install different types of service panels using the appropriate mounting hardware.

CRITERION REFERENCED MEASURE:
Questions:
1. The service disconnecting means permitted by the National Electrical Code, shall consist of not more than ______ switches or circuit breakers mounted in a single enclosure.
   a. two, double-pole
   b. four
   c. six
   d. five

PERFORMANCE OBJECTIVE V-TECS 26 (Continued)

2. Who decides where the main service disconnect is to be located?
   a. The electrician
   b. The general contractor
   c. The local utility company
   d. Both a and c
3. The main service disconnect placement is determined by the location of the:
   a. Residential driveway
   b. Heavy concentration of loads
   c. Meter
   d. Meter and heavy concentration of loads.

Answers:

1. c
2. d
3. d

PERFORMANCE GUIDE:

1. Locate main service panel as near to the point of service entrance as possible.
2. Locate height of main disconnecting means from floor level as required by the National Electrical Code.
3. Remove knockout from main service panel.
4. Mark hole for raceway.
5. Cut hole through storm sheathing 1/2-inch larger than circle drawn for knockout.
6. Install raceway from point of entrance to main service panel.
7. Attach service panel to structure.

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 27

TASK: Install mast-type (through the roof) service entrance.

STANDARD OF PERFORMANCE OF TASK: All work must be done in a manner to prevent water from entering the system. Service mast must also be able to support service drop. The roof clearances, size and type of conduit must meet the requirements of the National Electrical Code (Article 230, Part C and Article 310) and the local authority having jurisdiction. Service entrance conductors must not be shorted or grounded and be the correct size and type.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 59-60, 124-161.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Necessary equipment and the basic tool kit
2. One roof flange (sized to conduit)
3. Weatherproof weatherhead
4. Fittings.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Rockis. **Residential Wiring,** Unit 11.
Colvin. **Electrical Wiring,** pp. 127-132.

TEACHING ACTIVITIES:
1. Explain the purpose of the mast type service entrance.
2. Demonstrate the procedure for the installation of the meter base as spotted by the power supplier.
3. Demonstrate the procedure for the routing of the mast from meter base through the roof.
4. Demonstrate the procedure for installing the roof flange and weatherhead.
5. Demonstrate the proper procedure for placing the service entrance conductors into the conduit using wire lubricants.
6. Demonstrate the testing procedures for shorts and grounds in the service entrance conductors.
7. Have the students list all the parts needed to install a mast-type service entrance.
8. Have the students assemble a mast-type service entrance, using accepted practices and testing procedures.

PERFORMANCE OBJECTIVE V-TECS 27 (Continued)

CRITERION REFERENCED MEASURE:

Questions:

1. The service entrance weatherhead should be installed so that the service drop conductors are at least _____ feet above ground level.
   a. 15
   b. 12
   c. 10
   d. 8
2. The meter socket is normally mounted:
   a. A maximum of 7 feet to top of meter
   b. A minimum of 4 feet above service entrance ell
   c. At eye level, 66 inches above grade
   d. At the height of the owner.
3. Conduit passing from the outside to the inside must be sealed:
   a. To prevent rain water from entering conduit
   b. To prevent rodents from entering the building
   c. To prevent the installation of too many wires
   d. To prevent air circulation through the conduit.

Answers:

1. c
2. c
3. d

PERFORMANCE GUIDE:

1. Request power supplier to spot meter base.
2. From meter base, construct a vertical line to the roof overhang.
3. Locate center of hole on soffit board.
4. Bore a hole slightly larger than conduit, through soffit board, decking, and roofing.
5. Install conduit through roof down to meter base.
6. Tighten conduit into hub of meter base.
7. Fasten conduit to wall with rigid conduit straps.
8. Install roof flange around conduit, secure to roof.
9. Run service entrance conductors down to meter base and leave enough of free conductor from top of conduit to meet local requirements.
10. Connect service entrance conductors to line lugs of meter base and tighten securely.
11. Run conductors from load lugs of meter base to disconnect in main service panel.
12. Install weatherhead with one wire per hole in weatherhead.
13. Where conduit enters soffit board, seal with waterproof sealant.
14. Test service entrance conductors for shorts or grounds.

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 28

TASK: Install main service disconnect.

STANDARD OF PERFORMANCE OF TASK: The main service disconnect must be installed so that it simultaneously disconnects all ungrounded service entrance conductors. The main service disconnect must be qualified for use in the service entrance and must be of the proper amperage. The main service disconnect must meet the requirements as outlined by the National Electrical Code (Article 230, Part H and Article 110 and 250) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 65-67, 83-110.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The main service disconnect
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Richter. **Practical Electrical Wiring,** pp. 225-230.
Mullin. **Electrical Wiring, Residential,** pp. 223-227.
National Electrical Code, 1981, Article 230.

TEACHING ACTIVITIES:
1. Explain the procedure for locating the main service disconnect using the **National Electrical Code,** Article 230.
2. Demonstrate the procedure for installing the main service disconnect enclosure to the wall surface using different types of mounting fixtures.
3. Have the students list all of the parts necessary to install a main service disconnect.
4. Have the students assemble a main service disconnect enclosure using typical material for their area.
5. Demonstrate the trimming out and testing of the main service disconnect.

CRITERION REFERENCED MEASURE:
Questions:
1. The service disconnecting means shall be installed at a readily accessible location nearest:
    a. The point of attachment of the service drop
    b. The point of entrance of the service conductors
    c. The grounding electrodes
    d. The meter location.

PERFORMANCE OBJECTIVE V-TECS 28 (Continued)

2. The purpose of the main disconnecting means is to disconnect all conductors in the building from the service entrance conductors with no more than _______ hand operations.
   a. two
   b. four
   c. six
   d. eight.
3. The meter base should be mounted on the outside wall surface:
   a. At eye level, 66" above grade
   b. Directly above main service disconnect
   c. On the street side of the mobile home
   d. Not more than 30 feet from the mobile home.

Answers:
1. b
2. c
3. c

PERFORMANCE GUIDE:
1. Locate installation point for the main service disconnect.
2. Attach the main service disconnect to the building structure.
3. Attach feed cables into main service disconnect.
4. Connect service conductors to the line lugs of the disconnect.
5. Connect load conductors to load lugs of the disconnect.
6. Terminate load conductors at load being served.

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 29

TASK: Install/connect mobile home service.

STANDARD OF PERFORMANCE OF TASK: Service must meet the unit data plate ratings of the mobile home. All wiring must be inspected by the local inspector. Connections must be made at designated points and must be tight using approved connectors. The installation and connections of a mobile home service must meet the requirements as outlined by the National Electrical Code (Article 550, 300-5 and 250) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 83-110, 114-115, 477-490.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret the local Code requirements.
3. Read and interpret the manufacturer's mobile home data plate.

RESOURCES:
Richter. **Practical Electrical Wiring,** pp. 446-452.
Rockis. **Residential Wiring,** pp. 183-184.

TEACHING ACTIVITIES:
1. Have the students read and discuss textbook **Practical Electrical Wiring,** pp. 446-452 and **Residential Wiring,** pp. 183-184.
2. Explain how a wiring permit is obtained from the local authority using standard procedures.
3. Have the students go through the actual procedure for obtaining a wiring permit for a sample installation.
4. Demonstrate the installation procedures for a sample mobile home service.
5. Have the students install the sample mobile home service using the locally approved materials and methods.
6. Have the local inspector inspect the installation, explaining each step in the inspection process.

CRITERION REFERENCED MEASURE:
Questions:
1. The ampere rating of the mobile home service can be found:
   a. By calculating the floor area and multiplying by the unit load per square foot
   b. By installing only 200 ampere services
   c. On the metal nameplate near the feeder entrance
   d. On the inside corner of the guest closet.

PERFORMANCE OBJECTIVE V-TECS 29 (Continued)

2. The wiring of the mobile home shall be subjected to a _____ -minute, _____ -volt, dielectric test between live parts and the mobile home ground.
   a. 1, 600
   b. 1, 900
   c. 2, 600
   d. 2, 900
3. The grounded circuit conductor (neutral) shall be _____ to/from the grounding conductors, equipment enclosures and other grounded parts.
   a. connected
   b. bonded
   c. insulated
   d. welded

Answers:
1. c
2. b
3. c

PERFORMANCE GUIDE:
1. Request power company representative to field check site before wiring is begun.
2. Obtain a wiring permit.
3. Erect a creosoted or treated pole as specified by local power service representative.
4. Anchor service pole opposite pull of service drop with approved equipment.
5. Open a trench to a depth to accommodate the installation method.
6. Attach meter base to pole at proper height (5'-6') above finish grade.
7. Install conduit nipple from meter base to waterproof disconnecting means.
8. Attach disconnecting means enclosure to pole.
9. Install conduit bushing on conduit inside meter base.
10. Attach conduit from meter base to top of pole.
11. Strap conduit to pole.
12. Run conductors from meter base to extend at least 16" outside of weatherhead.
13. Install weatherhead.
14. Drive ground rod or bury grounding electrode.
15. Fasten grounding electrode conductor to grounding electrode.
16. Run conductor from meter base to rain tight disconnecting means.
17. Install approved raceway from disconnecting means on pole to bottom of ditch for service entrance.
18. Install conduit bushing on conduit if applicable.
19. Install approved raceway from distribution panel in mobile home to bottom of trench.
20. Install conduit bushings if applicable.
21. Run entrance conductors from service pole disconnect to distribution panel in mobile home.
22. Make all wiring connections.
23. Insure that a grounding conductor from grounding terminal of mobile home distribution panel to frame of home is intact.
24. Have service inspected.
25. Fill trench with rock free dirt. If rocks exist, follow local power company rules for coverage.

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 30

TASK: Install service entrance cable to service drop.

STANDARD OF PERFORMANCE OF TASK: Service entrance cable must not be installed on masonry or metallic services and must be secured within twelve inches of termination and not to exceed intervals of 4½ feet. The installation of the service entrance must meet the requirements as outlined by the National Electrical Code (Article 230-54. 230-55. 338) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 64, 137-188.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A service entrance cable
2. A previously installed meter base
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring**, pp. 122-125.
Alerich. **Electrical Construction Wiring**, pp. 264-266.
Richter. **Practical Electrical Wiring**, pp. 291-293.

TEACHING ACTIVITIES:
1. Describe the commonly used service entrance (SE) cables using samples of each.
2. Explain the preparation procedures to follow when using aluminum cable.
3. Calculate the length of the SE cable from weatherhead to the meter base.
4. Demonstrate the removal of the SE cable outer covering.
5. Demonstrate the preparation of the neutral wire for installation at the weatherhead and the meter base.
6. Demonstrate the installation of the SE cable in the weatherhead.
7. Demonstrate the procedure for installing the weatherhead above the service drop attachment point.
8. Demonstrate the installation procedures for securing the SE cable to the wall surface.
9. Demonstrate the procedures for installing the water tight connector at the meter base.
10. Demonstrate the procedure for installing the SE cable to the meter base connectors.
11. Have the students list all the materials needed to install the SE cable from meter base to service drop attachment point.
12. Have the students install a SE cable from weatherhead to meter base on a typical wall surface.

PERFORMANCE OBJECTIVE V-TECS 30 (Continued)

CRITERION REFERENCED MEASURE:

Questions:

1. Service Entrance cables shall be supported within _____ inches of the meter base and at intervals not more than _____ feet.
   a. 6, 2
   b. 12, 2
   c. 12, 4
   d. 12, 4½
2. The weatherhead should be located:
   a. Below the service drop attachment point
   b. Above the service drop attachment point
   c. Not more than 24 inches from the service drop attachment point
   d. Either b or c.
3. To prevent moisture from entering the building, SE conductors shall be connected to the service drop conductors:
   a. Below the level of the weatherhead
   b. Below the level of the end of the SE cable sheath
   c. Below the roof overhang
   d. Either a or b.

Answers:

1. d
2. d
3. d

PERFORMANCE GUIDE:

1. Remove meter base cover.
2. Attach cable to line side of meter base using approved connectors.
3. Attach cable to surface of structure.
4. Connect cable to line lugs of meter base.
5. Terminate upper end of cable above termination of service drop.
6. Provide sufficient cable to form drip loop.
7. Replace meter base cover.

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 31

TASK: Install temporary service entrance.

STANDARD OF PERFORMANCE OF TASK: Install temporary service entrance. Installation must provide voltage and ampacity required. Branch circuits (15 and 20 ampere) must have ground fault protection. Service must be installed in weatherproof enclosure if located outside. The installation of a temporary service entrance must meet the requirements as outlined by the National Electrical Code (Article 305, 230, 250 and 210-8B) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 32, 57-74, 83-110, 122-124.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Rockis. **Residential Wiring,** Unit 11.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the location of the temporary service entrance (TSE).
2. Explain the procedure for determining the proper length of the TSE pole.
3. Describe the TSE components and their function in the installation.
4. Demonstrate the assembly of the components on the pole using local code requirements.
5. Have the students make a list of all the materials needed to assemble a TSE.
6. Have the students assemble a TSE using a typical pole and components.

CRITERION REFERENCED MEASURE:
Questions:
1. The service drop of a temporary service entrance must have a minimum clearance of _____ feet above grade.
   a. 10
   b. 12
   c. 15
   d. 18

2. To insure proper support, the pole should be put into the ground to a depth of _____ feet.
   a. 2
   b. 4
   c. 6
   d. 8
3. The meter base should be mounted on the service pole at a height:
   a. Eight feet above ground level
   b. Eye level to power supplier
   c. Five to six feet above ground level
   d. Four feet above ground level.

Answers:
1. a
2. b
3. c

PRACTICAL APPLICATION:

Install a temporary service entrance using typical electrical materials following local Code requirements.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use Checklist for Performance Objective 31 to determine if the assignment was completed with at least 80 percent proficiency.

PERFORMANCE GUIDE:

1. Request power supplier to approve the proposed location.
2. Lay pole on ground.
3. Mark off the depth the pole goes in the ground.
4. Attach meter base five to six feet above ground level.
5. Install raceway or service cable from meter base to top of service pole.
6. Attach raceway to service pole.
7. Install weatherhead.
8. Install raceway between meter base and main service panel.
9. Attach service panel to pole.
10. Install conduit from waterproof receptacle box(es) to service panel.
11. Attach receptacle box to pole.
12. Run all wiring and make wiring connections.
13. Install ground fault protection.
14. Run ground wire and fasten to pole down to ground level.
15. Dig hole for service pole.
16. Install service pole. Tamp dirt back tightly.
17. Drive ground rod or bury grounding electrode.
18. Fasten ground wire to ground rod or grounding electrode with approved device.
19. Install pole reinforcement as required.
20. Have installation inspected.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 31

PRACTICAL EVALUATION FOR TSE INSTALLATION

Student's Name **Date**

DIRECTIONS TO STUDENT: Install the temporary service entrance with at least 2, 20 ampere branch circuits having ground fault protection.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job at 80 percent proficiency level.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student has selected the correct length of pole.	______	______
2. The student mounted meter base at correct height.	______	______
3. The student secured the service cable properly.	______	______
4. The student installed the weatherhead properly.	______	______
5. The student installed the watertight connectors properly.	______	______
6. The student connected the conductors to meter base and service panel securely.	______	______
7. The student properly installed the outlets.	______	______
8. The student installed the ground fault protection.	______	______
9. The student installed the grounding conductor.	______	______
10. The student mounted the pole in the ground.	______	______

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 31 (Continued)

11. The student installed the grounding electrode. ______ ______

12. The student connected the grounding conductor to the grounding electrode. ______ ______

13. The student cleaned up the work area. ______ ______

APPROVED: Yes _____ No _____

____

Evaluator's Signature **Date**

DUTY: INSTALLING SERVICE ENTRANCE

PERFORMANCE OBJECTIVE V-TECS 32

TASK: Install underground service entrance.

STANDARD OF PERFORMANCE OF TASK: Underground service entrance must meet the requirements as outlined by the National Electrical Code (Article 230, Part D, 250, Chapter 9, Tables 2 and 3, and Article 300-5) and the local authority having jurisdiction as to conduit size, trench depth and other regulations.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 60-61, 83-110, 114-116, 633-636.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Mullin. **Electrical Wiring, Residential,** pp. 221-222.
Colvin. **Electrical Wiring,** pp. 135-138.
Alerich. **Electrical Construction Wiring,** pp. 259-261.

TEACHING ACTIVITIES:
1. Describe local power supplier requirements regarding supplier and consumer responsibilities.
2. Explain the use of conduit in service lateral installations.
3. Explain the use of conductors suitable for direct burial in the ground.
4. Demonstrate the procedure for installing conduit as required at the meter base and power supplier pole.
5. Have the students install a typical underground SE using a simulated job site.

CRITERION REFERENCED MEASURE:
Questions:
1. The minimum cover for direct burial cable is:
   a. 12 inches
   b. 12 inches if in conduit
   c. 24 inches
   d. 24 inches if in conduit
2. Residential branch circuits rated at not more than 300 volts, 30 amperes shall be covered at a minimum depth of _____ inches.
   a. 12
   b. 18
   c. 24
   d. 36

PERFORMANCE OBJECTIVE V-TECS 32 (Continued)

3. When underground service conductors are installed up a pole, mechanical protection must be provided at least _____ feet above ground level.
   a. 12
   b. 10
   c. 8
   d. 6

Answers:
1. c
2. a
3. c

PERFORMANCE GUIDE:
1. Request power supplier to spot meter base location.
2. Attach meter base to structure.
3. Open a trench from local power company pole to a point under meter base.
4. Install conduit from meter base to a point near the bottom of the trench.
5. Install plastic bushing on bottom of conduit.
6. Fasten required lengths of conduit together.
7. Prepare required raceway for conductors at pole.
8. Request inspection.

INSTALLING SWITCH BOXES AND OUTLET BOXES

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 33

TASK: Install (bar-hanger) mounted box.

STANDARD OF PERFORMANCE OF TASK: Box must be securely mounted to be flush with the finished ceiling and be located according to plans. The installation of the bar-hanger mounted box must meet the requirements as outlined by the National Electrical Code (Article 370) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 224-232.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Box
2. Set of floor plans showing the basic wiring system
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify and use the terminology associated with electrical boxes.
2. Use of proper hand tools and materials.
3. Read and interpret the information given on floor plans.
4. Recall the technique of locating the ceiling point.

RESOURCES:
Taylor. **Residential Wiring,** pp. 27-62.
Foley. **Electrical Wiring Fundamentals,** pp. 123-139.
National Electrical Code, 1981. Articles 370-5 to 370-19.
Colvin. **Electrical Wiring,** pp. 47-49.

TEACHING ACTIVITIES:
1. Instruct the student to read **Residential Wiring,** pp. 27-62, **Electrical Wiring Fundamentals,** pp. 123-139, and **National Electrical Code, 1981,** Articles 310-5 to 310-19.
2. Discuss different usage of electrical boxes.
3. Identify the different types of finish wall material.
4. Demonstrate procedure used to find installation point.
5. Have students practice finding the center points in given areas.
6. Have students discuss why proper installation is important.

CRITERION REFERENCED MEASURE:
Questions:
1. The most common shape electrical box for ceiling lights is:
   a. Round
   b. Octagon
   c. Rectangular
   d. Triangular.

PERFORMANCE OBJECTIVE V-TECS 33 (Continued)

2. In relationship to a finished wood ceiling, electrical boxes must be:
    a. Just above finish
    b. Surface mounted
    c. Supported with straps
    d. Flush with finished surface.
3. Electrical boxes should be located in rooms according to:
    a. Electrical inspector
    b. Home owners
    c. House plans
    d. N.E.C.

Answers:
1. b
2. d
3. c and d

PRACTICAL APPLICATION:

Install and secure a bar-hanger mounted box. The box must be flush with finished ceiling and in the center of the room.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist Performance Objective 33 to determine if the assignment was completed with at least a 90 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Attach bar to joist such that box will be flush with the finished ceiling.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 33 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF (BAR-HANGER) MOUNTED BOX

Student's Name **Date**

DIRECTIONS TO STUDENT: Install and secure a bar-hanger mounted box. Box must be flush with finished ceiling and in center of the room.

DIRECTIONS TO EVALUATOR: Instructor will observe student using proper safety techniques. Student is to complete task within reasonable amount of time and a score of 90 percent is required for competency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected proper materials.	______	______
2. The student used safety precautions.	______	______
3. The student demonstrated two methods for finding the center of the room.	______	______
4. The student secured the box to bar-hanger.	______	______
5. The student secured the box and hanger to the structural member.	______	______
6. The student found the center of the room.	______	______
7. The student mounted the box flush with the ceiling finish.	______	______
8. The student finished the task within a reasonable amount of time.	______	______
9. The student completed the task in a workmanship like manner.	______	______
10. The student dismantled the project and returned the materials to their proper places.	______	______

APPROVED: Yes _____ No _____

Evaluator's signature **Date**

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 34

TASK: Install flush mount junction box.

STANDARD OF PERFORMANCE OF TASK: Box must be flush with the finished surface and be located according to plans. Junction box must be accessible after installation. The installation of the flush mount junction box must meet the requirements as outlined by the National Electrical Code (Article 370, Part B) and the local authority having jurisdiction.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A flush mount junction box
2. A set of floor plans showing the basic wiring system
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify and use electrical boxes which are utilized as junction boxes.
2. Use the proper hand tools and materials.
3. Read and interpret the information given on electrical plans.
4. Identify the condition of the surface the box is to be mounted in.

RESOURCES:
Foley. **Electrical Wiring Fundamentals**, p. 124.
National Electrical Code, 1981. Article 370-19.

TEACHING ACTIVITIES:
1. Instruct the students to read **Electrical Wiring Fundamentals**, p. 124 and **Electrical Wiring**, p. 89.
2. Discuss with students the types of wall surfaces and installation procedures.
3. Demonstrate the procedure for locating the installation point.
4. Discuss what is meant by "accessible."
5. Show boxes that are presently mounted in the building.

CRITERION REFERENCED MEASURE:

Questions:
1. How must electrical boxes used as junction boxes be covered?
2. All wiring in junction boxes must be ______________.
3. How is a junction box normally shown on a blueprint?
4. Junction boxes are used for what purpose?

Answers:
1. With a solid blank plate of like material
2. Accessible
3. With a "J" in the middle of the symbol
4. Splicing of conductors in a location not suitable for a device.

PERFORMANCE OBJECTIVE V-TECS 34 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Locate junction box so it is accessible.
3. Attach junction box to structure such that it will be flush with the finished surface.

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 35

TASK: Install flush mount switch and outlet box in a dry wall, lath or plaster wall, or paneled wall.

STANDARD OF PERFORMANCE OF TASK: Switch box and/or outlet box must comply with governing codes, must be mounted securely and flush with the finished surface, and be located according to plans. The installation type and location of switch boxes and outlet boxes must meet the requirements as outlined by the National Electrical Code (Article 370, Part B) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 225-230.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Switch box
2. A set of floor plans showing the basic wiring system and/or outlet box
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify and use electrical boxes which are utilized for switch and outlet installations in drywall, paneling, etc.
2. Use the proper hand tools and materials.
3. Read and interpret the information given on electrical plans.
4. Identify the thickness of finished surfaces.

RESOURCES:
Foley. **Electrical Wiring Fundamentals**, pp. 35-49.
National Electrical Code, 1981. Articles 370-5 to 370-19.

TEACHING ACTIVITIES:
1. Instruct students to read **Electrical Wiring Fundamentals**, pp. 129-132 and **Electrical Wiring**, pp. 35-49.
2. Discuss with students the different types of wall surfaces and installation procedures.
3. Have students measure different wall finish materials.
4. Demonstrate the procedure for locating installation point.
5. Demonstrate the different mounting procedures.

CRITERION REFERENCED MEASURE:
Questions:
1. The mounting of electrical switch and outlet boxes must meet:
   a. OSHA standards
   b. N.E.C. regulations
   c. Owners need
   d. U.L. regulations

PERFORMANCE OBJECTIVE V-TECS 35 (Continued)

2. The location of switches and outlets are shown on the:
    a. Specification sheets
    b. Symbol sheet
    c. Electrical plans
    d. Detail drawings.
3. An electrical box mounted between studs will require:
    a. Plaster rings
    b. External brackets
    c. Expansion anchors
    d. Box supports.

Answers:
1. b
2. c
3. d

PRACTICAL APPLICATION:

Install electrical box for switch at 48 inches to center above finish floor.
Install electrical box for outlet at 12 inches to center above finish floor.
Both boxes are to be securely mounted on the side of the stud and flush with the finish wall of 1/2 inch.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use Checklist Performance Objective 35 to determine if the assignment was completed with at least a 90 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Determine the thickness of the finished surface.
3. Position switch box and/or outlet box.
4. Attach to structure so that the box will be flush with the finished surface.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 35 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF SWITCH AND OUTLET BOXES IN DRYWALL

Student's Name ______________________________ **Date** __________

DIRECTIONS TO STUDENT: Install electrical box for switch at 48" to center above finish floor.
Install electrical box for outlet at 12" to center above finish floor.
Both boxes are to be securely mounted on the side of the stud and flush with finish wall of 1/2 inch drywall.

DIRECTIONS TO EVALUATOR: Instructor will observe the student using proper safety techniques and items to be evaluated. The student is to complete the task within a reasonable amount of time and a score of 90 percent is required for competency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected the proper materials.	________	________
2. The student used safety precautions.	________	________
3. The student mounted the switch box at the proper height.	________	________
4. The student mounted the outlet box at the proper height.	________	________
5. The student properly secured the boxes to the stud.	________	________
6. The student mounted switch box flush to 1/2 inch drywall finish.	________	________
7. The student mounted outlet box flush to 1/2 inch drywall finish.	________	________
8. The student finished the task within a reasonable amount of time.	________	________
9. The student completed the task in a workmanship like manner.	________	________
10. The student dismantled the project and returned the materials to their proper places.	________	________

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________________ **Date** __________

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 36

TASK: Install flush mount switch and outlet boxes in a masonry wall.

STANDARD OF PERFORMANCE OF TASK: Boxes must be installed so they will not be recessed more than 1/8 inch from finished surface. Box must be installed level across the top and be of correct size to accept switch or outlet and be anchored permanently. The installation of the boxes must meet the requirements as outlined by the National Electrical Code (Article 370, Part B) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 225-230.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Box
2. A floor plan showing the basic wiring system
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify and use the electrical boxes which are utilized for switch and outlet installations in a masonry wall.
2. Use the proper hand tools and materials.
3. Read and interpret the information given on electrical plans.
4. Identify the procedure for the supporting of an electrical box in a masonry wall.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 367-371.

TEACHING ACTIVITIES:
1. Instruct the students to read **Electrical Construction Wiring,** pp. 367-371.
2. Illustrate the construction of a concrete block.
3. Demonstrate the procedure for marking the outline for an electrical box.
4. Demonstrate the procedure for chiseling a hole for an electrical box installation.
5. Provide the students with a field trip to a construction site to view electrical boxes being installed.

CRITERION REFERENCED MEASURE:
Questions:
1. What is the best tool to use for cutting a hole in a masonry wall for an electrical box?
2. One method of securing an electrical box in a masonry wall is by using ____________.
3. The ideal area to cut an electrical box into block is in a ____________.

PERFORMANCE OBJECTIVE V-TECS 36 (Continued)

Answers:
1. A concrete chisel
2. Wood wedges
3. Hollow space

PRACTICAL APPLICATION:
Install and secure both a switch and outlet box in a masonry wall. The box must be secure, level and within an 1/8 inch from the finish surface.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Checklist Performance Objective 36 to determine if the assignment was completed with at least a 90 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Attach previously roughed in cable or conduit in box.
3. Position box in the wall.
4. Anchor box in wall.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 36 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF SWITCH AND OUTLET BOX IN A MASONRY WALL

____
Student's Name **Date**

DIRECTIONS TO STUDENTS: Install and secure both a switch and an outlet box in a masonry wall. The box must be secure, level and within 1/8 inch from the finish surface.

DIRECTIONS TO EVALUATOR: Instructor will observe the student using proper safety techniques and items to be evaluated. The student is to complete the task within a reasonable amount of time. A score of 90% is required for competency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected the proper materials.	______	______
2. The student marked the boxes on the wall.	______	______
3. The student used chisel to outline the box.	______	______
4. The student finished the box cutout neatly.	______	______
5. The student leveled the electrical boxes.	______	______
6. The student installed electrical boxes within 1/8 inch from the finish surface.	______	______
7. The student installed the cable to the box.	______	______
8. The student secured the box to the wall.	______	______
9. The student finished the task within a reasonable amount of time.	______	______
10. The student dismantled the project and returned the materials to their proper places.	______	______

APPROVED: Yes _____ No _____

____
Evaluator's Signature **Date**

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 37

TASK: Install gangable boxes.

STANDARD OF PERFORMANCE OF TASK: Gangable boxes must be of required size and type. Boxes must be fastened securely to the structure and be level across the top. The installation of the boxes must meet the requirements as outlined by the National Electrical Code (Article 370, Part B) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 225-230.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Gangable boxes
2. A set of floor plans showing the basic wiring system
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify and recall the construction of an electrical gangable box.
2. Use proper hand tools and materials.
3. Read and interpret the information given on the electrical plans.
4. Identify the methods of supporting electrical boxes.

RESOURCES:
Foley. **Electrical Wiring Fundamentals,** pp. 127-128.
National Electrical Code, 1981. Articles 370-5 -- 370-19.

TEACHING ACTIVITIES:
1. Instruct the students to read **Electrical Wiring Fundamentals,** pp. 127-128.
2. Discuss what is meant by "gangable."
3. Demonstrate the procedure for locating the installation point.
4. Discuss "when" and "when not" to use a gangable box.
5. Have the students connect two or more gangable switch boxes.

CRITERION REFERENCED MEASURE:
Questions:
1. A "gangable" box should be supported between two studs with the help of what materials?
2. What must be done to increase the size of a "gangable" box?
3. What does the N.E.C. require all unused openings in electrical boxes to be?

Answers:
1. Metal or wood strips
2. Remove side cover of box
3. Effectively closed

PERFORMANCE OBJECTIVE V-TECS 37 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Determine number of boxes needed.
3. Fasten boxes together.
4. Attach boxes to structure as to be flush with finished surface.

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 38

TASK: Install octagon outlet box.

STANDARD OF PERFORMANCE OF TASK: The outlet box must be mounted securely to the structure and be located according to the plans. The installation and location of octagon outlet boxes must meet the requirements as outlined by the National Electrical Code (Article 370, Part B) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 225-230.

CONDITIONS FOR PERFORMANCE OF TASK:
1. An octagon outlet box
2. A set of floor plans showing the basic wiring system
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the shape or design of an octagon box.
2. identify the different sizes of octagon outlet boxes.
3. Use proper hand tools and materials.
4. Read and interpret the information given on the electrical plans.
5. Use knowledge of locating the position and installation of an octagon outlet box.

RESOURCES:
Miller. **Residential Electrical Wiring,** pp. 206-209.
Colvin. **Electrical Wiring,** pp. 47-49.

TEACHING ACTIVITIES:
1. Instruct the students to read **Electrical Wiring,** pp. 47-49 and **Residential Electrical Wiring,** pp. 206-209.
2. Discuss and show the different types of octagon boxes.
3. Demonstrate the procedure for locating the installation point.
4. Have the students discuss where octagon outlet boxes should be installed.
5. Review the methods used for attaching octagon boxes to structural members.

CRITERION REFERENCED MEASURE:
Questions:
1. Octagon boxes come in sizes of:
    a. Single and double gang
    b. Three and four inches
    c. Large and small
    d. All of the above.

PERFORMANCE OBJECTIVE V-TECS 38 (Continued)

2. The space of an octagon box can be increased to hold more conductors with the use of an:
   a. Outlet box cover
   b. Expandable bar hanger
   c. Extension box
   d. Any of the above.
3. Octagon boxes are:
   a. Square
   b. Eight sided
   c. Round
   d. Six sided.

Answers:
1. b
2. c
3. b

PERFORMANCE GUIDE:
1. Locate installation point on structure.
2. Attach octagon outlet box to structure according to electrical plans.

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 39

TASK: Install outlet boxes for receptacles and switches in existing wall.

STANDARD OF PERFORMANCE OF TASK: Installed receptacles and/or switch boxes in existing wall must be of required size and type. They must be located as specified in the floor plans and must be level across the top. The installation of the fixture housing must meet the requirements as outlined by the National Electrical Code (Article 370, Part B) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 225-230.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Wall boxes
2. Power source
3. A set of floor plans showing the basic wiring system
4. Previously roughed in wiring
5. The basic tool kit
6. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify and use the electrical boxes which are for installing receptacles and switches in an existing wall.
2. Use proper end tools and materials.
3. Read and interpret the information given on the electrical plans.
4. Use knowledge locating the stud for mounting the electrical box.
5. Identify the circuit route where electrical boxes will be fed.

RESOURCES:
Miller. **Residential Electrical Wiring,** pp. 292-302.
Alerich. **Electrical Construction Wiring,** pp. 405-424.

TEACHING ACTIVITIES:
1. Have the students read **Residential Electrical Wiring,** pp. 292-302 and **Electrical Construction Wiring,** pp. 405-424.
2. Discuss with the students the terms and definitions associated with electrical remodeling.
3. Review the students on the different types of wall surfaces that might be encountered.
4. Demonstrate the procedure for finding studs.
5. Discuss possible problems that can arise in cutting in electrical boxes in existing walls.
6. Demonstrate the proper technique for cutting a box opening in a wall.
7. Demonstrate the attachment of boxes to the structure flush with the finished surface.

PERFORMANCE OBJECTIVE V-TECS 39 (Continued)

CRITERION REFERENCED MEASURE:

Questions:

1. What is the standard "stud" spacing normally found in existing structures?
2. What tool is used to find a stud?
3. What is used as a common method of installing an electrical box?
4. What must all electrical boxes after installations be?

Answers:

1. 16 inches on center
2. Stud finder
3. Metal box supports
4. Flush to finished surface and level across the top

PRACTICAL APPLICATION:

Install and secure both a switch and receptacle box in an existing wall made of drywall. The switch box is to be mounted on a stud at 48" to center. The receptacle box is to mounted in center of the studs and 12" to the center. Both are to be mounted flush with the finish wall and level across the top. A finish plate must cover opening cut out for a box.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist Performance Objective 39 to determine if the assignment was completed with at least a 90 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Draw outline of box on wall near stud, if possible.
3. Cut holes in existing wall of size to accept box to be installed or remove paneling or wall board.
4. Attach and level box to structure.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 39 EVALUATION

PERFORMANCE TEST FOR INSTALLING ELECTRICAL BOXES IN EXISTING WALLS

____

Student's Name **Date**

DIRECTIONS TO STUDENT: Install and secure both a switch and receptacle box in an existing wall made of drywall. Switch box is to be mounted on stud at 48 inches to center. Receptacle box is to be mounted in the center of the studs and 12 inches to center. Both are to be mounted flush with the finish wall and level across the top. A finish plate must cover the opening cut out for the box.

DIRECTIONS TO EVALUATOR: Instructor will observe the student using proper safety techniques and items to be evaluated.The student is to complete the task within a reasonable amount of time. A score of 90% is required for competency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected proper materials.	______	______
2. The student used a box for template layout of both switch and receptacle.	______	______
3. The student cut out a hole for switch by stud neatly.	______	______
4. The student cut out hole for the receptacle in the center of the wall between the studs neatly.	______	______
5. The switch box is mounted at 48 inches to the center of the box.	______	______
6. The receptacle box is mounted at 12 inches to the center of the box.	______	______
7. The boxes are mounted flush and level to the wall.	______	______
8. The finish plates cover opening cut out for the box.	______	______
9. The student finished the task within a reasonable amount of time.	______	______
10. The student dismantled the project and returned the materials to their proper places.	______	______

APPROVED: Yes _____ No _____

____

Evaluator's Signature **Date**

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 40

TASK: Install recessed fixture housing in ceiling.

STANDARD OF PERFORMANCE OF TASK: Box must be mounted in correct location and must be strong enough to support the fixture. Fixture must be controlled by a switch or other means. Fixture must be installed according to manufacturer's recommended clearances. The installation of the recess fixture housing must meet the requirements as outlined by the National Electrical Code (Article 410, Part B, and 410-8) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 268-269.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Recessed fixture box
2. A floor plan showing the basic wiring system
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the meaning of "recessed."
2. Use proper hand tools and materials.
3. Read and interpret the information given on electrical plans.
4. Use knowledge of the installation of the boxes.
5. Read and interpret the manufacturer's specifications.

RESOURCES:
National Electrical Code, 1981. Articles 410-4 to 410-8.
Alerich. **Electrical Construction Wiring.** pp. 424-428.

TEACHING ACTIVITIES:
1. Instruct the students to read **National Electrical Code,** Articles 410-4 to 410-8 and **Electrical Construction Wiring,** pp. 424-428.
2. Discuss the recommendations made by the manufacturer.
3. Identify the potential problems when installing into existing ceilings.
4. Demonstrate the process for measuring and cutting of the correct size hole for a fixture.
5. Review mounting of fixture housings.

CRITERION REFERENCED MEASURE:
Questions:
1. Recessed fixtures installed where combustible materials are stored must have:
   a. Ten inch clearance
   b. Six inch clearance
   c. Eighteen inch clearance
   d. Twenty four inch clearance.

PERFORMANCE OBJECTIVE V-TECS 40 (Continued)

2. Lighting fixtures should utilize the fixture-to-stud mounting when:
   a. The fixtures are heavy
   b. The fixtures are at the end of a long wire run
   c. The fixtures have heavy ampere demand
   d. The fixtures are light.
3. Wires from the junction box of a recessed fixture must be:
   a. Rubber insulated
   b. Exposed in open
   c. Approved for high temperature
   d. Oversized.
4. A hanging fixture over a bathtub must be no closer than:
   a. Six feet above the rim of tub
   b. Four feet above the rim of tub
   c. Eight feet above the rim of tub
   d. Ten feet above the rim of tub.

Answers:
1. b
2. a
3. c
4. c

PERFORMANCE GUIDE
1. Locate installation point.
2. Measure clearances to meet manufacturer's recommendations.
3. Cut holes of correct size in ceiling at desired location.
4. Attach fixture housing to the structure per manufacturer's installation instructions.

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 41

TASK: Install surface mount junction box.

STANDARD OF PERFORMANCE OF TASK: Box must be installed to comply with governing codes. Box must be mounted securely and according to plans. The installation of surface mounted junction boxes must meet the requirements as outlined by the National Electrical Code (Article 370, Part B) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 225-230.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Junction box
2. A set of floor plans showing the basic wiring system
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Use proper hand tools and materials.
2. Read and interpret information given on the electrical plans.
3. Identify the different surface materials.

RESOURCES:
Foley. **Electrical Wiring Fundamentals,** pp. 124-125.
National Electrical Code, 1981. Articles 370-18 and 370-19.

TEACHING ACTIVITIES:
1. Instruct the students to read **Electrical Wiring Fundamentals,** pp. 124-125 and **National Electrical Code, 1981,** Articles 370-18 and 370-19.
2. Demonstrate the procedure for leveling and marking of the junction boxes on a surface.
3. Provide the students with different anchoring materials.
4. Review methods of anchoring electrical boxes.
5. Show the different electrical boxes and their covers used as junction boxes.

CRITERION REFERENCED MEASURE:
Questions:
1. Where would an electrician get the information necessary to install a surface mounted junction box?
2. What determines the proper method of anchoring a surface mounted junction box?
3. The mounting of electrical boxes must meet the standards of the National Electrical Code and what else?

PERFORMANCE OBJECTIVE V-TECS 41 (Continued)

Answers:
1. Electrical plans
2. Type of material the box is to be mounted on.
3. The local authority having jurisdiction.

PERFORMANCE GUIDE:
1. Locate installation point on structure.
2. Attach surface mount junction box to structure.

DUTY: INSTALLING SWITCH BOXES AND OUTLET BOXES

PERFORMANCE OBJECTIVE V-TECS 42

TASK: Install underground, watertight, cast iron box.

STANDARD OF PERFORMANCE OF TASK: Box must be located according to plans. The installation must be made so that the watertight integrity will be maintained.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A watertight, cast iron box, previously roughed in wiring
2. The basic tool kit
3. Manual hand tools or mechanical equipment (backhoe, shovel, picks)
4. A set of floor plans showing the basic wiring system.

ENABLING OBJECTIVE(S):
1. Identify and use electrical boxes which are utilized for underground installations.
2. Recall the standards set forth in the National Electrical Code covering underground installations.
3. Use proper hand tools and materials.
4. Read and interpret the information given on the electrical plans.
5. Identify the condition of the existing wiring.

RESOURCES:
National Electrical Code, 1981. Articles 300-5, 300-6 and 370-b and c.

TEACHING ACTIVITIES:
1. Instruct the students to read **National Electrical Code, 1981,** Articles 300- 5, 300-6 and 370 b and c.
2. Have students prepare the area for a box installation.
3. Review with the students the construction of watertight electrical boxes and materials.
4. Demonstrate the proper connections to an electrical box.
5. Invite a guest speaker to class to talk on experience with installation of underground electrical boxes.

CRITERION REFERENCED MEASURE:
Questions:
1. According to what standards are the location and depth of electrical underground boxes found?
2. An electrical box that is used for underground installation must be ______________.
3. Using the standard of the National Electrical Code, underground electrical boxes must be made of what type material?

PERFORMANCE OBJECTIVE V-TECS 42 (Continued)

Answers:
1. The National Electrical Code and the electrical plans
2. Watertight, raintight or rainproof
3. Material suitable for the environment in which they are to be installed.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Prepare installation site by removing soil with available tools or equipment.
3. Place watertight cast iron box in the ground.
4. Connect cables and/or conduit to box using approved connectors.
5. Seal box.

MAINTAINING EXISTING WIRING

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 43

TASK: Diagnose/repair fluorescent fixture.

STANDARD OF PERFORMANCE OF TASK: Defective parts must be replaced with equivalent parts. Light must burn when repairs are complete.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit.
2. The basic tool parts.

ENABLING OBJECTIVE(S):
1. Identify the main parts of a fluorescent fixtures and their functions.
2. Determine the proper tools and materials to be used.
3. Recall the fluorescent lamp and ballast characteristics.

RESOURCES:

Miller, et al., **Energy: Electricity/Electronics,** pp. 173-177.
Miller. **Industrial Electricity,** pp. 338-345.

TEACHING ACTIVITIES:
1. Instruct the students to read **Energy: Electricity/Electronics,** pp. 173-177 and **Industrial Electricity,** pp. 338-345.
2. Review with the students the operation of the fluorescent fixture.
3. Emphasize the importance in using good safety.
4. Review with the students the common causes in lamp failure in fluorescent fixtures.
5. Demonstrate the use of a voltmeter for troubleshooting.
6. Have the students identify the color of a fluorescent lamp in the class room.
7. Have the students practice wiring new ballasts using a wiring diagram on the ballast.
8. Have the students practice removing the fixture parts from a light fixture.

CRITERION REFERENCED MEASURE:

Questions:
1. How many more times efficient is a fluorescent tube than a incandescent lamp?
2. What is the device that is connected between the lamp and the power supply which limits the current flow?
3. What temperatures does a fluorescent lamp designed for indoor use operate best?
4. What kind of lighting does the National Electrical Code refer fluorescent lighting as?

PERFORMANCE OBJECTIVE V-TECS 43 (Continued)

Answers:
1. About 2.5 times
2. A ballast
3. 65 -- 90 degrees
4. Electric discharge lighting

PRACTICAL APPLICATION:
Diagnose a defective fluorescent light fixture and repair the defective parts. Equivalent parts must be used and the light must work properly when completed.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist Performance Objective 43 to determine if the assignment was completed with at least a 90 percent accuracy.

PERFORMANCE GUIDE:
1. Check voltage with voltmeter.
2. With proper voltage at fixture and power on, visually check bulbs for darkened ends, burning red at ends, or flashing on and off. Replace bulb if any of these conditions exists.
3. If bulbs are not defective, determine if fixture is self starting or uses separate starters. If it has starters, replace with new ones of correct size.
4. If bulbs and starters are not defective, turn power off.
5. Remove cover from fixture and check wiring inside fixture for loose connections.
6. If wiring is not loose and bulbs and starters are not defective, replace ballast.
7. Re-install cover and other parts removed for wiring inspection.
8. Turn power on.
9. Assure fluorescent light operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 43 EVALUATION

PERFORMANCE TEST FOR THE DIAGNOSIS AND REPAIR OF FLUORESCENT LIGHT FIXTURES

Student's Name **Date**

DIRECTIONS TO STUDENT: Diagnose a defective fluorescent light fixture and repair defective parts. Equivalent parts must be used and light must work properly when completed.

DIRECTIONS TO EVALUATOR: The instructor will observe the student using proper safety techniques. The student is to finish task in a reasonable amount of time. A score of 90 percent is required for competency. The defective part is the ballast.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected the proper tools.	____	____
2. The student checked voltage with voltmeter.	____	____
3. The student checked for bad tubes.	____	____
4. The student removed fixture covers carefully.	____	____
5. The student checked wiring and connections.	____	____
6. The student worked off the ladder properly.	____	____
7. The student turned the power off and tagged for safety.	____	____
8. The student determined the problem with the ballast.	____	____
9. The student replaced an old ballast with a new equivalent ballast.	____	____
10. The fluorescent light fixture is properly working.	____	____

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 44

TASK: Diagnose and repair/replace lights.

STANDARD OF PERFORMANCE OF TASK: Parts must be replaced with approved equivalent parts. Light must burn when repairs are complete.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
The basic tool kit and parts.

ENABLING OBJECTIVE(S):

1. Identify the main parts of an incandescent light fixture.
2. Determine the proper tools and materials to be used.

RESOURCES:

Foley, **Electrical Wiring Fundamentals,** pp. 152-156.
Miller, et al., **Energy: Electricity/Electronics,** pp. 169-173.
Miller, **Industrial Electricity,** pp. 36-338.

TEACHING ACTIVITIES:

1. Instruct the students to read **Electrical Wiring Fundamentals,** pp. 152-156 and **Energy: Electricity/Electronics,** pp. 169-173.
2. Identify the color of connection terminals on an incandescent light fixture.
3. Review the principle of reversed polarity.
4. Discuss procedures for troubleshooting incandescent light fixtures.
5. Have the students read the manufacturer's recommendations for installing incandescent light fixtures.
6. Have the students practice mounting different incandescent light fixtures.

CRITERION REFERENCED MEASURE:

Questions:

1. What are lamps using filaments that give off light called?
   a. Fluorescent
   b. Mercury-vapor
   c. Sodium-vapor
   d. Incandescent.
2. The glass bulb of an incandescent lamp is filled with:
   a. Oxygen
   b. Inert gases
   c. Neon gas
   d. Any of the above.
3. An incandescent lamp operates with the use of a:
   a. Starter
   b. Filament
   c. Starting electrode
   d. None of the above.

PERFORMANCE OBJECTIVE V-TECS 44 (Continued)

4. The lamp base that is standard on general service lamps of 300 watts and under is the:
   a. Mogul base
   b. Candelabra base
   c. Medium base
   d. Normal base.
5. A disadvantage of an incandescent lamp is:
   a. The cost of the lamp
   b. The natural color of objects
   c. The low cost of installation
   d. That it gives off a lot of heat.

Answers:
1. d
2. b
3. b
4. c
5. d

PRACTICAL APPLICATION:
Diagnose a defective incandescent light fixture and repair defective parts. Equivalent parts must be used and the light must work properly when completed.

PRACTICAL APPLICATION:
Diagnose a defective incandescent light fixture and repair defective parts. Equivalent parts must be used and the light must work properly when completed.

PERFORMANCE GUIDE:
1. Remove and test bulb with ohmmeter or other means.
2. If bulb is good, use volt meter to check for correct voltage at light fixture connections.
3. If voltage is correct in fixture connections, fixture must be repaired or replaced.
   a. Turn power off.
   b. Remove fixture.
   c. Repair or replace fixture.
   d. Re-install fixture.
4. If voltage is incorrect, check/correct for problems at power supply.
   a. Measure continuity of fuse(s)/breaker(s).
   b. Remove/replace faulty fuse(s)/breaker(s).

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 44 EVALUATION

PERFORMANCE TEST FOR THE DIAGNOSIS AND REPAIR OF INCANDESCENT LIGHT FIXTURES

____
Student's Name **Date**

DIRECTIONS TO STUDENT: Diagnose a defective incandescent light fixture and repair defective parts. Equivalent parts must be used and light must work properly when completed.

DIRECTIONS TO INSTRUCTOR: The instructor will observe the student using proper safety techniques. The student is to finish the task in a reasonable amount of time. A score of 90 percent is required for competency. Defective part is the breaker for that circuit.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected the proper tools.	______	______
2. The student checked the existing bulb with ohmmeter.	______	______
3. The student checked the condition of light socket.	______	______
4. The student checked for the proper voltage.	______	______
5. The student turned the power off and tagged for safety.	______	______
6. The student removed light fixture.	______	______
7. The student checked wiring connections.	______	______
8. The student checked the power supply (breaker).	______	______
9. The student re-installed the light fixture.	______	______
10. The student has the light fixture working properly.	______	______

APPROVED: Yes _____ No _____

____
Evaluator's Signature **Date**

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 45

TASK: Repair/replace relays and timers.

STANDARD OF PERFORMANCE OF TASK: Defective parts must be replaced with equivalent parts. Relay or timer must operate when power is restored.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. An appliance with a defective relay or timer
2. The basic tool kit and repair parts.

ENABLING OBJECTIVE(S):
1. Identify the main parts of relays and timers.
2. Determine the proper tools and materials to be used.
3. Recall operating characteristics of relays and timers.
4. Interpret the electrical schematics of an appliance.

RESOURCES:
Miller, et al., **Energy: Electricity/Electronics,** pp. 245-253.

TEACHING ACTIVITIES:
1. Instruct the students to read **Energy: Electricity/Electronics,** pp. 245-253.
2. Discuss the different types and applications of relays.
3. Review parts of a simple relay.
4. Show the students examples of relays.
5. Have the students wire up a low voltage relay.

CRITERION REFERENCED MEASURE:
Questions:
1. The operation of an electrical appliance may be stopped by a bad relay. When checking for the proper voltage at the relay, one must first check:
   a. Contact
   b. Voltage to coil
   c. The armature
   d. The return spring.
2. A relay/timer must be operated with voltage rated at:
   a. The same as controlled circuit
   b. The coil voltage rating
   c. The normal circuit rating
   d. None of the above.
3. The ideal instrument for troubleshooting an electrical appliance is the:
   a. Wattmeter
   b. Amprobe
   c. Power supply
   d. V.O.M.

PERFORMANCE OBJECTIVE V-TECS 45 (Continued)

4. The mechanism that regulates the sequence of fill, drain, spin modes on a washing machine is the:
   a. Selector switch
   b. Solenoid valve
   c. Overload protector
   d. Timer.

Answers:
1. b
2. b
3. d
4. d

PERFORMANCE GUIDE:
1. Turn power off.
2. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
3. Replace relay or timer with an equivalent part.
4. Turn power on.
5. Assure relay/timer operation.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 46

TASK: Repair water heater.

STANDARD OF PERFORMANCE OF TASK: All replacements must be made with equivalent parts. Water heater must be equipped with pressure relief valve. When repairs are completed, water heater must heat at rated capacity and to temperature of thermostat setting.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
The basic tool kit and repair parts

ENABLING OBJECTIVE(S):
1. Identify the main parts of the hot water heater.
2. Determine the proper tools and materials to be used.
3. Recall operating characteristics of the hot water heaters.
4. Recall the procedures for troubleshooting hot water heaters.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 206-208.
Miller. **Residential Electrical Wiring,** pp. 322-323.

TEACHING ACTIVITIES:
1. Have the students read **Electrical Construction Wiring,** pp. 206-208.
2. Discuss the different types of hot water heaters.
3. Explain the steps in heating of water in the tank.
4. Review terminology and operation of the main parts of a hot water heater system.
5. Have the students find and record temperature settings of their hot water heaters at home.
6. Show the different examples of hot water heaters in class.
7. Demonstrate troubleshooting techniques with volt-ohm meter.

CRITERION REFERENCED MEASURE:
Questions:
1. A large family of today is more likely to have what type of electric water heater?
2. What devices are installed as safety features on a modern electrical hot water heater?
3. Most modern electric hot water heaters operate off what voltage?
4. The replacement of a bad element on a 4500 watt dual element hot water, should be replaced with what size element?

Answers:
1. A double (or dual) element heater
2. A high pressure relief valve, high temperature cutoff
3. 220-240 volts
4. 4500 watt of equivalent size

PERFORMANCE OBJECTIVE V-TECS 46 (Continued)

PRACTICAL APPLICATION:

Diagnose hot water heater that is not supplying hot water. Make necessary repairs or replacement as required. Use only replacement parts equivalent to manufacturer's. Unit must include the proper safety devices and operate to specifications.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist Performance Objective 46 to determine if the assignment was completed with at least a 90 percent proficiency.

PERFORMANCE GUIDE:

1. Turn power off.
2. Remove access panel from water heater.
3. Inspect wiring and terminal connections.
4. If wiring is secure and routed as required, turn power on.
5. Using voltage tester, check for correct voltage at line terminals on high limit control.
6. Without correct voltage at this point, check power supply.
7. Check voltage at load terminals on high limit control.
8. If there is no voltage at load terminals, press reset button on high limit control.
9. If power is not restored, replace high limit control.
10. Check voltage at load terminals on thermostat.
11. If correct voltage is not present, replace thermostat.
12. Turn power off.
13. Check heating element(s), using ohmmeter, for open shorts and grounds.
14. If element(s) must be replaced, turn off water supply, drain tank and replace element.
15. Determine if pressure relief valve is in place.
16. With element in place, turn water supply on and open hot water faucet to let air escape while tank is filling.
17. When tank is full, turn faucet off and check for leaks.
18. Turn power on.
19. Assure required operation with ampmeter.
20. Replace access panel.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 46 EVALUATION

PERFORMANCE TEST FOR REPAIR OF AN ELECTRIC HOT WATER HEATER

Student's Name ______________________ **Date** __________

DIRECTIONS TO STUDENT: Diagnose a hot water heater that is not supplying hot water. Make necessary repairs or replacement as required. Use only replacement parts equivalent to manufacturer's parts. Unit must include proper safety devices and operate to specifications.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to items to be evaluated. Watch for safety violation. Allow student a reasonable amount of time as would be required on a job site. A score of 90 percent is required for competency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student turned power off.	______	______
2. The student removed access panel and checked power again.	______	______
3. The student checked wiring and terminal connections.	______	______
4. The student turned power on and checked line terminals of high limit control for correct voltage.	______	______
5. The student checked for same voltage on load side of high limit control.	______	______
6. The student pressed reset button if no voltage on load side.	______	______
7. The student replaced the high limit control if power not restored.	______	______
8. The student checked voltage at load terminals on thermostat.	______	______
9. The student replaced thermostat if correct voltage not present.	______	______
10. The student turned power off.	______	______

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 46 EVALUATION (Continued)

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
11.	The student checked elements with ohmmeter.	______	______
12.	The student determined element is bad.	______	______
13.	The student turned off water supply and drained tank.	______	______
14.	The student replaced the element.	______	______
15.	The student checked pressure relief valve.	______	______
16.	The student refilled tank with water.	______	______
17.	The student turned the power on.	______	______
18.	The student checked element load with ammeter.	______	______
19.	The student replaced access panel.	______	______
20.	The student finished task in reasonable amount of time.		

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 47

TASK: Install and maintain emergency lighting.

STANDARD OF PERFORMANCE OF TASK: The wiring must be kept entirely independent of all other wiring and equipment. Emergency lights must operate when electrical power goes off. The installation of the emergency lighting must meet the requirements as outlined by the National Electrical Code (Article 700) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 577-581.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Wiring for emergency lighting
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the main parts of an emergency lighting system.
2. Determine the proper tools and materials to be used.
3. Recall the operating characteristics of an emergency lighting system.
4. Interpret the information supplied by the manufacturer for installation.
5. Read and interpret the National Electrical Code.

RESOURCES:
National Electrical Code, 1984. Article 700.

TEACHING ACTIVITIES:
1. Instruct the students to read **National Electrical Code, 1984,** Article 700.
2. Discuss the use of an emergency lighting system.
3. Review a set of manufacturer's instructions with the students.
4. Demonstrate the procedures for troubleshooting of an emergency system.
5. Have the students design a layout for an emergency lighting from a set of blueprints of a school.

CRITERION REFERENCED MEASURE:
Questions:
1. The article of the National Electrical Code that covers the installation of an emergency lighting system is:
   a. Article 336
   b. Article 550
   c. Article 700
   d. Article 730.
2. The wiring of an emergency lighting system must.
   a. Always exist within some enclosure as main wiring
   b. Always be of a lower voltage
   c. Be kept entirely independent of all other wiring
   d. Always be of a higher voltage.

PERFORMANCE OBJECTIVE V-TECS 47 (Continued)

3. Which of the following is not a recommendation by the National Electrical Code for the testing of an emergency lighting system?
    a. Witness test upon the installation of the system
    b. Keep written records of the tests and maintenance
    c. Test the system under load
    d. Check and test the system monthly.

Answers:
1. c
2. c
3. d

PERFORMANCE GUIDE:
1. Make wiring connections according to manufacturer's instructions.
2. Connect power to unit and assure required operation.
3. Locate lighting so that designated escape routes are clearly visible.
4. Test periodically.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 48

TASK: Repair or replace frayed service cords.

STANDARD OF PERFORMANCE OF TASK: Insulating materials and cord must be required size and type for conditions encountered. Defective parts must be replaced with equivalent parts. The repair of the service cords must meet the requirements as outlined by the National Electrical Code (Article 400-7-8-9 and tables) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 257-259, 243-258.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Service cord
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the size and type of cord conductors.
2. Determine the proper tools and materials to be used.
3. Recognize when to repair or when to replace frayed service cords.
4. Read and interpret the National Electrical Code.

RESOURCES:
Miller, et al., **Energy: Electricity/Electronics,** pp. 209-210.
National Electrical Code, 1984. Article 400.

TEACHING ACTIVITIES:
1. Instruct students to read **Energy: Electricity/Electronics,** pp. 209-210.
2. Review Article 400-1 to 400-9 of the **National Electrical Code, 1984,** with the students.
3. Show examples of service cords that would require replacement.
4. Demonstrate the procedure for checking of conductors with volt- ohmmeter.
5. Have the students check a home or place of business for cords in need of repair.

CRITERION REFERENCED MEASURE:
Questions:
1. One area where flexible cords are not to be used is:
   a. For wiring of cranes and hoists
   b. Where concealed behind building walls
   c. For wiring of fixtures
   d. Connection of portable lamps or appliances.

PERFORMANCE OBJECTIVE V-TECS 48 (Continued)

2. Flexible cords when initially installed must:
    a. Be oversized for protection
    b. Be fused for protection
    c. Be installed within a flexible conduit
    d. Be in continuous lengths
    e. None of the above.
3. Which type cord is classified as "hard usage:"
    a. SJ
    b. HSJ
    c. 500
    d. HS
    e. All of the above.

Answers:

1. b
2. d
3. e

PERFORMANCE GUIDE:

1. Turn power off.
2. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
3. If replacement of service cord is made, cord must be sufficient size for load being served.
4. Remove old cord from appliance and points of attachment.
5. Attach new cord to appliance and secure ends of cord in boxes, leaving sufficient free ends for connections. Maintain strain relief if necessary.
6. Remove sufficient insulation from conductor ends for connections.
7. Connect ends of cable to existing wires or terminals making sure polarity is correct.
8. Turn power on.
9. Check circuit being served for required voltage and polarity.
10. Assure required operation of appliance.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 49

TASK: Replace existing interior load center.

STANDARD OF PERFORMANCE OF TASK: Load center must be replaced with approved equivalent parts. The replacement of an existing interior load center must meet the requirements as outlined by the National Electrical Code (Article 110, Part A, 230, 250, 300, and 240) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-21, 57-110, 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Load center
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify existing load center for the size and type.
2. Determine the proper tools and materials to be used.
3. Recall the proper procedures for removing the old load center.
4. Analyze the condition of the existing mounting surface.
5. Apply the standards of the replacing load centers as required by the National Electrical Code or a local authority.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 115-119.
Foley. **Electrical Wiring Fundamentals,** pp. 251-253.

TEACHING ACTIVITIES:
1. Instruct the students to read **Electrical Wiring,** pp. 115-119 and **Electrical Wiring Fundamentals,** pp. 251-252.
2. Demonstrate the proper connections for checking the voltage.
3. Discuss the procedures for changing an existing service.
4. Have the students identify the main parts of a load center.
5. Make an assignment for the students to bring information on home service center and be ready to describe what would be needed to change it.

CRITERION REFERENCED MEASURE:
Questions:
1. All are ways to increase the load center size except:
   a. Install larger service conductors and increase load center main breaker.
   b. Install complete new service conductors, raceway, weather head, and change load center interior.
   c. Install new meter base in parallel with existing meter.
   d. Make a complete service change out.

PERFORMANCE OBJECTIVE V-TECS 49 (Continued)

2. The article of the National Electrical Code that covers "services" is:
   a. Article 250
   b. Article 220
   c. Article 130
   d. Article 230.
3. The replacing of an existing load center requires strict attention to:
   a. OSHA regulations
   b. The local authority having jurisdiction
   c. Underwriters Laboratories
   d. The National Electrical Code.

Answers:
1. c
2. d
3. b and d

PERFORMANCE GUIDE:
1. Turn power off.
2. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
3. Remove wires from old box and mark circuits.
4. Remove old box.
5. Attach new load center to structure.
6. Connect existing wires to new load center.
7. Insert breakers of proper size and type.
8. Connect existing wires to breakers.
9. Turn power on.
10. Test all circuits.
11. Fill out circuit directory.
12. Replace cover.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 50

TASK: Replace cable.

STANDARD OF PERFORMANCE OF TASK: The replaced cable must meet the requirements as outlined by the National Electrical Code (Article 300, part A. and Article 200) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 25-27, 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Cable
2. The basic tool kit.

ENABLING OBJECTIVE(S):
1. Identify type and size of cable to be replaced.
2. Determine the proper tools and materials to be used.
3. Identify the construction members common in existing dwellings.
4. Recall the methods of passing around construction members.

RESOURCES:
Miller, **Residential Electrical Wiring,** pp. 296-302.
Foley, **Electrical Wiring Fundamentals,** pp. 253-259.

TEACHING ACTIVITIES:
1. Discuss the terms associated with cable installations of existing dwellings.
2. Discuss the problem areas associated with replacing cable in existing dwellings.
3. Instruct the students to read **Residential Electrical Wiring,** pp. 296-302.
4. Demonstrate the techniques for the fishing of new cables.
5. Provide the students with a field trip to an old house in the process of remodeling, to view exposed construction members.

CRITERION REFERENCED MEASURE:
Questions:
1. A construction member that might exist between two 2 x 4 studs is called:
   a. Rafter
   b. Pier
   c. Girder
   d. Fire stop.
2. Cables run through notches in wood must be protected by a steel plate of:
   a. 1.16 inches thick
   b. 1/4 inches thick
   c. 1/8 inches thick
   d. 3/16 inches thick.

PERFORMANCE OBJECTIVE V-TECS 50 (Continued)

3. The general N.E.C. rule is that cable installed in exposed areas must be:
   a. Run in short lengths
   b. Of galvanized materials
   c. Protected from damage
   d. At least #8 copper.

Answers:
1. d
2. a
3. c

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Remove old cable being replaced.
5. Terminate cable inside an enclosure through approved connectors.
6. Connect cable to terminals or splice to other conductors with approved splices. Connections must be tight and polarity correct.
7. Tape or otherwise insulate connections to withstand applied voltage where required.
8. Turn power on.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 51

TASK: Replace circuit breakers.

STANDARD OF PERFORMANCE OF TASK: Breakers must be identified for use with panel, must be of required size and type, and must be fully inserted to engage with the busses.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Breakers
2. The basic tool kit.

ENABLING OBJECTIVE(S):
1. Identify the type and size of the circuit breakers.
2. Determine the proper tools and materials to be used.
3. Recognize the method of removing the circuit breakers.
4. Recall the proper safety techniques.

RESOURCES:

Alerich, **Electrical Construction Wiring,** pp. 280-282.
Foley, **Electrical Wiring Fundamentals,** pp. 169-172.

TEACHING ACTIVITIES:
1. Provide the students with various types of circuit breakers.
2. Discuss the differences in circuit breakers.
3. Instruct the students to read **Electrical Construction Wiring,** pp. 280-282.
4. Demonstrate the procedure for changing circuit breakers.
5. Have students identify the brand and size of circuit breakers used at home load center.
6. Conduct a tour for the students to view circuit breakers in different parts of the building.

CRITERION REFERENCED MEASURE:

Questions:
1. What position will a circuit breaker be in after being tripped?
2. Why is it desirable for overcurrent protection devices to allow short term, moderate overloads without cutting off power to circuit?
3. What are circuit breakers, like fuses rated for?
4. What sizes are circuit breakers rated for residential use?
5. The National Electrical Code requires what of circuit breakers?

Answers:
1. Center position, usually with a red flag as an indication for being tripped.
2. This provides enough delay to allow a motor driven appliance to be used without tripping the circuit breaker.
3. For voltage and interrupting current.
4. 15 to 200 amperes.
5. Must be clearly marked "off" and "on."

PERFORMANCE OBJECTIVE V-TECS 51 (Continued)

PERFORMANCE GUIDE:

1. Turn power off.
2. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
3. Remove one breaker from panel.
4. Remove conductor from old breaker.
5. Connect new breaker to conductor.
6. Install breaker to panel.
7. Replace each breaker in the same manner.
8. Turn power on.
9. Assure required operation.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 52

TASK: Replace existing receptacle or switch.

STANDARD OF PERFORMANCE OF TASK: Switch and/or receptacle must be replaced with one of same type and voltage rating as original. Switch and/or receptacle must be mounted in same position as original and covers in place, straight, and plumb. The installation of the switch and/or receptacle must meet the requirements as outlined by the National Electrical Code (Article 210) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 27-38.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the type and size of the receptacle or switch.
2. Determine the proper tools and materials to be used.
3. Recall the proper safety techniques.

RESOURCES:
Foley, **Electrical Wiring Fundamentals,** pp. 141-152.
Colvin, **Electrical Wiring,** pp. 78-90, 94-111.

TEACHING ACTIVITIES:
1. Discuss the terms associated with receptacles and switches.
2. Provide the students with various types of receptacles and switches.
3. Instruct students to read **Electrical Wiring Fundamentals,** pp. 141-152.
4. Demonstrate the procedure for changing receptacles or switches.
5. Have the students practice making wire connections on receptacles and switches.

CRITERION REFERENCED MEASURE:
Questions:
1. The most common type of receptacle is:
   a. Single receptacle type
   b. Single receptacle with a switch
   c. Duplex receptacle with weatherproof cover
   d. Standard grounding duplex receptacle.
2. By removing the break off connection tab between the brass terminals of a receptacle, you:
   a. Make it a fire hazard
   b. Have a reduced utility bill
   c. Create a short circuit
   d. Make it possible to connect a separate circuit.

PERFORMANCE OBJECTIVE V-TECS 52 (Continued)

3. You can identify the common terminal on a 3-way switch by:
    a. The different color than other terminals
    b. The word "common" on back of switch
    c. Using an ohmmeter
    d. All of the above.

Answers:
1. d
2. d
3. d

PERFORMANCE GUIDE:
1. Turn power off.
2. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
3. Remove switch or receptacle from box.
4. Disconnect conductor from existing receptacle and switch.
5. Connect switch or receptacle observing correct polarity.
6. Connect ground wire to grounding terminal on receptacle.
7. Push switch or receptacle into outlet box and tighten screws.
8. Replace outlet covers.
9. Turn power on.
10. Check for proper polarity.
11. Turn switch on.
12. Assure receptacle/switch.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 53

TASK: Replace fuses.

STANDARD OF PERFORMANCE OF TASK: The fuses must meet the requirements as outlined by the National Electrical Code (Article 240, Part E) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 80-81.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Assortment of fuses
2. The basic tool kit.

ENABLING OBJECTIVE(S):
1. Identify the various types of fuses.
2. Determine the proper tools and materials to be used.
3. Determine the cause for replacing fuses.
4. Test the condition of the new fuse.

RESOURCES:
Foley, **Electrical Wiring Fundamentals,** pp. 166-169.
Alerich, **Electrical Construction Wiring,** pp. 282-289.

TEACHING ACTIVITIES:
1. Provide the students with various types and sizes of fuses for viewing.
2. Demonstrate the procedure for checking fuses with a volt ohmmeter.
3. Demonstrate the use of a fuse puller.
4. Instruct the students to read Article 240 from the **National Electrical Code.**
5. Conduct a tour for the students to view various fuses used throughout the building.
6. Instruct the students to read **Electrical Wiring Fundamentals,** pp. 166-169.

CRITERION REFERENCED MEASURE:
Questions:
1. Generally speaking, what is the maximum voltage of a circuit that a plug fuse can be used in?
2. What are the amperage ratings of plug fuses used in residences?
3. Circuits rated over 30 amperes must use what type of fuse?
4. What type of fuse is used when a heavy starting current is drawn by a motor?
5. What is a nontamperable type fuse that uses a special mechanical design?

PERFORMANCE OBJECTIVE V-TECS 53 (Continued)

Answers:

1. 125 volts between conductors: 240-50 A. N.E.C.
2. 15, 20, 25, and 30 amperes
3. Cartridge type fuses
4. A time delay fuse
5. A type "S" fuse

PERFORMANCE GUIDE:

1. Turn power off serving fuse panel.
2. Remove cover from fuse panel so wire size can be observed if there is a question as to fuse size.
3. Check wiring connections.
4. Insert all fuses of correct size and type. Be sure all fuses are tight in holders.
5. Turn power on.
6. Check voltage with tester at each fuse holder.
7. Replace fuse panel cover.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 54

TASK: Replace grounding electrode conductor.

STANDARD OF PERFORMANCE OF TASK: Connections must be made at designated points and must be tight. The installation of the grounding electrode conductor must meet the requirements as outlined by the National Electrical Code (Article 250-92 and Table 250-94) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 102-104.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Grounding electrode conductor
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the proper size conductor to be used.
2. Determine the proper tools and materials to be used.
3. Determine the proper points of connection.

RESOURCES:
National Electrical Code, 1984. Article 250-92 and 250-94.

TEACHING ACTIVITIES:
1. Provide the students with various sizes of grounding conductors.
2. Demonstrate the procedures for checking voltage on conductors.
3. Emphasize the importance of secure fittings.
4. Show the students the points of connection to system.
5. Conduct a field trip for the students to view examples of proper installations.
6. Instruct the students to read **National Electrical Code,** Article 250-92 and 250-94.

CRITERION REFERENCED MEASURE:
Questions:
1. Aluminum or copper clad aluminum cannot be used in contact with masonry or earth. (True or False)
2. Grounding electrode conductor connections must be made on the load side termination lugs of a meter. (True or False)
3. Number 6 or larger conductors must be in conduit if subject to physical damage. (True or False)
4. A grounding electrode conductor can originate at the load center or in the meter base. (True or False)
5. The National Electrical Code lists the minimum size grounding electrode conductors used. (True or False)

PERFORMANCE OBJECTIVE V-TECS 54 (Continued)

Answers:
1. True
2. False
3. True
4. True
5. True

PERFORMANCE GUIDE:
1. Call power company to turn power off.
2. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
3. Locate termination points of conductor.
4. Loosen terminals and remove defective conductor from terminals and structure.
5. Apply corrosive inhibitor, if required by local authorities.
6. Terminate grounding conductor at points designated by authority having jurisdiction.
7. Fasten conductor to previously installed grounding electrode with clamp approved for direct burial. Connections must be tight.
8. Attach conductor securely to structure.
9. Call power company to turn power on.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 55

TASK: Replace pilot light bulb.

STANDARD OF PERFORMANCE OF TASK: The bulb must burn, be of the required size and voltage, and indicate when the appliance or equipment is working. All connections must be tight. Connectors must be suitable for the conditions encountered.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Pilot bulb
2. The basic tool kit.

ENABLING OBJECTIVE(S):
1. Identify the proper size and voltage rating of pilot light replacement.
2. Determine the proper tools and materials to be used.
3. Determine the proper disconnection of power for the replacement of the pilot light bulb.

RESOURCES:
Miller. **Industrial Electricity,** p. 308.

TEACHING ACTIVITIES:
1. Demonstrate to the students the various types of pilot lights.
2. Demonstrate the procedure for checking voltage at the point of connections.
3. Demonstrate the removal of the pilot light lamp.
4. Have the students read and trace wiring diagram for proper connection.
5. Instruct the students to read **Industrial Electricity,** p. 308.

CRITERION REFERENCED MEASURE:

Questions:
1. What is the most important part in the changing of a pilot light lamp?
2. What does a lit pilot light usually indicate?
3. What two things does an unlit pilot light usually indicate?

Answers:
1. The new lamp must be of required size and voltage.
2. The equipment or appliance is working.
3. The power is either not on or the lamp is burned out.

PERFORMANCE OBJECTIVE V-TECS 55 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Remove required cover plates and trim to get to bulb.
5. Replace the bulb with the new one.
6. Make necessary wiring connections, if any.
7. Replace cover plates.
8. Replace trim.
9. Turn power on.
10. Assure required operation of pilot light.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 56

TASK: Replace service entrance.

STANDARD OF PERFORMANCE OF TASK: All service equipment and wiring must have sufficient ampacity to serve the purpose. All connections must be tight. The service entrance must be grounded. The replacement of the service entrance must meet the requirements as outlined by the National Electrical Code (Article 230, 250, 310, and 110) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 16-24, 57-74, 83-110, 124-161.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Installation/electrical materials
2. The basic tool kit.

ENABLING OBJECTIVE(S):
1. Identify service entrance materials by terminology.
2. Determine proper tools and materials to be used.
3. Identify the requirements of National Electrical Code dealing with service entrance replacement.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 255-294.
Foley. **Electrical Wiring Fundamentals,** pp. 176-197.

TEACHING ACTIVITIES:
1. Discuss the local policies dealing with service changes.
2. Invite the local electrical inspector to talk to the class.
3. Provide the students with a list of terms associated with services for discussion.
4. Show and explain parts of a service entrance.
5. Have the students calculate a residential service size.
6. Instruct the students to read **Electrical Construction Wiring,** pp. 255-294.
7. Conduct a field trip for the students to view various examples of service entrance installations.

CRITERION REFERENCED MEASURE:
Questions:
1. The portion of a service raceway that extends through a roof or eave is called:
   a. Roof lashing
   b. Service lateral
   c. Service drop
   d. Service mast.

PERFORMANCE OBJECTIVE V-TECS 56 (Continued)

2. The National Electrical Code specifies that conductors for 120/240 volt services must:
   a. Be 10 feet above grade or ground level
   b. Be attached under the eaves
   c. Never cross a sidewalk or driveway
   d. Be 18 feet above the point of attachment.
3. Which is not a main part of a service entrance?
   a. Service head
   b. Meter
   c. Service panel
   d. Water pipe ground.
4. Which is not another name for service panel?
   a. Distribution panel
   b. Load control
   c. Panelboard
   d. Load center.
5. The size of service equipment will:
   a. Determine the size of the grounding electrode.
   b. Have sufficient ampacity to serve the purpose.
   c. Determine the power companies service conductors.
   d. Include all the above.

Answers:
1. d
2. a
3. d
4. b
5. d

PRACTICAL APPLICATION:

Replace an old existing service entrance with a new system. The service must be of sufficient ampacity and be well grounded. It must also meet all local and national requirements.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist Performance Objective 56 to determine if the assignment was completed with at least a 90 percent accuracy.

PERFORMANCE GUIDE:

1. Remove power from existing service. (Check with power distributor).
2. Remove existing service entrance.
3. Attach new meter base to structure.
4. Attach new service panel to the structure.
5. Run conduit or service cable from the service panel to the meter base.
6. Run conduit or service cable from the meter base to the service drop.
7. Attach conduit or cable to the structure.
8. If conduit, run conductors through conduit.
9. Install weatherhead.
10. Install new grounding electrode and grounding electrode conductor if required.
11. Test for shorts and grounds.
12. Have service entrance inspected.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 56 EVALUATION

SERVICE ENTRANCE REPLACEMENT

Student's Name **Date**

DIRECTIONS TO STUDENT: Replace an old existing service entrance with a new system. The service must be of sufficient ampacity and be well grounded. It must also meet all local and national requirements.

DIRECTIONS TO INSTRUCTOR: Observe the student. Pay close attention to the items to be evaluated. Watch for safety violations. Allow the student a reasonable amount of time as would be required on the job site. A score of 90 percent is required for competency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student checked for power disconnection.		
2. The student removed the existing service entrance.		
3. The student determined the size for the new service.		
4. The student attached a new meter base to structure.		
5. The student attached a new service panel to structure (if needed).		
6. The student connected the service panel to meter with conduit or service cable.		
7. The student attached the conduit or cable riser.		
8. The student attached weatherhead.		
9. The student ran conductors through conduit (if needed).		
10. The student installed a new grounding electrode and grounding electrode conductor.		

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 56 EVALUATION (Continued)

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
11. The student prepared all terminal connections tight and with lubricant.	______	______
12. The student checked for proper voltages after connection by the power company.	______	______
13. The student called for an inspection.	______	______
14. The student followed safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ Date

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 57

TASK: Replace transformer.

STANDARD OF PERFORMANCE OF TASK: The transformer must match or exceed the rating of the original transformer.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A transformer
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the type and sizes of transformers.
2. Determine the proper tools and materials to be used.
3. Identify the terms associated with transformers.
4. Determine the correct voltage readings.

RESOURCES:

Alerich. **Electricity 3,** pp. 129-148.
Gebert. **Transformers,** pp. 314-332.
National Electrical Code Committee, National Electrical Code, 1981. Article 450.

TEACHING ACTIVITIES:
1. Provide the students with various types and sizes of transformers for viewing.
2. Illustrate various transformer diagrams.
3. Have the students view different transformer plates for hook-ups.
4. Discuss Article 450 of the **National Electrical Code** on transformers with the students.
5. Provide the students with a tour of a plant containing many transformers.
6. Invite a representative from a transformer company to speak to the class.
7. Make a transformer for demonstration.
8. Demonstrate the proper and safe method of using an insulation tester to test a transformer.

CRITERION REFERENCED MEASURE:

Questions:
1. According to the National Electrical Code, where should the high voltage side of a transformer be located?
   a. Inside junction box
   b. Near center of stud
   c. Near an air vent
   d. In open areas only.

PERFORMANCE OBJECTIVE V-TECS 57 (Continued)

2. The most commonly used transformer in residential usage is:
    a. One-to-one type
    b. Autotransformer
    c. Step-up type
    d. Step-down type.
3. When replacing an old transformer, you should:
    a. Be concerned about physical size
    b. Purchase a higher rated voltage
    c. Use the manufacturer's recommendations
    d. None of the above.

Answers:

1. a
2. d
3. c

PERFORMANCE GUIDE:

1. Locate existing transformer.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Remove the existing transformer.
5. Read manufacturer's instructions for the replacement transformer.
6. Attach the transformer to the device.
7. Remove cover plates.
8. Make necessary wiring connections, using appropriate connectors.
9. Replace all cover plates.
10. Turn power on.
11. Assure required operation of the transformer.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 58

TASK: Service electric motors.

STANDARD OF PERFORMANCE OF TASK: The motor must be cleaned of dust and other foreign materials. Connections must be checked. All bearings must be oiled or greased.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Electric motors
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the terminology associated with motors.
2. Determine the proper tools and materials to be used.
3. Identify the importance of selecting the proper cleaning materials.

RESOURCES:
Alerich. **Electricity 4,** pp. 141-153.

TEACHING ACTIVITIES:
1. Review the routine maintenance recommendations with students.
2. Demonstrate the special areas for cleaning.
3. Provide the students with various types and sizes of motors for viewing.
4. Demonstrate the proper techniques for checking the voltage on motors.
5. Invite a motor manufacture representative to talk to the class on servicing electric motors.
6. Demonstrate the proper procedure for cleaning to prevent damage to interior motor wiring.
7. Demonstrate proper procedures for checking motor lead connections for tightness, routing and continuity.
8. Demonstrate proper procedure for lubricating different types of bearings.

CRITERION REFERENCED MEASURE:
Questions:
1. Careful motor troubleshooting requires the use of:
   a. The sense of smell
   b. The sense of feel
   c. Hearing and vision
   d. All of these.
2. Ball bearings should be removed from a motor shaft using a:
   a. Ball pin hammer
   b. Bearing puller
   c. Balance tester
   d. Gear puller.

PERFORMANCE OBJECTIVE V-TECS 58 (Continued)

3. Periodic inspection of motors is important because:
   a. It is required by the job standards
   b. It completes a day's work
   c. It is a requirement of supervision
   d. It gives advance notice of impending trouble.

Answers:
1. d
2. b
3. d

PERFORMANCE GUIDE:
1. Locate motor to be serviced.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Remove protective covers as required.
5. Clean motor of all foreign materials (dust, straw, lint etc.).
6. Check all wiring connections.
7. Oil or lubricate as required.
8. Replace all protective covers.
9. Turn power on.
10. Assure required operation of motor.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 59

TASK: Test for correct voltage.

STANDARD OF PERFORMANCE OF TASK: Voltage must be equal to the unit data plate requirements or the same as supplied by the power distributor for a given circuit.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A power source
2. The basic tool kit.

ENABLING OBJECTIVE(S):
1. Determine the proper tools to be used.
2. Identify the needed voltage for the correct operations.

RESOURCES:
Foley. **Electrical Wiring Fundamentals,** pp. 68-72.

TEACHING ACTIVITIES:
1. Discuss the different types of voltage recording devices.
2. Demonstrate the ways to find circuit to be tested for correct voltage.
3. Have the students measure low voltage and high voltage with a volt ohmmeter.
4. Have students measure unknown voltages set up by the instructor.
5. Discuss the safety practices that should be used when measuring live circuits.

CRITERION REFERENCED MEASURE:

Questions:
1. How must a voltmeter be connected to measure voltage across a load?
2. Why should voltage testers be tested before use?
3. If the National Electrical color code has been followed, what color will a wire circuit be?

Answers:
1. It must be connected parallel with circuit load.
2. To assure there is no breaks in the test leads
3. Black, white and red

PERFORMANCE GUIDE:
1. Locate circuit to be tested.
2. Determine what voltage should be.
3. Turn circuit on at the distribution service panel or switch.
4. Check voltage using voltmeter.

DUTY: MAINTAINING EXISTING WIRING

PERFORMANCE OBJECTIVE V-TECS 60

TASK: Troubleshoot a branch circuit.

STANDARD OF PERFORMANCE OF TASK: A circuit must be checked for open circuits, short circuits, correct voltage and correct polarity. All connections must be tight. The voltage must be as required and the circuit must function.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A defective branch circuit
2. The basic tool kit.

ENABLING OBJECTIVE(S):
1. Identify the principles of the electrical circuit operation.
2. Identify the conditions that effect proper electrical operation.
3. Determine the proper tools and materials to be used.

RESOURCES:
Foley. **Electrical Wiring Fundamentals,** pp. 230-242.
Miller. **Industrial Electricity,** pp. 343-345.

TEACHING ACTIVITIES:
1. Define "troubleshooting."
2. Have the students read **Electrical Wiring Fundamentals,** pp. 230-242.
3. Demonstrate the simple circuit problems using troubleshooting process.
4. Invite a potential employer to discuss the importance of sound troubleshooting techniques.
5. Have the class work together on designing a troubleshooting chart.
6. Demonstrate troubleshooting techniques used to locate an open or a short circuit in a typical bench circuit.
7. Demonstrate the procedure for checking the voltage and polarity of a typical branch circuit.

CRITERION REFERENCED MEASURE:
Questions:
1. What type of tests are made to check connections for breaks in wiring?
2. What are the two most common problems in electrical work?
3. Define troubleshooting.
4. When an outlet or device is properly wired, it is said to have what?

Answers:
1. A continuity test
2. Short circuits and open circuits
3. The systematic diagnosis of malfunctions
4. Correct polarity.

PERFORMANCE OBJECTIVE V-TECS 60 (Continued)

PRACTICAL APPLICATION:

Troubleshoot a defective fluorescent light fixture. Make the needed repairs to assure the proper operations.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist Performance Objective 60 to determine if the assignment was completed with at least a 90 percent accuracy.

PERFORMANCE GUIDE:

1. Turn power off, if required.
2. Locate the power source and the route of the circuit to be checked.
3. Remove all cover plates.
4. Check all connections.
5. Check voltage with voltmeter at each outlet beginning at the service panel.
6. Check each outlet for correct polarity.
7. When short, open, or faulty circuit has been located, using ohmmeter, repair or replace the circuit.
8. Replace all protective covers.
9. Turn power on.
10. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 60 EVALUATION

PERFORMANCE TEST FOR TROUBLESHOOTING

Student's Name **Date**

DIRECTIONS TO STUDENT: Troubleshoot a defective fluorescent light fixture. Make needed repairs to assure proper operation.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to items to be evaluated. The student is to complete the task in a reasonable amount of time with a score of 90 percent for competency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student turned the power off.	____	____
2. The student removed the fixture cover.	____	____
3. The student turned the power on.	____	____
4. The student checked for proper lamp alignment.	____	____
5. The student visually checked wiring.	____	____
6. The student checked the lamp sockets.	____	____
7. The student replaced the lamps with new lamps.	____	____
8. The student checked for proper voltage.	____	____
9. The student turned the power off.	____	____
10. The student replaced the ballast with a new one.	____	____
11. The student completed the task in a reasonable amount of time.	____	____
12. The student followed safety procedures.	____	____

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

OPERATING BUSINESS

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 61

TASK: Develop employee work schedules.

STANDARD OF PERFORMANCE OF TASK: The schedule must insure that all work will be finished by scheduled completion dates.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A list of employees (including a description of employee's competencies).
2. Lists of jobs to be accomplished (including scheduled completion dates).

ENABLING OBJECTIVE(S):
1. Identify and use materials and tools needed for the assignment.
2. Identify technique of scheduling around assemblies and holidays.
3. Interpret areas needing revisions to accomplish work as scheduled.

RESOURCES:
Weaver. **Shop Organization and Management,** pp. 81-90.

TEACHING ACTIVITIES:
1. Instruct the student to read bulletins and job sheet on the job to be completed as used as the textbook **Shops Organization and Management,** pp. 81-90.
2. Discuss the different methods of job assignments.
3. Determine if the job requires shift work.
4. Identify the type of personnel required for the assignment.
5. Have the student practice working up a schedule.

CRITERION REFERENCED MEASURE:
Questions:
1. The student's knowledge of a particular task:
   a. Should be considered
   b. Makes no difference
   c. Helps when making assignment
   d. Both a and c.
2. What items should be considered when planning a schedule?
   a. Personnel, equipment, experience, and time
   b. Personnel, experience and equipment
   c. Personnel, experience
   d. None of the above.
3. Things that could interrupt a work schedule are:
   a. Customer
   b. Holidays
   c. Worker experience
   d. All of the above.

PERFORMANCE OBJECTIVE V-TECS 61 (Continued)

Answers:
1. d
2. a
3. d

PERFORMANCE GUIDE:
1. Prioritize jobs to be accomplished.
2. Assign employees to jobs consistent with their competencies.
3. Assign employees to jobs according to priority.
4. Assign employees to job according to time required to complete job.
5. Schedule work around use of equipment and facilities.
6. Schedule work around special occasions: i.e., holidays, customer convenience, etc.
7. Revise schedule to insure completion of work by scheduled date.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 62

TASK: Develop/maintain filing system.

STANDARD OF PERFORMANCE OF TASK: Any randomly selected document should be retrieved within one minute.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A requirement for a filing system
2. Supplies
3. Materials to be filed.

ENABLING OBJECTIVE(S):
1. Use proper methods for setting up filing system.
2. Read and interpret directives to establish a filing system.
3. Recall the techniques in setting up a filing system.

RESOURCES:
Weaver. **Shop Organization and Management,** p. 134

TEACHING ACTIVITIES:
1. Instruct the student to read sample directives, establishing the local filing system.
2. Discuss the different types of filing systems.
3. Identify the different types of folders used to set up files.
4. Demonstrate how the files are indexed.
5. Have students practice filing.
6. Explain the reasons for maintaining a file.

CRITERION REFERENCED MEASURE:
Questions:
1. Why should test be filed?
   a. Security
   b. Convenient
   c. Reference
   d. All of the above.
2. A file should be maintained on each:
   a. Student
   b. Trainer
   c. Test
   d. Office bulletin.
3. Where should official records be stored?
   a. Homeroom
   b. Guidance office
   c. Central office.

PERFORMANCE OBJECTIVE V-TECS 62 (Continued)

Answers:
1. d
2. a
3. c

PERFORMANCE GUIDE:
1. Analyze record keeping requirements.
2. Scan data/materials for possible classifications/groupings.
3. List logical methods of filing, i.e., alphabetical, numerical, geographical, chronological, or functional.
4. Select appropriate system and subsystem if applicable.
5. Write out plan.
6. Sort and assemble data in accordance with system or method selected.
7. Prepare folders, labels, and index in accordance with method selected.
8. ..e the materials.
9. Perform file maintenance as necessary.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 63

TASK: Establish and record pay scale and benefits for employees.

STANDARD OF PERFORMANCE OF TASK: The developed pay scale and benefits must assure competitive compensation for retention of qualified employees.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Access to employee wage, hour, and tax information.
2. Potential benefits for workers.

ENABLING OBJECTIVE(S):
1. Identify the terminology used with payroll deductions.
2. Use proper procedures in figuring salary deductions.
3. Read and interpret information given in sample district bulletins.

RESOURCES:
Richland School District Two Employee Handbook, 1985-86.

TEACHING ACTIVITIES:
1. Instruct the student to read a sample employee handbook.
2. Discuss incentive pay for the outstanding employee.
3. Identify the basic pay scale.
4. Demonstrate procedures used in determining salary deductions.
5. Explain the company fringe benefit policy.

CRITERION REFERENCED MEASURE:
Questions:
1. Gross salary includes earnings before:
   a. Social security
   b. Federal tax
   c. State tax
   d. Retirement
   e. Annuity
   f. All of the above.
2. Fringe benefits are ___________ to gross earnings.
   a. in addition
   b. included
   c. voluntary
   d. none of the above.
3. One standard deduction is:
   a. Insurance
   b. United fund
   c. Social security
   d. Car payment.

PERFORMANCE OBJECTIVE V-TECS 63 (Continued)

Answers:
1. f
2. a
3. c

PERFORMANCE GUIDE:
1. Establish wage incentives.
2. Establish and record base pay.
3. Establish fringe benefits.
4. Establish and record dollar value of fringe benefits.
5. Establish and record tax advantages of fringe benefits.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 64

TASK: Estimate cost of a job.

STANDARD OF PERFORMANCE OF TASK: The estimate must include the cost of materials, cost of labor, overhead cost, and expected profit and must be within ± 5% of that estimated by the architect or chief estimator.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The drawings and specifications of a specific installation
2. All the necessary forms, schedules, and current pricing information.

ENABLING OBJECTIVE(S):
1. Determine proper forms used in estimating job cost.
2. Read and interpret blueprints.
3. Recall technique of figuring labor schedule.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 453-467.

TEACHING ACTIVITIES:
1. Instruct the student to read **Electrical Construction Wiring,** pp. 453-467.
2. Discuss initial cost of material, labor and overhead.
3. Determine the profit expected from the job.
4. Demonstrate the procedures used completing the estimate forms.
5. Have students practice estimate from a floor plan.
6. Have students discuss why a proper estimate is important.

CRITERION REFERENCED MEASURE:

Questions:
1. List three proper pricing steps for determining an electrical estimate.
2. How are labor units expressed?
3. What is meant by the term price cost?
    a. Materials
    b. Labor
    c. Materials, labor, overhead, and profit
    d. Materials and labor.

Answers:
1. Cost of materials
2. Operation and time
3. d

PERFORMANCE OBJECTIVE V-TECS 64 (Continued)

PERFORMANCE GUIDE:

1. Study all the drawings and specifications provided.
2. Draw up a list of any or all of the following needed:
   a. Branch circuit schedule
   b. Lighting fixture schedule
   c. Branch circuit materials schedule
   d. Service, feeder, and panel schedule
   e. Labor unit schedule.
3. Transfer the above information to an estimating form including:
   a. Unit cost of materials
   b. Material cost
   c. Unit labor and hours
   d. Labor cost.
4. Add all materials and labor costs.
5. When making an estimate for bidding:
   a. Add overhead
   b. Add tax
   c. Add the expected profit
   d. Add any expense not listed above.
6. Submit the estimate to the requesting authority.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 65

TASK: Terminate employee.

STANDARD OF PERFORMANCE OF TASK: The termination of an employee must be in accordance with established labor practices and laws. The terminated employee must know the reason he/she is discharged and have separation notice. Current work records without errors of the employee must be kept on file.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
A situation where termination of an employee is warranted.

ENABLING OBJECTIVE(S):

1. Interpret grievance procedures.
2. Recall techniques of filing for grievance procedures.

RESOURCES:
Adkins. **Life Skills Program — Keeping My Job: Habits That Help.**

TEACHING ACTIVITIES:

1. Instruct the student to read office policies and procedures for employee termination.
2. Discuss with the employee reasons for termination.
3. Identify the methods of recourse the employee may have.
4. Demonstrate procedures for warning the employee.
5. Have the student practice terminating a employee.
6. Have the student discuss why proper procedures are important.

CRITERION REFERENCED MEASURE:

Questions:

1. Before the employee is terminated all warnings should be:
   a. Oral
   b. Documented.
2. An employee can be terminated for:
   a. Age
   b. Race, creed
   c. Insubordination
   d. Personality conflict.

Answers:

1. b
2. c

PERFORMANCE OBJECTIVE V-TECS 65 (Continued)

PERFORMANCE GUIDE:

1. Document all warnings.
2. Meet with the employee on a one-to-one basis.
3. Discuss the reason for the termination.
4. Document the firing and file with employee records.
5. Notify employee of actions by mail.
6. Complete necessary forms for local, state, and federal agencies as required.
7. File copy for your records.
8. Notify bookkeeper so company records can be adjusted to show termination of employee.
9. Give employee his severance pay.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 66

TASK: Hire employee.

STANDARD OF PERFORMANCE OF TASK: Hiring should be done in accordance with all governing labor practices and laws. Employee must be informed of salary, benefits, and job description.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
A situation where additional employees are needed.

ENABLING OBJECTIVE(S):
1. Fill out a job application.
2. Conduct an interview.

RESOURCES:
Hayden. Job Market.

TEACHING ACTIVITIES:
1. Instruct the student to read office procedures.
2. Identify the need for employment.
3. Role play interviewing a prospective employee.
4. Have student check sample references and work experience.
5. Have student simulate notification of applicants about their standing, and thank them for their interest in the company.
6. Demonstrate procedure for notifying the applicants that they have been selected.

CRITERION REFERENCED MEASURE:
Questions:
1. The interviewee's should be notified of their standings. (True or False)
2. The selectee should be notified:
   a. By telephone
   b. In Writing
   c. Neither (a) nor (b)
   d. Both (a) and (b).
3. The interviewee should __________ for the interview.
   a. chew gum
   b. bring a friend
   c. be on time
   d. talk continuously.

Answers:
1. True
2. d
3. c

PERFORMANCE OBJECTIVE V-TECS 66 (Continued)

PERFORMANCE GUIDE:

1. Determine there is a need to hire an employee.
2. Establish work qualifications needed to fill the job.
3. Advertise the open job.
4. Accept applications and resumes for specified time.
5. Evaluate applications.
6. Schedule interviews.
7. Interview selected applicants.
8. Follow-up on references and prior work experience.
9. Select applicant to be hired.
10. Notify applicant that he/she has been selected.
11. Inform applicant of starting date, time, and other pertinent information.
12. Notify remaining applicants expressing gratitude for their interest in your company. Make them aware that their application will be held for future openings.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 67

TASK: Maintain time records.

STANDARD OF PERFORMANCE OF TASK: The time records must be maintained without computational errors.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Time records
2. Supplies
3. Calculator.

ENABLING OBJECTIVE(S):
1. Use proper records to be maintained.
2. Interpret information to be recorded.
3. Recall technique of time keeping.

RESOURCES:
Weaver. **Shop Organization and Management, p.** 122.

TEACHING ACTIVITIES:
1. Instruct the student to read sample office policy on time keeping.
2. Discuss the different methods of maintaining time records.
3. Identify the different types of time cards, time sheets, etc.
4. Demonstrate posting the time data on the time record.
5. Have the student calculate a sample time for a pay period.

CRITERION REFERENCED MEASURE:
Questions:
1. Most companies pay once every:
   a. Week
   b. Two weeks
   c. Month
   d. Day.
2. Large companies use a ___________ for time keeping.
   a. sign in sheet
   b. token system
   c. time clock
   d. supervisor.
3. What is the advantage of keeping records for time spent on production?
   a. Scheduling
   b. Planning
   c. Neither (a) or (b)
   d. Both (a) and (b).

PERFORMANCE OBJECTIVE V-TECS 67 (Continued)

Answers:
1. b
2. c
3. d

PERFORMANCE GUIDE:
1. Locate all time sheets, cards, etc.
2. Post data on permanent time sheets.
3. Compute total time for pay period.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 68

TASK: Negotiate credit.

STANDARD OF PERFORMANCE OF TASK: Interest rates and payment schedules must be analyzed from at least two sources.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
A need for credit.

ENABLING OBJECTIVE(S):
1. Define terms of credit.
2. Use and interpret credit forms.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 453-467.

TEACHING ACTIVITIES:
1. Instruct the student to read loan agency, policy and guide lines.
2. Discuss the amount of credit needed and purpose of credit.
3. Identify different types of credit available.
4. Demonstrate procedures of completing application forms.
5. Have student formulate personal references.

CRITERION REFERENCED MEASURE:

Questions:
1. The loan officer conducting the interview is protecting:
   a. His money
   b. The agency
   c. Your company
   d. Both (b) and (c).
2. Your references should be from:
   a. Relatives
   b. Friends
   c. Acquaintances
   d. Business acquaintance.
3. What is meant by prime cost?
   a. Materials
   b. Labor
   c. Materials and labor
   d. Materials, labor, plus overhead expenses.

Answers:
1. d
2. d
3. c

PERFORMANCE OBJECTIVE V-TECS 68 (Continued)

PERFORMANCE GUIDE:

1. Determine amount of credit needed.
2. Make appointment with bank, loan agency, etc.
3. Assemble data to show that your company is a good credit risk.
4. Meet with loan agency and present your proposal to loan agency for credit with data to substantiate your request.
5. Evaluate proposals.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 69

TASK: Obtain insurance.

STANDARD OF PERFORMANCE OF TASK: Insurance coverage must not deviate from prescribed liabilities.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The need for insurance
2. A list of qualified agents

ENABLING OBJECTIVE(S):
1. Determine the types of insurance.
2. Interpret the insurance terminology.

RESOURCES:
Weaver, Shop Organization and Management.

TEACHING ACTIVITIES:
1. Instruct the student to read office policies on insurance requirements.
2. Discuss the type and amount of insurance required.
3. Identify the different policies offered.
4. Have the student complete an insurance application.
5. Discuss the advantage of liability insurance.

CRITERION REFERENCED MEASURE:
Questions:
1. As an electrician you would be required to have a. ________ b. ________ c. ________ coverage.
2. In addition to the above a. ________ b. ________ c. ________ coverage is offered in most cases.
3. What are the advantages of reporting accidents in a formal written report?
   a. Legal support
   b. None
   c. Satisfy the boss
   d. Satisfy the student.

Answers:
1. Fire, theft and liability
2. Hospitalization, life and dental
3. a

PERFORMANCE OBJECTIVE V-TECS 69 (Continued)

PERFORMANCE GUIDE:

1. Determine the type of insurance coverage needed. Example: fire, theft, liability, hospitalization, life, dental, etc.
2. Contact two or more insurance agencies to prepare programs for you.
3. Study and compare the different programs to determine the program which best suits your needs.
4. Obtain a legal opinion of the policies.
5. Select the program which best suits your need.
6. Purchase the insurance program.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 70

TASK: Prepare payroll records.

STANDARD OF PERFORMANCE OF TASK: Prepare a payroll without errors in entries or computations.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Withholding tables
2. Completed time cards
3. Employee earning records
4. Payroll register
5. Checkbook

ENABLING OBJECTIVE(S):
1. Identify and use forms of a payroll record.
2. Interpret techniques for maintaining payroll records.

RESOURCES:
Ross. **Accounting,** pp. 440-452.

TEACHING ACTIVITIES:
1. Have the student read office policies on maintaining payroll.
2. Discuss the deductions.
3. Determine the social security to be withheld.
4. Have the student compute taxes and retirement.
5. Have the student prepare the pay voucher.
6. Have the student prepare the check showing all withholdings.

CRITERION REFERENCED MEASURE:
Questions:
1. List the mandatory deductions from the pay check.
   a. ________
   b. ________
   c. ________
2. FICA and state tax are voluntary deductions in most states. (True or False)
3. The employee may select direct payments for:
   a. House payment
   b. Car payment
   c. Alimony
   d. Credit union.

Answers:
1. FICA, federal and state tax
2. False
3. d

PERFORMANCE OBJECTIVE V-TECS 70 (Continued)

PERFORMANCE GUIDE:

1. Match time cards with employee earning record.
2. Compute gross pay.
3. Determine withholding from federal tax tables.
4. Compute FICA withholding.
5. Compute other withholding or adjustments.
6. Compute net pay.
7. Prove register.
8. Enter data on employee earning record and register.
9. Prepare check in amount of net pay.

DUTY: OPERATING BUSINESS

PERFORMANCE OBJECTIVE V-TECS 71

TASK: Take inventory of materials and tools.

STANDARD OF PERFORMANCE OF TASK: Inventory must contain all materials in stock by quantity and description of like items.

SOURCE OF STANDARD:
Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A supply room or any area containing quantities of equipment
2. Materials
3. Supplies.

ENABLING OBJECTIVE(S):
1. Define the terminology of tools and equipment.
2. Read and interpret information given on instruction sheets.
3. Recall techniques of storing tools.

RESOURCES:
Weaver. **Shop Organization and Management.** pp. 64-70.

TEACHING ACTIVITIES:
1. Instruct the student to read office procedures on inventory.
2. Discuss the different methods maintaining an inventory.
3. Identify the different ways to display tools and equipment.
4. Demonstrate procedures used in documenting inventory.
5. Have student practice locating identification tags on equipment.

CRITERION REFERENCED MEASURE:
Questions:
1. How could errors be avoided when checking in tools and materials?
   a. Use token
   b. Use sign-in-out sheet
   c. Neither (a) nor (b)
   d. Either (a) or (b).
2. Give advantage _____________ or disadvantage _____________ of perpetual inventory.
3. Tools should be marked to prevent:
   a. Theft
   b. Damage
   c. Loaning.

Answers:
1. d
2. Less loss, time consuming
3. a

PERFORMANCE OBJECTIVE V-TECS 71 (Continued)

PERFORMANCE GUIDE:

1. Sort and separate the pieces of equipment.
2. Sort and separate the materials.
3. Sort and separate the supplies.
4. Count and record the number of each item of equipment, materials, and supplies.
5. Recount the number of each item comparing the second count to the record made of the first.

ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 72

TASK: Rough in 120 or 240 volt circuits to distribution panel using nonmetallic sheathed cable (N.M.C.).

STANDARD OF PERFORMANCE OF TASK: Cable(s) must be installed with sufficient length to reach the point of connection. Cable(s) must enter panel through approved connectors. Circuits must be identified as to voltage or load served. The circuits must meet the requirements as outlined by the National Electrical Code (Article 336-5, 336-10) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code. pp. 185-186.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 62-65.

TEACHING ACTIVITIES:
1. Describe the differences in the various distribution panels using a typical panel as an example.
2. Demonstrate the procedure for installing the cable connectors using a typical panel as an example.
3. Explain the procedure for determining the proper cable length inside the panel.
4. Explain the identification of the branch circuits using marking tape and/or panel chart.
5. Have the students install several cables in a typical panel using cable connectors.

CRITERION REFERENCED MEASURE:
Questions:
1. To facilitate ease of maintenance, at least _______ inches of free wire should be protruding from any electrical box.
   a. 4
   b. 6
   c. 8
   d. 10

PERFORMANCE OBJECTIVE V-TECS 72 (Continued)

2. Bends in nonmetallic sheathed cable should not exceed ________ times the diameter of the cable.
   a. 3
   b. 4
   c. 5
   d. 6
3. When installing nonmetallic cable in a box with clamps, you should leave ______ inch of cable sheathing exposed past the clamp in the box.
   a. 1/4
   b. 1/2
   c. 1/4 - 1/2
   d. 1

Answers:
1. b
2. c
3. c

PERFORMANCE GUIDE:
1. Locate installation point.
2. Remove proper size knockout from distribution panel.
3. Attach a nonmetallic connector to distribution panel.
4. Pull cable from the outside of distribution panel through the cable connector to opposite side of panel.
5. Tighten clamp on cable. Be careful not to damage insulation.
6. Identify circuits as to load served.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 73

TASK: Rough in armored cable to outlet box.

STANDARD OF PERFORMANCE OF TASK: Exposed cable must be supported at intervals not exceeding 4½ feet and must be supported within 12 inches of box or fitting. Insulating bushing must be visible after installation. The cable must meet the requirements as outlined by the National Electrical Code (Article 333) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code. pp. 179-181.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Richter. **Practical Electrical Wiring,** pp. 184-189.
Mullin. **Electrical Wiring, Residential.** pp. 32-35.

TEACHING ACTIVITIES:
1. Explain the various uses for armored cable.
2. Demonstrate the procedure for cutting the metal covering from the armored cable.
3. Demonstrate the procedure for installing the armored cable to the outlet box using the various connectors available.
4. Explain the importance of installing the insulating bushing at the end of the metal covering.
5. Have the students install an armored cable to an outlet box using typical connectors.

CRITERION REFERENCED MEASURE:
Questions:
1. Armored cable may be bent to a radius of not less than ______ times the diameter of the cable.
   a. 5
   b. 6
   c. 8
   d. 10

PERFORMANCE OBJECTIVE V-TECS 73 (Continued)

2. To protect the wire insulation from damage by the cut ends of the armor, you should:
   a. Insert a fiber bushing between the armor and wires
   b. File the cut armor ends smooth
   c. Be sure the filler paper protects the wires
   d. Use electrical tape to cover the wires.
3. The armor can be cut from the armored cable using a:
   a. Hacksaw
   b. BX cutter
   c. Pair of lineman pliers
   d. Either (a) or (b).

Answers:
1. d
2. a
3. d

PRACTICAL APPLICATION:
Install armored cable to an outlet box using two conductor cable and a standard armored cable connector.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Checklist for Performance Objective No. 73 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:
1. Remove proper size knockout from outlet box.
2. Remove six inches of armor from cable end.
3. Attach armored cable connector to outlet box.
4. Install insulating bushing.
5. Feed wire through cable connector until cable bottoms out in connector.
6. Tighten connector on armored cable.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 73

PRACTICAL EVALUATION FOR INSTALLING ARMORED CABLE TO AN OUTLET BOX

Student's Name ______________________ **Date** __________

DIRECTIONS TO STUDENT: Rough in armored cable to an outlet box using an armored cable connector.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with 80 percent proficiency level.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	Armor was cut correctly using a hacksaw or BX cutter.	______	______
2.	Fiber antishort bushing was properly placed.	______	______
3.	Armored cable connector was securely installed on cable.	______	______
4.	Knockout in outlet box was properly removed.	______	______
5.	Cable connector was securely installed in knockout opening.	______	______
6.	Locknut was tightened so the teeth bite into the metal box.	______	______
7.	At least six inches of free wire was left in the outlet box.	______	______
8.	Armored cable was secured within twelve inches of the outlet box.	______	______
9.	Work area was cleaned.	______	______

APPROVED: Yes ____ No _____

Evaluator's Signature ______________________ **Date** __________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 74

TASK: Rough in cable between an existing box and newly installed box.

STANDARD OF PERFORMANCE OF TASK: Cable must be of sufficient ampacity to serve the connected load and must be suitable for the location. Interior wall finish must not be damaged. The cable must meet the requirements as outlined by the National Electrical Code (Article 300, Part A) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Power source
2. Previously roughed in wiring
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Richter. **Practical Electrical Wiring,** Chapter 22.
Alerich. **Electrical Construction Wiring,** Chapter 15.

TEACHING ACTIVITIES:
1. Describe the various building construction methods which may be encountered in roughing in the cable.
2. Explain the procedure for determining the cable routing path.
3. Demonstrate the procedure for routing the cable through the existing wall.
4. Demonstrate the procedure for connecting the cable to the outlet boxes using a typical outlet box and cable.
5. Demonstrate the procedure for installing the new outlet box in the existing wall without damage to the wall finish.
6. Have the students rough in the cable in a typical wall structure to a new outlet box.

CRITERION REFERENCED MEASURE:
Questions:
1. The mounting ears on the ends of an outlet box are adjustable to allow for:
    a. Space to work around box
    b. Use in soft wall material
    c. Ease of installation
    d. Various thickness of walls.

PERFORMANCE OBJECTIVE V-TECS 74 (Continued)

2. Cable clamps are not necessary in outlet boxes if the cable can be supported within ______ inches of the box.
   a. 6
   b. 8
   c. 10
   d. 12
3. When pulling type NM cable, the Code states that no bend shall have a radius less than ______ times the diameter of the cable.
   a. 3
   b. 4
   c. 5
   d. 6

Answers:
1. d
2. b
3. c

PRACTICAL APPLICATION:

Rough in a nonmetallic sheathed cable between an existing outlet box and a newly installed outlet box.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use Checklist for Performance Objective No. 74 to determine if the assignment was completed with at least 80 percent proficiency.

PERFORMANCE GUIDE:

1. Turn power off.
2. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
3. Determine route for the cable to travel.
4. Bore holes for cable as needed.
5. Remove knockout from both boxes.
6. Run cable.
   a. If armored cable, fasten cable to boxes with appropriate connector and install insulated bushing.
   b. If nonmetallic cable, run cable into boxes and fasten cable to structure. Be sure to leave approximately six inches of free standing wire in each box.
7. Turn power on.
8. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 74

PRACTICAL EVALUATION FOR ROUGHING IN TYPE NM CABLE TO EXTEND A CIRCUIT

____

Student's Name **Date**

DIRECTIONS TO STUDENT: Rough in the NM cable from an existing outlet box to a newly installed box in old work.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency level.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student turned off power.	______	______
2. The student properly routed the cable.	______	______
3. The student properly supported the cable.	______	______
4. The student installed the connectors.	______	______
5. The student left six inches of free wire in each box.	______	______
6. The student left 1/4 to 1/2 inch of outer sheathing in each box.	______	______
7. The student checked for proper operation.	______	______
8. The student cleaned the work area.	______	______

APPROVED: Yes _____ No _____

____

Evaluator's Signature **Date**

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 75

TASK: Rough in cable or conduit for branch circuits.

STANDARD OF PERFORMANCE OF TASK: The installation must be completed without damaging the interior finish. Cable or conduit must be of correct size for the load to be served. Cable or conduit must extend from power source to the outlet box of the load served and must terminate in approved fittings. The branch circuits must meet the requirements as outlined by the National Electrical Code (Article 300, part A, and Article 250) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 83-110, 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 151-156.
Richter. **Practical Electrical Wiring,** pp. 164-180.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the correct size of conduit for the installation.
2. Describe the various types of conduit and connectors using examples of each.
3. Demonstrate the procedure for preparing the conduit for installation.
4. Demonstrate the procedure for supporting the conduit using the various means available.
5. Demonstrate the roughing in of the conduit using a typical wall structure and materials.
6. Demonstrate the procedure for pulling the conductors in the conduit.
7. Have the students install a branch circuit using conduit and individual conductors.

CRITERION REFERENCED MEASURE:
Questions:
1. A run of conduit must not contain more than the equivalent of:
    a. Four quarter bends per ten feet of conduit;
    b. Two quarter bends per ten feet of conduit;
    c. Two quarter bends per two sections of conduit;
    d. Four quarter bends totaling 360 degrees.

PERFORMANCE OBJECTIVE V-TECS 75 (Continued)

2. EMT conduit must be supported within _____ feet of each outlet box and at least every _____ feet thereafter.
   a. 1, 10
   b. 2, 6
   c. 3, 10
   d. 3, 6
3. EMT shall **NOT** be used:
   a. Where it will be subject to severe physical damage;
   b. Where protected from corrosion solely by enamel;
   c. In cinder concrete or cinder fill where subject to moisture;
   d. All of the above.

Answers:
1. d
2. c
3. d

PRACTICAL APPLICATION:

Install the conduit and conductors for a branch circuit from power source to the outlet box.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective No. 75 to determine if the assignment was completed with at least 80 percent proficiency.

PERFORMANCE GUIDE:

1. Determine the location for installing the cable or conduit.
2. Remove knockout or provide opening for boxes.
3. Install cable connector or conduit connector.
4. Pull cable for circuit or run conduit for circuit.
5. If conduit, pull conductors through conduit.
6. If metallic conduit, install insulated bushing.
7. Attach cables or raceway to structure as required.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 75

PRACTICAL EVALUATION FOR ROUGHING IN CONDUIT AND CONDUCTORS FOR BRANCH CIRCUITS

Student's Name ________________________ **Date** ________

DIRECTIONS TO STUDENT: Rough in the conduit and conductors for a branch circuit from the power source to the outlet box using EMT.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job at an 80 percent proficiency level.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected the correct size conduit.	____	____
2. The student routed the conduit properly.	____	____
3. The student installed the connectors properly.	____	____
4. The student pulled the required conductors into the conduit.	____	____
5. The student supported the conduit per Code requirements.	____	____
6. The student left at least six inches of free wire.	____	____
7. The student cleaned the work area.	____	____

APPROVED: Yes _____ No _____

Evaluator's Signature ________________________ **Date** ________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 76

TASK: Rough in the circuit for a device controlled by two three way switches with feed to the switch box.

STANDARD OF PERFORMANCE OF TASK: The cable must be installed in the most direct path. Power source must terminate at one of the switch outlets. There must be sufficient conductors in each box for the circuit to function. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300, Part A) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 55-67.
Rockis. **Residential Wiring,** pp. 79-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the cable size of sufficient ampacity for the load.
2. Describe the various types of nonmetallic cable to be used in three way switch circuits.
3. Demonstrate the routing and securing of the cable using a typical wall structure and nonmetallic cable.
4. Demonstrate the procedure for securing the cable to the outlet boxes using the various types of connectors available.
5. Demonstrate the procedure for stripping the outer covering from the cable in the outlet box.
6. Have the students install a three way switch circuit using nonmetallic cable.

CRITERION REFERENCED MEASURE:
Questions:
1. Type NM cable must be secured within ______ inches of the outlet box and at intervals of not more than ______ feet.
   a. 8, 2
   b. 10, 2
   c. 12, 3
   d. 12, 4½

PERFORMANCE OBJECTIVE V-TECS 76 (Continued)

2. Bends made in nonmetallic cable shall have a radius less than ______ times the diameter of the cable.
   a. four
   b. five
   c. six
   d. seven
3. To facilitate ease of maintenance, at least ______ inches of free wire should be left inside each outlet box.
   a. four
   b. five
   c. six
   d. seven

Answers:
1. d
2. b
3. c

PRACTICAL APPLICATION:
Rough in the nonmetallic sheathed cable to a three way switch circuit with the source at the switch outlet box.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for Performance Objective 76 to determine if the assignment was completed with at least 80 percent proficiency.

PERFORMANCE GUIDE:
1. Locate previously installed boxes.
2. Run a two wire cable of proper size to the device being controlled from the remaining switch box.
3. Strip at least six inches of outer jacket from each cable.
4. Attach cable in outlet boxes using approved connectors.
5. Attach cable to building structure at required intervals.
6. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 76

PRACTICAL EVALUATION FOR ROUGHING IN A THREE WAY SWITCH CIRCUIT

Student's Name **Date**

DIRECTIONS TO STUDENT: Rough in a three way switch circuit using Type NM cable with power source at one of the switch outlets.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job at an 80 percent proficiency level.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student routed the cable in the most direct path.	______	______
2. The student secured the cable at proper intervals.	______	______
3. The student secured the cable to the outlet box using approved connectors.	______	______
4. The student removed sufficient outer covering at each outlet box.	______	______
5. The student installed enough conductors in each box for circuit to operate.	______	______
6. The student cleaned up the work area.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 77

TASK: Rough in the circuit for a device controlled by tw three way switches with feed to the device outlet box.

STANDARD OF PERFORMANCE OF TASK: The cable must be installed in the most direct pat . Power source must terminate at the device outlet box. There must be sufficient conductors in each box for the circuit to function. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300, Part A) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 55-67.
Rockis. **Residential Wiring,** pp. 79-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the cable size of sufficient size for the load.
2. Describe the various types of nonmetallic cable to be used in three way switch circuits.
3. Demonstrate the routing and securing of the cable using a typical wall structure and type NM cable.
4. Demonstrate the procedure for securing the cable to the outlet boxes using the various types of connectors available.
5. Demonstrate the procedure for stripping the outer covering from the cable in the outlet box.
6. Have the students install a three way switch circuit using Type NM cable.

CRITERION REFERENCED MEASURE:
Questions:
1. Type NM cable must be secured within _______ inches of the outlet box and at intervals of not more than _______ feet.
   a. 8, 2
   b. 10, 2
   c. 12, 3
   d. 12, 4½

2. Bends made in Type NM cable shall have a radius less than ______ times the diameter of the cable.
   a. four
   b. five
   c. six
   d. seven
3. To facilitate ease of maintenance, at least ______ inches of free wire should be left inside each outlet box.
   a. four
   b. five
   c. six
   d. seven

Answers:
1. d
2. b
3. c

PRACTICAL APPLICATION:
Rough in type NM cable to a three way switch circuit with the source at the load device box.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for Performance Objective 77 to determine if the assignment was completed with at least 80 percent proficiency.

PERFORMANCE GUIDE:
1. Locate previously installed boxes.
2. Run feeder cable of proper size into the device outlet box.
3. Run a three wire cable of proper size from one switch box to the device outlet box.
4. Run a three wire cable of proper size from the other switch box to the device outlet box.
5. Strip at least six inches of outer jacket from each cable.
6. Attach cable in outlet boxes using approved connectors.
7. Attach cable to building structure at required intervals.
8. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 77

PRACTICAL EVALUATION FOR ROUGHING IN A THREE WAY SWITCH CIRCUIT

Student's Name **Date**

DIRECTIONS TO STUDENT: Rough in a three way switch circuit using Type NM cable with the power source at the load device box.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job at an 80 percent proficiency level.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student routed the cable in the most direct path.	______	______
2.	The student secured the cable at proper intervals.	______	______
3.	The student secured the cable to the outlet box using approved connectors.	______	______
4.	The student removed enough outer covering at each outlet box.	______	______
5.	The student installed enough conductors in each box for circuit to operate.	______	______
6.	The student cleaned up the work area.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 78

TASK: Rough in the circuit for a device controlled by two three way switches and one four way switch (with feed to a three way switch).

STANDARD OF PERFORMANCE OF TASK: The cable must be installed in the most direct path. Power source must terminate at the three way switch. There must be sufficient conductors in each box for the circuit to function. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300, Part A) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 55-67.
Rockis. **Residential Wiring,** pp. 79-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the correct cable size for the load.
2. Describe the different types of nonmetallic cable to be used in three way and four way switch circuits.
3. Demonstrate the routing and securing of the cable using a typical wall structure and type NM cable.
4. Demonstrate the procedure for securing the cable to the outlet boxes using the different connectors available.
5. Demonstrate the procedure for stripping the outer covering from the cable in the outlet box.
6. Have the students install a three way and four way switch circuit using type NM cable.

CRITERION REFERENCED MEASURE:
Questions:
1. Type NM cable must be secured within ______ inches of the outlet box and at intervals of not more than ______ feet.
   a. 8, 2
   b. 10, 2
   c. 12, 3
   d. 12, 4½

PERFORMANCE OBJECTIVE V-TECS 78 (Continued)

2. Bends made in type NM cable shall have a radius less than ______ times the diameter of the cable.
   a. four
   b. five
   c. six
   d. seven
3. To facilitate ease of maintenance, at least _____ inches of free wire should be left inside each outlet box.
   a. four
   b. five
   c. six
   d. seven

PRACTICAL APPLICATION:

Rough in type NM cable for a three way and four way switch circuit with the source at one of the three way switches.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 78 to determine if the assignment was completed with at least 80 percent proficiency.

PERFORMANCE GUIDE:

1. Locate previously installed boxes.
2. Run feed or cable of proper size to one of the three way switch boxes.
3. Run a three wire cable from the feed switch box to the four way switch box.
4. Run a three wire cable from the four way switch box to the remaining three way switch box.
5. Run a two wire cable from the three way switch box in step 4 to the device being controlled.
6. Strip at least six inches of outer jacket from each cable.
7. Attach cable in outlet boxes using approved connectors.
8. Attach cable to building structure at required intervals.
9. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 78

PRACTICAL EVALUATION FOR ROUGHING IN A THREE WAY AND FOUR WAY SWITCH CIRCUIT

Student's Name **Date**

DIRECTIONS TO STUDENT: Rough in a three way and four way switch circuit using type NM cable with the power source at one of the three way switches.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job at an 80 percent proficiency level.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student routed the cable in the most direct path.	____	____
2. The student secured the cable at proper intervals.	____	____
3. The student secured the cable to the outlet box using approved connectors.	____	____
4. The student removed enough outer covering at each outlet box.	____	____
5. The student installed enough conductors in each box for circuit to operate.	____	____
6. The student cleaned up the work area.	____	____

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 79

TASK: Rough in the circuit for a device controlled by two three way switches and one four way switch with feed to the device.

STANDARD OF PERFORMANCE OF TASK: The cable must be installed in the most direct path. Power source must terminate at the device outlet box. There must be sufficient conductors in each box for the circuit to function. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300, Part A) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 55-67.
Rockis. **Residential Wiring,** pp. 79-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the size of cable for the load.
2. Describe the different types of nonmetallic cable to be used in three way and four way switch circuits.
3. Demonstrate the routing and securing of the cable using a typical wall structure and type NM cable.
4. Demonstrate the procedure for securing the cable to the outlet boxes using the different types of connectors available.
5. Demonstrate the procedure for stripping the outer jacket from the cable.
6. Have the students install a three way and four way switch circuit using type NM cable.

CRITERION REFERENCED MEASURE:
Questions:
1. Type NM cable must be secured within _____ inches of the outlet box and at intervals of not more than _____ feet.
   a. 8, 2
   b. 10, 2
   c. 12, 3
   d. 12, 4½

PERFORMANCE OBJECTIVE V-TECS 79 (Continued)

2. Bends made in type NM cable shall have a radius less than _____ times the diameter of the cable.
   a. four
   b. five
   c. six
   d. seven
3. To facilitate ease of maintenance, at least _____ inches of free wire should be left inside each outlet box.
   a. four
   b. five
   c. six
   d. seven

Answers:
1. d
2. b
3. c

PRACTICAL APPLICATION:
Rough in type NM cable to a three way and four way switch circuit with the feed at the load device box.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for V-TECS Guide 79 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:
1. Locate previously installed boxes.
2. Run feeder cable into the device outlet box.
3. Run a two-wire cable of proper size from device outlet box to one of the three way switches.
4. Run a three wire cable of proper size from one three way switch box to four way switch box.
5. Run a three wire cable of proper size from four way switch box to other three way switch box.
6. Strip at least six inches of outer jacket from each cable.
7. Attach cable in outlet boxes using approved connectors.
8. Attach cable to building structure at required intervals.
9. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 79

PRACTICAL EVALUATION FOR ROUGHING IN A THREE WAY AND FOUR WAY SWITCH CIRCUIT

Student's Name ____________________ Date ________

DIRECTIONS TO STUDENT: Rough in a three way and four way switch circuit with the power source at the load device box.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student routed the cable in the most direct path.	____	____
2. The student installed correct cables for the circuit to operate.	____	____
3. The student left at least six inches of free wire at each cable end.	____	____
4. The student secured the cable to the boxes using proper connectors.	____	____
5. The student secured the cable at proper intervals.	____	____
6. The student cleaned up the work area.	____	____
7. The student followed all safety procedures.	____	____

APPROVED: Yes _____ No _____

Evaluator's Signature ____________________ Date ________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 80

TASK: Rough in the circuit for a device controlled by two three way switches and two four way switches with feed to a three way switch.

STANDARD OF PERFORMANCE OF TASK: The cable must be installed in the most direct path. There must be sufficient conductors in each box for the circuit to function. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300, Part A) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 55-67.
Rockis. **Residential Wiring,** pp. 79-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the size of cable for the load.
2. Describe the different types of nonmetallic cable to be used in three way and four way switch circuits.
3. Demonstrate the routing and securing of the cable using a typical wall structure and type NM cable.
4. Demonstrate the procedure for securing the cable to the outlet boxes using the different types of connectors available.
5. Demonstrate the procedure for stripping the outer jacket from the cable.
6. Have the students install a three way and four way switch circuit using type NM cable.

CRITERION REFERENCED MEASURE:
Questions:
1. Type NM cable must be secured within ______ inches of the outlet box and at intervals of not more than _____ feet.
   a. 8, 2
   b. 10, 2
   c. 12, 3
   d. 12, 4½

PERFORMANCE OBJECTIVE V-TECS 80 (Continued)

2. Bends made in type NM cable shall have a radius less than ______ times the diameter of the cable.
   a. four
   b. five
   c. six
   d. seven
3. To facilitate ease of maintenance, at least _____ inches of free wire should be left inside each outlet box.
   a. four
   b. five
   c. six
   d. seven

Answers:
1. d
2. b
3. c

PRACTICAL APPLICATION:
Rough in type NM cable to a switch circuit using two three way switches and two four way switches to control a load device with the feed at a three way switch.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for V-TECS Guide 80 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:
1. Locate previously installed boxes.
2. Run feeder cable into three way switch box.
3. Run three wire cable of proper size from three way switch box to four way switch box.
4. Run three wire cable of proper size from the first four way switch to the second four way switch box.
5. Run three wire cable of proper size from second four way switch box to the second three way switch box.
6. Run two wire cable of proper size from device to the second three way switch box.
7. Strip at least six inches of outer jacket from each cable.
8. Attach cable in outlet boxes using approved connectors.
9. Attach cable to building structure at required intervals.
10. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 80

PRACTICAL EVALUATION FOR ROUGHING IN A THREE WAY AND FOUR WAY SWITCH CIRCUIT

Student's Name _______________________________________ **Date** ________

DIRECTIONS TO STUDENT: Rough in a switch circuit using type NM cable, two three way switches and two four way switches to control a load device with the feed at a three way switch.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student routed the cable in the most direct path.	______	______
2. The student installed correct cables for the circuit to operate.	______	______
3. The student left at least six inches of free wire at each cable end.	______	______
4. The student secured the cable to the boxes using proper connectors.	______	______
5. The student secured the cable at proper intervals.	______	______
6. The student cleaned up the work area.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature _______________________________________ **Date** ________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 81

TASK: Rough in the circuit for door chime system.

STANDARD OF PERFORMANCE OF TASK: Wire of correct size must be run from each door and the transformer to the point where the chime system will be located. Sufficient length of wire must be left for future connection of door chime system. Transformer must be approved for the location.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A door chime unit
2. The basic tool kit
3. Necessary materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret cal Code requirements.

RESOURCES:
Mullin. **Electrical Wiring, Residential,** pp. 191-194.
Richter. **Practical Electrical Wiring,** pp. 356-358.
Mix. **Housewiring Simplified,** pp. 101-104.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the wire size for the system.
2. Describe the different types of transformers used for the chime system.
3. Demonstrate the method for securing the low voltage wiring with approved staples.
4. Demonstrate the procedure for routing the low voltage wiring between outlet boxes.
5. Have the students rough in the door chime wiring using typical wiring and building structures.

CRITERION REFERENCED MEASURE:
Questions:
1. Conductors in a low voltage chime system shall be separated at least _____ inches from conductors of any electric light or power circuits.
   a. 2
   b. 4
   c. 6
   d. 8

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PERFORMANCE OBJECTIVE V-TECS 81 (Continued)

2. Low voltage chime wiring:
   a. Must not be installed in the same raceway as power and light conductors;
   b. Must not be installed in outlet boxes containing power and light conductors;
   c. May be stapled along ceiling joists and wall studs;
   d. All of the above.
3. Conductors for chime systems are usually AWG number:
   a. 8
   b. 12
   c. 18
   d. 24.

Answers:
1. a
2. d
3. c

PRACTICAL APPLICATION:
Rough in a door chime system using typical electrical materials following Code requirements.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Checklist for V-TECS 81 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Install a junction box and mount transformer.
3. Run feeder cable to junction box from power source.
4. Run the door bell wire from transformer to chime unit.
5. Run the wire from each push button location to the chime unit location.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 81

PRACTICAL EVALUATION FOR THE ROUGH IN OF A DOOR CHIME SYSTEM

Student's Name **Date**

DIRECTIONS TO STUDENT: Rough in a two door chime system using AWG #18 type T bell wire and a door chime kit.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected the proper wiring for each wire run.	______	______
2. The student routed the wiring using the most direct route.	______	______
3. The student secured the wiring using approved staples.	______	______
4. The student left enough wire at each outlet box.	______	______
5. The student cleaned up the work area.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 82

TASK: Rough in circuit for intercom system.

STANDARD OF PERFORMANCE OF TASK: Cables and rough in kits must be installed for each location in accordance with manufacturer's installation instructions.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A layout of system
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.
4. Read and interpret manufacturer's installation instructions.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 143-145.
Rockis. **Residential Wiring,** pp. 203-205.

TEACHING ACTIVITIES:
1. Explain the various uses for intercom systems.
2. Explain the procedure for determining the number of conductors in each run of cable.
3. Demonstrate the routing of the cable in relation to other circuit conductors.
4. Demonstrate the methods of supporting the cable for each run.
5. Have the students install an intercom system using typical intercom components.

CRITERION REFERENCED MEASURE:
Questions:
1. Conductors in an intercom system shall be separated at least _____ inches from conductors of any electric light or power circuit.
   a. 2
   b. 4
   c. 6
   d. 8
2. Low voltage communication wiring:
   a. Must not be installed in the same raceway as power and light conductors;
   b. Must not be installed in outlet boxes containing power and light conductors;
   c. May be supported along ceiling joists and wall studs;
   d. All of the above.

PERFORMANCE OBJECTIVE V-TECS 82 (Continued)

3. Conductors for intercom systems are usually AWG Number:
   a. 8
   b. 12
   c. 18
   d. 24.

Answers:
1. a
2. d
3. c

PERFORMANCE GUIDE:
1. Read manufacturer's installation instructions.
2. Run a power cable to master station.
3. Attach rough in kits to building structure.
4. Run required size cable(s) from master station to each remote station.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 83

TASK: Rough in line voltage thermostat wiring.

STANDARD OF PERFORMANCE OF TASK: The wiring must have sufficient ampacity to serve its intended purpose and must terminate in an approved outlet box. The line voltage thermostat wiring must meet the requirements as outlined by the National Electrical Code (Article 300, Part A) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Outlet box for thermostat
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Colvin. **Electrical Wiring,** pp. 55-67.
Rockis. **Residential Wiring,** pp. 79-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the size of cable needed for the load.
2. Demonstrate the routing of the cable through a typical wall structure.
3. Demonstrate the support necessary for the different cable runs.
4. Demonstrate the method of securing the cable to the outlet box.
5. Demonstrate the procedure for stripping the outer covering from the cable in the outlet box.
6. Have the students install the cable runs for a line voltage thermostat.

CRITERION REFERENCED MEASURE:
Questions:
1. Nonmetallic cabie must be secured within _____ inches of the outlet box and at intervals of not more than ______ feet.
   a. 8, 2
   b. 10, 2
   c. 12, 3
   d. 12, 4½

PERFORMANCE OBJECTIVE V-TECS 83 (Continued)

2. Bends made in nonmetallic cable shall have a radius less than _____ times the diameter of the cable.
   a. four
   b. five
   c. six
   d. seven
3. To facilitate ease of maintenance, at least _____ inches of free wire should be left inside each outlet box.
   a. four
   b. five
   c. six
   d. seven

Answers:
1. d
2. b
3. c

PRACTICAL APPLICATION:
Rough in the line voltage thermostat wiring using nonmetallic sheathed cable and typical outlet boxes.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Checklist for V-TECS 83 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:
1. Run correct size cable from service panel to outlet box.
2. Attach cable to outlet box at thermostat location.
3. Pull cable from thermostat location to location of device being controlled.
4. Strip at least six inches of outer jacket from each cable.
5. Attach cable in outlet boxes using approved connectors.
6. Attach cable to building structure at required intervals.
7. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 83

PRACTICAL EVALUATION FOR ROUGHING IN A LINE VOLTAGE THERMOSTAT CIRCUIT

Student's Name ______________________ Date ________

DIRECTIONS TO STUDENT: Rough in a line voltage thermostat circuit using nonmetallic cable and metal outlet boxes.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student routed the cable in the most direct path.	______	______
2. The student secured the cable at proper intervals.	______	______
3. The student secured the cable to the outlet box using approved connectors.	______	______
4. The student removed sufficient outer covering at each outlet box.	______	______
5. The student installed enough conductors in each box for circuit to operate.	______	______
6. The student cleaned up the work area.	______	______
7. The student followed safety precautions.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ Date ________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 84

TASK: Rough in low-voltage thermostat wiring.

STANDARD OF PERFORMANCE OF TASK: The wiring must have sufficient number of conductors in the cable to control the device being served. The rough in circuits for low-voltage thermostat wiring must meet the requirements as outlined by the National Electrical Code (Article 725, Part C) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 602-607.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Thermostat wire
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.
4. Read and interpret manufacturer's installation instructions.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 143-145.
Rockis. **Residential Wiring,** pp. 203-205.

TEACHING ACTIVITIES:
1. Explain the various types of cable used for low-voltage wiring.
2. Explain the procedure for determining the number of conductors in each run of cable.
3. Demonstrate the routing of the cable in relation to other circuit conductors.
4. Demonstrate the methods of supporting the cable for each run.
5. Have the students install the low-voltage thermostat wiring using a typical thermostat installation kit.

CRITERION REFERENCED MEASURE:
Questions:
1. Conductors in a low-voltage thermostat system shall be separated at least _______ inches from conductors of any electric light or power circuit.
   a. 2
   b. 4
   c. 6
   d. 8

PERFORMANCE OBJECTIVE V-TECS 84 (Continued)

2. Low-voltage thermostat wiring:
   a. Must not be installed in the same raceway as power and light conductors;
   b. Must not be installed in outlet boxes containing power and light conductors;
   c. May be supported along ceiling joists and wall studs;
   d. All of the above.
3. Conductors for low-voltage thermostat wiring is usually AWG number:
   a. 8
   b. 12
   c. 18
   d. 24

Answers:
1. a
2. d
3. c

PERFORMANCE GUIDE:
1. Read manufacturer's installation instructions.
2. Locate installation point of thermostat.
3. Run low-voltage wire from the equipment to the make up point of thermostat location.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 85

TASK: Install nonmetallic cable in outlet boxes.

STANDARD OF PERFORMANCE OF TASK: Cable must be secured so as not to damage insulation. Cables must be installed according to type of outlet boxes (plastic or metal) being utilized and must have six inches of free wire for connections in the box. The cable must meet the requirements as outlined by the National Electrical Code (Article 336-5-10 and Article 300-14) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 117, 185-186.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Rockis. **Residential Wiring,** pp. 83-84, 92-94.

TEACHING ACTIVITIES:
1. Explain the various types of outlet boxes and their typical uses.
2. Describe the different types of metal boxes using examples of each.
3. Describe the different types of nonmetallic boxes using examples of each.
4. Demonstrate the procedure for securing the cable in metal and nonmetallic boxes.
5. Have the students install nonmetallic cable in a metal and nonmetallic box using type NM cable.

CRITERION REFERENCED MEASURE:
Questions:
1. If a plastic outlet box without internal clamps is used, the cable must be secured within ______ inches of the box.
   a. 6
   b. 8
   c. 10
   d. 12
2. If a metal outlet box with clamps is used, tighten the clamp:
   a. As tight as possible on the cable;
   b. As tight as possible, then back off 1/2 turn;
   c. So as to secure the cable but not damage the outer sheathing;
   d. To 150 inch-pounds.

PERFORMANCE OBJECTIVE V-TECS 85 (Continued)

3. To facilitate ease of maintenance, at least _____ inches of free wire should be left inside each box.
   a. four
   b. five
   c. six
   d. seven

Answers:
1. b
2. c
3. c

PRACTICAL APPLICATION:
Install a nonmetallic cable in a metal outlet box using Romex cable connectors.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for V-TECS Guide 85 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:
1. Remove one knockout from the outlet box for each cable entering the box.
2. Extend the cable into the outlet box six inches.
   a. If the outlet box is metal, tighten clamp on cable.
   b. If the outlet box is plastic, attach cable to building structure within 8 inches.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 85

PRACTICAL EVALUATION FOR INSTALLING TYPE NM IN AN OUTLET BOX

Student's Name ______________________ Date __________

DIRECTIONS TO STUDENT: Install a nonmetallic cable in a device box with 1/2 inch knockouts using romex cable connectors.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student removed the correct knockout.	____	____
2. The student installed the cable connector securely.	____	____
3. The student secured the cable in the clamp without damage to the insulation.	____	____
4. The student left at least six inches of free wire in the device box.	____	____
5. The student folded the free wire back into the box.	____	____
6. The student cleaned up the work area.	____	____
7. The student followed safety procedures.	____	____

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ Date __________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 86

TASK: Rough in duplex receptacles circuit with two three way switches controlling one half of each of two duplex receptacles.

STANDARD OF PERFORMANCE OF TASK: Sufficient conductors must be installed at each box for the circuit to function. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300-14, 380, and 300-4) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 114, 238-241.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Richter. **Practical Electrical Wiring,** pp. 226-330.
Colvin. **Electrical Wiring,** pp. 84-86, 103-105.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the cable ampacity for the circuit.
2. Demonstrate the procedure for wiring a split duplex receptacle using two and three conductor nonmetallic cable.
3. Demonstrate the routing and securing of the nonmetallic cable in a typical wall structure.
4. Demonstrate the use of the different types of clamps used to secure the cable to the outlet boxes.
5. Demonstrate the procedure for preparing the cable ends at the outlet boxes.
6. Have the students install two and three conductor nonmetallic cable in the outlet boxes for three way switch control of two split duplex receptacles.

CRITERION REFERENCED MEASURE:
Questions:
1. Nonmetallic cable shall be supported within ______ inches of a device box and at intervals of not more than _____ feet.
   a. 8, 2
   b. 10, 2
   c. 12, 3
   d. 12, 4½

PERFORMANCE OBJECTIVE V-TECS 86 (Continued)

2. Bends made in nonmetallic cable shall have a radius less than _____ times the diameter of the cable.
   a. four
   b. five
   c. six
   d. seven
3. To facilitate ease of maintenance, at least _____ inches of free wire should be left in each outlet box.
   a. four
   b. five
   c. six
   d. seven

Answers:
1. d
2. b
3. c

PRACTICAL APPLICATION:
Rough in a duplex receptacle circuit with two three way switches controlling the lower half of two duplex receptacles.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use Checklist for V-TECS 86 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:
1. Locate previously installed boxes.
2. Run a power source into one three way switch box.
3. Run a three wire cable of correct size between the three way switch boxes.
4. Run a two wire cable from the other receptacle box to one three way switch box.
5. Run a wire cable between the two receptacle boxes.
6. Strip at least six inches of outer jacket from each cable.
7. Attach cable in outlet boxes using approved connectors.
8. Attach cable to building structure at required intervals.
   CAUTION: The tabs must be removed from the duplex receptacles.
9. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 86

PRACTICAL EVALUATION FOR ROUGHING IN A THREE WAY SWITCH CONTROLLED SPLIT RECEPTACLE CIRCUIT

Student's Name **DATE**

DIRECTIONS TO STUDENT: Rough in a duplex receptacle circuit using two three way switches to control the lower half of two duplex receptacles.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student routed the cable in the most direct path.	____	____
2.	The student secured the cable at proper intervals.	____	____
3.	The student secured the cable to the outlet box using approved connectors.	____	____
4.	The student removed sufficient outer covering at each outlet box.	____	____
5.	The student installed enough conductors in each box for circuit to operate.	____	____
6.	The student cleaned up the work area.	____	____
7.	The student followed safety procedures.	____	____

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 87

TASK: Rough in cables for single pole switch controlling one or more lights or devices with feed to switch box.

STANDARD OF PERFORMANCE OF TASK: Six inches of free wire must be left at each box. The rough in of cables must meet the requirements as outlined by the National Electrical Code (Article 300-4, 300-14 and 380) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 114, 117, 238-241.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Previously installed outlet boxes
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.

RESOURCES:
Kubala. **Electricity 1,** pp. 92-93.
Rockis. **Residential Wiring,** pp. 83-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the cable size for the circuit.
2. Describe the type of cable to be used for the various runs in the circuit.
3. Demonstrate the routing and securing of the cable using a typical building structure.
4. Demonstrate the procedure for securing the cable to the outlet boxes using the various types of clamps and connectors.
5. Demonstrate the procedure for preparing the cable ends at the outlet boxes.
6. Have the students rough in the cable for a single pole switch circuit.

CRITERION REFERENCED MEASURE:
Questions:
1. When drilling holes in the wall studs to rough in nonmetallic cable, the hole must not be less than ______ inches from the edge of the wall stud.
   a. 1
   b. 1½
   c. 1½
   d. 2

PERFORMANCE OBJECTIVE V-TECS 87 (Continued)

2. If the outlet box is nonmetallic and has no internal clamps, the nonmetallic cable should be secured within ______ inches of the box.
   a. four
   b. six
   c. eight
   d. ten
3. To facilitate ease of maintenance, at least ______ inches of free wire should be left inside each outlet box.
   a. six
   b. eight
   c. ten
   d. twelve

Answers:
1. b
2. c
3. a

PRACTICAL APPLICATION:

Rough in the nonmetallic cable for a single pole switch circuit controlling one or more load devices with the source at the switch box.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for V-TECS Guide 87 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate previously installed boxes.
2. Run cable from power source to box for switch.
3. Run cable from switch box to first light/device outlet box.
4. If more than one light/device is to be controlled by this switch, run cable from first outlet box to second and succeeding outlet boxes.
5. Strip at least six inches of outer jacket from each cable.
6. Attach cable in outlet boxes using approved connectors.
7. Attach cable to building structure at required intervals.
8. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 87

PRACTICAL EVALUATION FOR ROUGHING IN A SINGLE POLE SWITCH CIRCUIT

Student's Name ______________________ **Date** __________

DIRECTIONS TO STUDENT: Rough in a single pole switch circuit using type NM cable with the power source at the switch box.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student routed the cable in the most direct path.	______	______
2.	The student secured the cable at proper intervals.	______	______
3.	The student secured the cable to the outlet box using approved connectors.	______	______
4.	The student removed sufficient outer sheathing at each outlet box.	______	______
5.	The student installed enough conductors in each box for circuit to operate.	______	______
6.	The student cleaned up the work area.	______	______
7.	The student followed safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ **Date** __________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 88

TASK: Rough in cables for single pole switch controlling one or more lights/devices with feed to light/device box.

STANDARD OF PERFORMANCE OF TASK: Six inches of free wire must be left at each box. The cables must meet the requirements as outlined by the National Electrical Code (Article 300-4, 300-14, 380, and 336-5) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 114, 117, 185, 238-241.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Previously installed outlet boxes
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Read and interpret the National Electrical Code.
2. Read and interpret local Code requirements.
3. Read and interpret residential blueprints.

RESOURCES:
Kubala. **Electricity 1,** pp. 92-93.
Rockis. **Residential Wiring,** pp. 83-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the cable size for the circuit.
2. Describe the type of cable to be used for the various runs in the circuit.
3. Demonstrate the routing and securing of the cable using a typical building structure.
4. Demonstrate the procedure for securing the cable to the outlet boxes using the various types of clamps and connectors.
5. Demonstrate the procedure for preparing the cable ends at the outlet boxes.
6. Have the students rough in the cable for a single pole switch circuit.

CRITERION REFERENCED MEASURE:

Questions:
1. When drilling holes in the wall studs to rough in nonmetallic cable, the edge of the hole must be not less than _____ inches from the edge of the wall stud.
   a. 1
   b. 1¼
   c. 1½
   d. 2

2. If the outlet box is nonmetallic and has no internal clamps, the nonmetallic cable should be secured within ____ inches of the box.
   a. four
   b. six
   c. eight
   d. ten
3. To facilitate ease of maintenance, at least _____ inches of free wire should be left inside each outlet box.
   a. six
   b. eight
   c. ten
   d. twelve

Answers:
1. b
2. c
3. a

PRACTICAL APPLICATION:

Rough in the nonmetallic cable for a single pole switch circuit controlling one or more lights with the source at the light boxes.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for V-TECS Guide 88 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate previously installed boxes.
2. Run feeder cable from power source to first light/device box.
3. Run cable from first light/device box to box at switch location.
4. If more than one light/device is to be controlled by this switch, extend cable from first light/device box to second and succeeding outlet boxes.
5. Strip at least six inches of outer jacket from each cable.
6. Attach cable in outlet boxes using approved connectors.
7. Attach cable to building structure at required intervals.
8. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 88

PRACTICAL EVALUATION FOR ROUGHING IN A SINGLE POLE SWITCH CIRCUIT

Student's Name ______________________ **Date** __________

DIRECTIONS TO STUDENT: Rough in a single pole switch circuit using type NM cable with the power source at the light box.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	The student routed the cable in the most direct path.	____	____
2.	The student secured the cable at proper intervals.	____	____
3.	The student secured the cable to the outlet boxes using approved connectors.	____	____
4.	The student removed sufficient outer sheathing at each outlet box.	____	____
5.	The student installed enough conductors in each box for circuit to operate.	____	____
6.	The student cleaned up the work area.	____	____
7.	The student followed safety procedures.	____	____

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ **Date** __________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 89

TASK: Rough in a circuit for a single pole switch controlling three lights or devices with feed to the end light device box.

STANDARD OF PERFORMANCE OF TASK: The cable must extend from the power source to the last light or device box. The cable must be of the required size and type for the load being served. At least six inches of free conductors must be left at each outlet box and switch boxes. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300-4, 300-14, 380, 336-5) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 114, 117, 185, 238-241.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Previously installed outlet boxes
2. Installation/electrical materials
3. The basic tool kit.

ENABLING OBJECTIVE(S):
1. Read and interpret residential blueprints.
2. Read and interpret the National Electrical Code.
3. Read and interpret local Code requirements.

RESOURCES:
Kubala. **Electricity I,** pp. 92-93.
Rockis. **Residential Wiring,** pp. 83-94.

TEACHING ACTIVITIES:
1. Explain the procedure for determining the cable size for the circuit.
2. Describe the type of cable to be used for the various runs of cable in the circuit.
3. Demonstrate the routing and securing of the cable using a typical building structure.
4. Demonstrate the procedure for securing the cable to the outlet boxes using the various types of clamps and connectors.
5. Demonstrate the procedure for preparing the cable ends at the outlet boxes.
6. Have the students rough in the cable for a single pole switch circuit controlling three lights, power source at the last light.

CRITERION REFERENCED MEASURE:
Questions:
1. When drilling holes in the wall studs to rough in nonmetallic cable, the edge of the hole must not be less than _____ inches from the edge of the wall stud.
   a. 1
   b. 1¼
   c. 1½
   d. 2

PERFORMANCE OBJECTIVE V-TECS 89 (Continued)

2. If the outlet box is nonmetallic and has no internal clamps, the nonmetallic cable should be secured within _____ inches of the box.
   a. four
   b. six
   c. eight
   d. ten
3. To facilitate ease of maintenance, at least _____ inches of free wire should be left inside each outlet box.
   a. six
   b. eight
   c. ten
   d. twelve

Answers:
1. b
2. c
3. b

PRACTICAL APPLICATION:

Rough in a single pole switch circuit controlling three lights with the power source at the last light box.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for V-TECS Guide 89 to determine if the assignment was completed with at least 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate previously installed outlet boxes.
2. Run a feed cable from the power source to the last light/fixture device box.
3. Run a three wire cable from one light device box to the other light box.
4. Repeat step 3 until all light or device boxes are connected together with three wire cable.
5. Run a two wire cable to the switch box from the last light or device in a series.
6. Strip at least six inches of outer jacket from each cable.
7. Attach cable in outlet boxes using approved connectors.
8. Attach cable to building structure at required intervals.
9. Fold conductors back into box.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 89

PRACTICAL EVALUATION FOR ROUGHING IN A SINGLE POLE SWITCH CIRCUIT

____

Student's Name **Date**

DIRECTIONS TO STUDENT: Using nonmetallic cable and existing outlet boxes, rough in a single pole switch circuit to control three lights with the power source at the last light box.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. Be sure the task is completed within a reasonable time as would be required on the job with an 80 percent proficiency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student routed the cable in the most direct path.	______	______
2. The student secured the cable at proper intervals.	______	______
3. The student secured the cable to the outlet boxes using approved connectors.	______	______
4. The student removed sufficient outer sheathing at each outlet box.	______	______
5. The student installed enough conductors in each box for circuit to operate.	______	______
6. The student cleaned up the work area.	______	______
7. The student followed safety procedures.	______	______

APPROVED: Yes _____ No _____

____

Evaluator's Signature **Date**

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 90

TASK: Rough in a circuit for a split circuit duplex receptacle.

STANDARD OF PERFORMANCE OF TASK: The rough in circuit for a split circuit duplex receptacle must meet the requirements as outlined by the National Electrical Code (Article 210-4, 210-6, Subsection C, 1 and 2) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 28-30.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Previously installed receptacle box
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the construction of a duplex receptacle.
2. Determine the proper tools and materials to be used.
3. Identify the principles of the electrical circuit operation.
4. Determine the process for installing a new cable.
5. Identify the National Electrical Code requirements applying to the installation of split wired duplex grounding receptacles.

RESOURCES:
Foley. **Electrical Wiring Fundamentals,** pp. 213-216.
National Electrical Code, 1981. Article 210-4,6.

TEACHING ACTIVITIES:
1. Discuss the terms associated with receptacle outlets.
2. Identify the parts of a duplex grounding type receptacle.
3. Have the students read **Electrical Wiring Fundamentals,** pp. 213-216.
4. Discuss articles 210-4 and 210-6 of the **National Electrical Code.**
5. Have the students draw a schematic diagram of a split wired duplex grounding type receptacle.

CRITERION REFERENCED MEASURE:
Questions:
1. What type of circuit is a split wired outlet classified by the National Electrical Code?
2. What is meant by the ungrounded conductor?
3. What must be done to prevent a short circuit when wiring a split wired duplex receptacle?
4. How does the National Electrical Code require a split wired duplex receptacle be disconnected?
5. How many conductors will a split wired duplex receptacle have attached to its terminals?

PERFORMANCE OBJECTIVE V-TECS 90 (Continued)

Answers:
1. A "multiwire" branch circuit
2. The "hot" conductor that is fuse protected
3. The tie bar fin must be broken off on the ungrounded side terminals.
4. Both sides of a split wired duplex receptacle must close simultaneously by a z-pole circuit breaker or by two single pole circuit breakers with a handle tie.
5. Three

PERFORMANCE GUIDE:
1. Locate previously installed wall box.
2. Run three wire cable from the power source to the wall box.
3. Strip at least six inches of outer jacket from each cable.
4. Attach cable in outlet boxes using approved connectors.
5. Attach cable to building structure at required intervals.
6. Fold conductors back into box.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 91

TASK: Rough in circuit for two three way switches controlling one device using conduit and 4" square boxes with plaster rings.

STANDARD OF PERFORMANCE OF TASK: The plaster ring must be flush with the interior wall finish. Approximately six inches of free conductor must be left at each outlet or switch box. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300-4, 314, and 336-5) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 114, 117, 185.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A predetermined size and type conduit and fittings
2. The location of the device
3. Power source to the device box
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify the construction of a three way switch.
2. Determine the proper tools and materials to be used.
3. Identify the principles of wiring a three way switch controlled circuit.
4. Determine the process for the installation of conduit.
5. Identify the National Electrical Code requirements applying to the installation of wiring.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 115-120.
National Electrical Code, 1984. Articles 300-4, 300-14 and 336-5.

TEACHING ACTIVITIES:
1. Discuss the terms associated with switching situations.
2. Identify the parts of a three way switch.
3. Have the students read **Electrical Construction Wiring,** pp. 115-120.
4. Discuss Articles 300-4, 300-14 and 336-5 of the National Electrical Code.
5. Have the students draw a schematic diagram of two three way switches controlling a single device.
6. Demonstrate the procedure for identifying common terminal on a three way switch.
7. Demonstrate the installation and connection of conduit to structure.

PERFORMANCE OBJECTIVE V-TECS 91 (Continued)

CRITERION REFERENCED MEASURE:

Questions:

1. The National Electrical Code requires how many inches of free conductor left at each outlet or switch?
   a. 4 inches
   b. 6 inches
   c. 5 inches
   d. 8 inches
2. Where subject to physical damage, conductors shall be:
   a. Installed higher than 5 feet
   b. Of rigid conduit only
   c. Not installed
   d. Adequately protected.
3. The two wires that go from three way to three way are called:
   a. Switch legs
   b. Connectors
   c. Travelers
   d. Suppliers.

Answers:

1. b
2. d
3. c

PERFORMANCE GUIDE:

1. Install four inch boxes with plaster rings.
2. Install conduit between four inch square boxes.
3. Install conduit from one four inch square box to the device box.
4. Attach conduit to all boxes with approved devices.
5. Install conduit bushings if needed.
6. Attach conduit to structure.
7. Pull three wires in conduit between four inch boxes.
8. Pull two wires in conduit between device box and switch box.
9. Fold conductors back into box.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 92

TASK: Install conduit underground.

STANDARD OF PERFORMANCE OF TASK: The conduit to be installed must be of materials acceptably resistant to moisture and corrosive agents. The conduit must be identified for the applications for which it is to be installed. The installation of the conduit must meet the requirements as outlined by the National Electrical Code (Article 300-5, Table 300-5) and by the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 114-115.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify conduit that is acceptable for underground use.
2. Determine the proper tools and materials to be used.
3. Identify the requirements by the National Electrical Code for underground conduit installations.

RESOURCES:
Alerich. **Electrical Construction Wiring,** pp. 259-260.
National Electrical Code, 1981. Article 300-5.

TEACHING ACTIVITIES:
1. Show students various types of underground conduit.
2. Review the different types of accessories that are available with conduit.
3. Discuss the potential hazards of installing underground conduit.
4. Have the students read **National Electrical Code,** Article 300-5.
5. Have the students dig a trench to a set depth.

CRITERION REFERENCED MEASURE:

Questions:
1. What is the minimum burial depth for installing rigid metal conduit?
2. PVC is a rigid nonmetallic conduit sometimes used underground, what does it stand for?
3. Why is it desirable to plan your layout of conduit run, before it is dug?

Answers:
1. Six inches
2. Polyvinyl chloride
3. To save time and effort.

PERFORMANCE OBJECTIVE V-TECS 92 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Open trench for conduit to a depth no less than the minimum requirements of the National Electrical Code or local power system having jurisdiction.
3. Install conduit in open trench.
4. Install all bushings.
5. Fill trench.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 93

TASK: Rough in direct burial cable.

STANDARD OF PERFORMANCE OF TASK: The cable must be manufactured for direct burial and must be of the correct size and type for the load being served. The rough in of the direct burial cable must meet the requirements as outlined by the National Electrical Code (Article 300-5, Table 300-5) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 114-115.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Identify terminology used with U.F. Cable.
2. Determine the proper tools used and materials to be used.
3. Interpret blueprints and manufacturer's instructions.
4. Recall techniques for burying a U.F. Cable.
5. Read and interpret the National Electrical Code.

RESOURCES:
Mullin, **Electrical Wiring Residential,** pp. 77-80.
Alerich, **Electrical Construction Wiring,** pp. 86-87.
National Electrical Code, 1981, Article 230.

TEACHING ACTIVITIES:
1. Instruct students to read **The National Electrical Code,** Articles 230-49, **Electrical Wiring Residential,** pp. 77-80, and **Electrical Construction Wiring,** pp. 86-87.
2. Discuss different usage of U.F. Cable.
3. Identify different types of direct burial cable.
4. Demonstrate the procedures used when burying a cable.
5. Have the students discuss why depths are important.

CRITERION REFERENCED MEASURE:
Questions:
1. How may a direct burial cable be used?
    a. Service entrance
    b. Grounding devices
    c. Landscape
    d. Commercial garages.

2. U.F. Cable must be buried ________ deep when protected with 2" concrete pad.
   a. 18"
   b. 6"
   c. 24"
   d. 12"
3. What article of the National Electrical code covers question 2?
   a. 230
   b. 300
   c. 400
   d. 700

Answers:
1. c
2. d
3. b

PRACTICAL APPLICATION:

Install a yard light using direct burial cable. The cable must be of correct amperage and type. The cable must be buried at least 18 inches.

METHODS OF EVALUATING PRACTICAL APPLICATION:

Use Checklist Performance Objective 93 to determine if the task was completed within a reasonable time limit and with a 90 percent proficiency.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Open trench for cable to a depth no less than the minimum requirements of the National Electrical Code and local power system having jurisdiction.
3. Install conduit with required bushings where cable enters and leaves trench.
4. Install cable through conduit and trench leaving extra cable for future connections.
5. Fill trench.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 93 EVALUATION

PERFORMANCE TEST FOR INSTALLATION OF DIRECT BURIAL CABLE

Student's Name ______________________ **Date** ________

DIRECTIONS TO STUDENT: Using tools and materials furnished open the trench and rough in a direct burial cable.

DIRECTIONS TO EVALUATOR: The instructor will observe that safety procedures are followed. The task is to be completed in reasonable time limit with 90 percent proficiency.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. The student selected proper materials.	______	______
2. The student used safety precautions.	______	______
3. The student demonstrated two methods for opening trench and roughing in cable.	______	______
*4. The student secured the trench.	______	______
*5. The student secured the U.F. Cable.	______	______
*6. The student found the proper location for mounting U.F. Cable.	______	______
*7. The student mounted the direct burial cable and prepared for connection.	______	______
8. The student finished the task within a reasonable amount of time.	______	______
9. The student completed the task in a workmanship like manner.	______	______
10. The student dismantled the project and returned the materials to their proper places.	______	______

*Required for competency

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ **Date** ________

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 94

TASK: Make joint using crimp type connectors (splices).

STANDARD OF PERFORMANCE OF TASK: The joint must be made using appropriate tool to assure required mechanical strength. Insulation applied to joint must be equivalent to insulation rating of conductor. Connecting device must be approved for application. The joint must meet the requirements as outlined by the National Electrical Code (Article 110-14) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 18-19.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use appropriate electrical tools for the task.
2. Read and interpret the **National Electrical Code.**

RESOURCES:
Buban, et al. **Understanding Electricity and Electronics**, pp. 287-288.
National Electrical Code, 1981, pp. 70-20.

TEACHING ACTIVITIES:
1. Show how to strip insulation from conductors.
2. Identify conductors that are to be grouped together.
3. Demonstrate how to install crimp and use crimping tool.
4. Explain how to check conductors for proper connections.
5. Demonstrate how to properly insulate conductors.

CRITERION REFERENCED MEASURE:
Questions:
1. Arrange the following steps in the correct sequence for properly crimping conductors together.
   a. Cut wires to length.
   b. Place metal sleeve connector over wires and crimp.
   c. Strip wires and twist together.
   d. Place insulation over sleeve.
2. The length insulation that should be removed from a conductor for crimping is:
   a. 1/4"
   b. 1/2"
   c. 3/4"
   d. 1".

PERFORMANCE OBJECTIVE V-TECS 94 (Continued)

3. The joint must meet the requirements as outlined by the ______________.

Answers:

1. cbad
2. c
3. National Electrical Code (Article 110-14)

PERFORMANCE GUIDE:

1. Remove approximately 3/4's inch of insulation from each conductor.
2. Group conductors together and insert wires into connector.
3. Using correct crimp tool, apply pressure to make connection.
4. Remove crimp tool and cut off excess wire outside crimp.
5. Check each conductor by pulling on it to be sure the joint is mechanically strong.
6. Tape or otherwise insulate connection to withstand applied voltage.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 95

TASK: Make pigtail splice (joint).

STANDARD OF PERFORMANCE OF TASK: Splice must be mechanically strong and insulated electrically to withstand applied voltage. The splice must meet the requirements as outlined by the National Electrical Code (Article 110-14) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 18-19.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use appropriate tools for the task.
2. Read and interpret the **National Electrical Code.**

RESOURCES:
Richter, **Practical Electrical Wiring,** pp. 116-123.
National Electrical Code, 1984, pp. 70-20.

TEACHING ACTIVITIES:
1. Show how to remove insulation from the conductor.
2. Demonstrate how to twist the conductors together.
3. Explain soldering techniques to be used.
4. Demonstrate how to solder conductors together.
5. Explain how to properly insulate conductors.
6. Discuss other methods of splicing conductors.

CRITERION REFERENCED MEASURE:
Questions:
1. Arrange the following steps in the correct sequence for making a pigtail splice:
   a. Twist conductors together
   b. Remove insulation from conductor
   c. Clean and solder conductors
   d. Insulate conductors.
2. The length of insulation to be removed from a conductor for soldering two conductors together is:
   a. 1/2"
   b. 1"
   c. 1 1/2"
   d. 2".

PERFORMANCE OBJECTIVE V-TECS 95 (Continued)

3. The splice must meet the requirements as outlined by the ____________.

Answers:
1. bacd
2. b
3. National Electrical Code (Article 110-14)

PERFORMANCE GUIDE:
1. Remove approximately one inch of insulation from each conductor.
2. Cross the ends.
3. Hold the wires together and twist for 6 or 8 turns.
4. Double ends back with pliers so that insulation will not be punctured.
5. Solder the tip of the splice.
6. Insulate wire with approved means.
7. Tape or otherwise insulate connection to withstand applied voltage.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 96

TASK: Make splices using mechanical type connectors (split bolt connectors, lugs, and wire nuts).

STANDARD OF PERFORMANCE OF TASK: The splice(s) must be made to assure mechanical strength. The splice(s) must be insulated to withstand applied voltage. The splices must meet the requirements as outlined by the National Electrical Code (Article 110-14) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 18-19.

CONDITIONS FOR PERFORMANCE OF TASK:
1. The basic tool kit
2. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use appropriate electrical tool to perform the task.
2. Read and interpret the **National Electrical Code.**

RESOURCES:
Richter, **Practical Electrical Wiring**, pp. 124-127.
National Electrical Code, 1984, pp. 70-20.

TEACHING ACTIVITIES:
1. Discuss methods of making splices.
2. Show how to remove the insulation from the conductor.
3. Explain how to select the proper size connector for joining the conductors together.
4. Demonstrate how to join the conductors together to fasten the connector to them.
5. Explain how to properly insulate the conductors.

CRITERION REFERENCED MEASURE:
Questions:
1. Arrange the following steps in the correct sequence for making splices using mechanical type connectors.
   a. Properly insulate the spliced conductors.
   b. Remove the insulation from the conductor.
   c. Align conductors for joining them.
   d. Install mechanical connector.
2. The length of insulation that should be removed for splicing conductors using mechanical type connectors is:
   a. 1/2"--3/4"
   b. 1"--1½"
   c. 1½"--2"
   d. 2" or more.

PERFORMANCE OBJECTIVE V-TECS 96 (Continued)

3. The splices must meet the requirements as outlined by the ____________.

Answers:

1. bcda
2. a
3. National Electrical Code (Article 110-14)

PERFORMANCE GUIDE:

1. Remove 1/2" to 3/4" insulation from each conductor to be joined.
2. Select the appropriate connectors for the connection(s) to be made.
3. Group conductors together and insert wires into connectors.
4. Tighten connector on conductors.
5. Check each conductor by pulling on it to be sure the joint is mechanically strong.
6. Tape or otherwise insulate connection to withstand applied voltage.

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 97

TASK: Rough in a single pole switch circuit.

STANDARD OF PERFORMANCE OF TASK: Approximately six inches of free wire must be left at each box for future connections and splices. The circuit must meet the requirements as outlined by the National Electrical Code (Article 300, Part A) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Previously installed box
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Use basic electrical tool kit and materials.
2. Read and interpret the National Electrical Code.

RESOURCES:
Mullin, **Electrical Wiring (Residential),** pp. 37, 44-46.
National Electrical Code, 1984, pp. 119-128.

TEACHING ACTIVITIES:
1. Explain how to determine the size wiring for the circuit.
2. Need circuit schematic to determine number of conductors needed.
3. Show how to drill holes in wall structure to provide path for cable to connect for fixture to switch box.
4. Demonstrate how to strip outer insulation from conductors and install in switch box and fixture box.
5. Explain method of stapling cable from switch box to light fixture.
6. Explain how to connect conductors for proper circuit operation.

CRITERION REFERENCED MEASURE:
Questions:
1. The cable must be strapped or stapled not more than _____ inches from a box or fitting.
   a. 4
   b. 8
   c. 12
   d. 16

2. The intervals between straps or staples must not exceed _____ feet.
   a. 1
   b. 2 1/2
   c. 4 1/2
   d. 6
3. Single pole switches are used to control one or more lights from _______ location(s).

Answers:
1. c
2. c
3. a

PRACTICAL APPLICATION:
Rough in a single pole switch circuit to National Electrical Code Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for Performance Objective 97 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:
1. Locate previously installed box.
2. If power source is to terminate at light switch:
   a. Run cable of correct size and type from power source to device switch location.
   b. Run cable of correct size and type from switch location to device outlet box.
3. If power source is to terminate in fixture/device box:
   a. Run cable of correct size and type from power source to device outlet box.
   b. Run cable of correct size and type from device outlet box to switch location.
4. Strip at least six inches of outer jacket from each cable.
5. Attach cable in outlet boxes using approved connector.
6. Attach cable to building structure at required intervals.
7. Fold conductors back into boxes.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 97 EVALUATION

PERFORMANCE TEST FOR ROUGHING IN A SINGLE POLE SWITCH CIRCUIT

Student's Name **Date**

DIRECTIONS TO STUDENT: Rough in a single pole switch circuit to National Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	Installed correct wiring size and number of conductors for lighting circuit.	______	______
2.	Stapled cable within 12 inches of the box.	______	______
3.	Removed outer jacket of cable from around conductors.	______	______
4.	Placed 6 inches of conductor into box and tightened cable clamp.	______	______
5.	Connected grounding conductor to box properly.	______	______
6.	Folded conductors back into box.	______	______
7.	Made material list.	______	______
8.	Used tools properly.	______	______
9.	Cleaned up work area.	______	______
10.	Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: ROUGHING IN FEEDERS, BRANCH CIRCUIT CABLES, AND CIRCUITS

PERFORMANCE OBJECTIVE V-TECS 98

TASK: Run feeder cable from main service panel to auxiliary panel.

STANDARD OF PERFORMANCE OF TASK: Sufficient cable must be left at each panel for connections. The cable must be run in the most direct route between panels. The cables must be attached to the panel boxes with approved connectors. The feeder cable must meet the requirements as outlined by the National Electrical Code (Article 300 and 384) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 113-122, 241-246.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Previously installed main service panel and auxiliary panel
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:
Mullin, **Electrical Wiring (Residential),** pp. 239, 244.
National Electrical Code, 1984, pp. 119, 264.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for auxiliary panels.
2. Explain the location requirements for auxiliary panel.
3. Show how to mount panel for surface and flush mounting.
4. Demonstrate how to remove knockout blanks for connectors.
5. Demonstrate how to remove outer jacket of insulation from the cable.
6. Explain National Electrical Code requirements for supporting cable.

CRITERION REFERENCED MEASURE:
Questions:
1. The maximum number of overcurrent devices in a panel box is:
   a. 20
   b. 36
   c. 42
   d. 60
2. A space of ______ feet or more shall be provided between the top of any switchboard and any combustible ceiling.
   a. 1
   b. 3
   c. 6
   d. 8

PERFORMANCE OBJECTIVE V-TECS 98 (Continued)

3. Which of the following statements is not a requirement for auxiliary panels?
   a. The neutral bus should be isolated from the grounding bus.
   b. A maximum of 42 circuits is permitted for a panel.
   c. Feeder cables do not have to be stapled or supported.
   d. A grounding conductor should be included in the cable to properly ground the panel.

Answers:
1. c
2. b
3. c

PRACTICAL APPLICATION:
Run a feed cable from the main service panel to auxiliary panel within National Electrical Code.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for Performance Objective 98 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Remove knockouts from panel boxes.
3. Install cable connector to each panel box.
4. Strip sufficient outer jackets from each cable ends.
5. Attach cable to each panel using approved connectors.
6. Attach cable to building structure at required intervals.
7. Fold conductors into panel boxes.

CHECKLIST FOR PERFORMANCE OBJECTIVE 98 EVALUATION

PERFORMANCE TEST FOR RUNNING FEEDER CABLE FROM MAIN SERVICE PANEL TO AUXILIARY PANEL

Student's Name ____________________ **Date** ________

DIRECTIONS TO STUDENT: Run a feeder cable from the main service panel to an auxiliary panel following the National Electrical Code using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. Selected proper size feeder cable for auxiliary panel.	______	______
2. Installed correct cable connector in main service panel and auxiliary panel.	______	______
3. Removed correct length of outer jacket of cable and install in panel boxes.	______	______
4. Stapled cable for support.	______	______
5. Cable was run in most direct route from panel to panel.	______	______
6. Made a list of materials used.	______	______
7. Cleaned up work area.	______	______
8. Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ____________________ **Date** ________

TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 99

TASK: Install/connect automatic garage door operator.

STANDARD OF PERFORMANCE OF TASK: If it is a plug-in model, the receptacle must be conveniently located. The manual low-voltage control must be installed to control the garage door operator (open and close).

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Pre-hung automatic garage door operator
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:
Mullin, **Electrical Wiring (Residential),** pp. 178-181.
National Electrical Code, 1984, p. 40.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for receptacle installation.
2. Explain the location requirements for garage door outlet boxes.
3. Demonstrate how to cut in outlet box in existing ceiling.
4. Show how to connect receptacle and plate.
5. Discuss control wiring procedures.
6. Show how to connect control wiring.
7. Demonstrate operation of automatic garage door opener.

CRITERION REFERENCED MEASURE:
Questions:
1. The outlet box for a garage door opener should be installed:
   a. On the wall and away from the opener;
   b. Flush with the ceiling and adjacent to the opener;
   c. By the back door for easier access;
   d. By using a drop cord for convenience.
2. Control wiring should be:
   a. A low voltage type wire;
   b. A high voltage type wire;
   c. Run in conduit for extra protection;
   d. Unnecessary because of remote controls being used.

PERFORMANCE OBJECTIVE V-TECS 99 (Continued)

3. Most garage door openers are:
   a. Remote control and do not need additional wiring;
   b. Not UL approved;
   c. Equipped with plug-in cords;
   d. Too expensive to install and operate.

Answers:

1. b
2. a
3. c

PERFORMANCE GUIDE:

1. Locate power supply and location point of receptacle to be installed.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Attach outlet box to structure so that it will be flush with finished surface.
5. Read manufacturer's installation instructions.
6. Run wire of correct size from outlet box to power source, using approved method.
7. Connect receptacle and install trim.
8. Run control wire of correct size from garage door operator to installation point of control switch and connect switch.
9. Connect control wire to door operator per manufacturer's installation instructions.
10. If it is a plug-in model, insert cord end into receptacle.
11. Turn power on.
12. Remove all objects from under door and close door by pressing manual switch.
13. Test operation of door using local control station.
14. Test operation of door using radio control unit.
15. Leave all keys, transmitters, instructions, etc. with owner.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 100

TASK: Connect deicing equipment.

STANDARD OF PERFORMANCE OF TASK: Wiring methods and connectors must be suitable for conditions encountered. Connections must be made in weathertight enclosures. The connecting of the deicing equipment must meet the requirements as outlined by the National Electrical Code (Article 426) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 302-307.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Power source
2. Unit of deicing equipment previously installed
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVES:
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, pp. 329-334.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for deicing equipment installation.
2. Explain the location requirements for deicing equipment.
3. Demonstrate how to lay cable for embedment in masonry or asphalt.
4. Show how to connect wiring for deicing equipment.
5. Discuss control wiring procedures.
6. Demonstrate operation of deicing equipment.

CRITERION REFERENCED MEASURE:
Questions:
1. The factory installed attachment plug of cord connected and plug- connected equipment rated ______ amperes or less and ______ volts or less shall be permitted to be the disconnecting means.
   a. 4, 24
   b. 20, 150
   c. 10, 240
   d. 5, 460

2. The ampacity of branch circuit conductors and the rating or setting of overcurrent protective devices supplying fixed outdoor electric deicing and snow melting equipment shall be not less than _______ percent of the total load of the heaters.
   a. 10
   b. 50
   c. 125
   d. 250
3. Deicing panels or units shall not exceed _______ watts per square foot of heated area.
   a. 25
   b. 80
   c. 120
   d. 200
4. ;pacing between adjacent cable runs is dependent upon the rating of the .ble, and shall be not less than ______ inch(es) on centers.
   a. 1
   b. 2
   c. 6
   d. 12
5. Deicing units, panels, or cables shall be installed on a substantial asphalt or masonry base at least _______ inches thick and have at least _______ inches of asphalt or masonry applied over the units, panels, or cables.
   a. 1,2
   b. 2, 1½
   c. 4, 4½
   d. 6, 6

Answers:

1. b
2. c
3. c
4. a
5. b

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Make wiring connection in weathertight enclosures.
6. Make wiring connections to temperature control devices.
7. Turn power on.
8. Assure required operation.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 101

TASK: Connect door chime system.

STANDARD OF PERFORMANCE OF TASK: Button at each location must cause chime to operate. The connecting of the door chime system must meet the requirements as outlined by the National Electrical Code (Article 725) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 599-607.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Components for door chime system
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, pp. 644-653.
Mullin, **Electrical Wiring (Residential),** pp. 207-210.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for door chime system installation.
2. Explain the location requirements for door chimes.
3. Show how to connect wiring for door chime.
4. Discuss control wiring procedures.
5. Demonstrate operation of door chime.

CRITERION REFERENCED MEASURE:
Questions:
1. Conductors of number ________ and _________ shall be permitted to be used for control wiring of door chimes provided that supply loads do not exceed the ampacities given in 402-5.
   a. 16, 18
   b. 14, 16
   c. 12, 14
   d. 10, 12

PERFORMANCE OBJECTIVE V-TECS 101 (Continued)

2. Door chimes are normally controlled by _______ devices located by the front, back, or side entrances.
   a. PBNC
   b. PBNO
   c. SPST
   d. SPDT
3. Control voltage for door chimes is produced by:
   a. Step-up transformers
   b. Step-down transformers
   c. Relays
   d. Solenoids.

Answers:
1. a
2. b
3. b

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Attach chime unit to structure.
6. Make low-voltage wiring connections.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 102

TASK: Connect/install duplex receptacle outlets.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using methods and connectors suitable for the purpose. Finished outlets must have correct polarity. Cover plate must be straight, cover the opening, and fit flush to the wall. All receptacles must be mounted in a manner to present a uniform appearance. The duplex receptacle outlets must meet the requirements as outlined by the National Electrical Code (Article 200-10, Article 200-11) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 26-27.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Duplex receptacle outlets
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, pp. 28-29, 36-40.
Mullin, **Electrical Wiring (Residential),** pp. 11-15.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for duplex receptacle outlet installation.
2. Explain the location requirements for duplex receptacles.
3. Show how to connect wiring for duplex receptacles.
4. Discuss wiring procedures for more than two sets of cables in a box.
5. Demonstrate operation of duplex receptacle.

CRITERION REFERENCED MEASURE:
Questions:
1. Conductors of numbers _______ and _______ shall be permitted to be used for duplex receptacles in a residence.
   a. 16, 18
   b. 14, 16
   c. 12, 14
   d. 10, 12

PERFORMANCE OBJECTIVE V-TECS 102 (Continued)

2. Duplex receptacles are normally controlled by ________ devices.
   a. PBNC
   b. PBNO
   c. SPDT
   d. Circuit breaker
3. The brass colored terminal on a receptacle usually designates the ________ conductor terminal.
   a. grounding
   b. neutral
   c. hot

Answers:

1. c
2. d
3. c

PRACTICAL APPLICATION:

Connect/install duplex receptacle outlets following the National Electrical Code Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 102 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Cut conductor at wall box to leave six inches of free conductor.
5. Remove approximately three fourths inch of insulation from each conductor.
6. Connect white conductors to silver or white terminals.
7. Connect black conductor to brass or gold colored terminals.
8. If there are two or more grounding conductors, they must be securely connected together using an approved means and fastened to receptacle and to box if required.
9. If box is metal, connect grounding conductors to green terminals and to wall box.
10. Fasten outlet to wall box.
11. Install cover plate.
12. Turn power on.
13. Test for correct polarity.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 102 EVALUATION

PERFORMANCE TEST FOR CONNECTING/INSTALLING DUPLEX RECEPTACLE OUTLETS

Student's Name **Date**

DIRECTIONS TO STUDENT: Connect/install duplex receptacle outlets following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. Prepared conductors for connection to device.	______	______
2. Selected correct device.	______	______
3. Prepared device for connections.	______	______
4. Proper connections performed.	______	______
5. Checked device for proper operation.	______	______
6. Performed proper troubleshooting techniques.	______	______
7. Made a list of materials used.	______	______
8. Cleaned up work area.	______	______
9. Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 103

TASK: Connect/install electric fence charger.

STANDARD OF PERFORMANCE OF TASK: System must function when power has been turned on unit as evidenced by high voltage indicator on unit.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Electric fence charger
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:

National Electrical Code, 1984, pp. 28-29, 36-40.
Mullin, **Electrical Wiring (Residential),** pp. 11-15.

TEACHING ACTIVITIES:
1. Read and discuss the National Electrical Code requirements for electric fence chargers.
2. Explain the location requirements for fence chargers.
3. Show how to connect wiring for fence charger operation.
4. Discuss wiring procedures for fence charger operations.
5. Demonstrate operation of fence charger.

CRITERION REFERENCED MEASURE:

Questions:
1. Fence chargers are used to contain animals by producing electric charges every __________.
   a. few hours
   b. few minutes
   c. few seconds.
2. Fence chargers are normally controlled by __________ devices.
   a. capacitor
   b. transformer
   c. transistor.
3. Most fence chargers have a green and red flashing light to indicate __________.
   a. faulty operation
   b. proper operation
   c. both.

PERFORMANCE OBJECTIVE V-TECS 103 (Continued)

Answers:
1. c
2. a
3. c

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Install suitable ground to charger.
6. Connect charger unit to power source using methods and connections suitable for the purpose.
7. Connect wiring from fence charger to fence.
8. Turn power back on circuit.
9. Turn fence charger unit on.
10. Check for high voltage output.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 104

TASK: Connect/install emergency warning system (burglar or fire).

STANDARD OF PERFORMANCE OF TASK: The emergency warning system must be installed so that each detector will give a warning signal if activated. The emergency warning system must meet the requirements as outlined by the National Electrical Code (Article 760) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 608-616.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Emergency warning system (burglar or fire)
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials
6. Layout of points to be monitored.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:
National Electrical Code, Article 700-C,D,E,F and Article 230-82, 83.
Mullin, **Electrical Wiring (Commercial),** p. 171.
Mullin, **Electrical Wiring (Industrial),** pp. 58-59.

TEACHING ACTIVITIES:
1. Read and discuss the National Electrical Code requirements for emergency warning systems. (Burglar or fire)
2. Explain the location requirements for warning system.
3. Show how to connect wiring for warning system.
4. Discuss wiring procedures for burglar and fire alarm systems.
5. Demonstrate the operation of a warning system.

CRITERION REFERENCED MEASURE:
Questions:
1. List three types of burglar alarm monitoring devices used to set off the alarm.
2. In the event of normal power failure, what is used to provide power to the alarm system?
3. What is the maximum number of fire alarm devices that can be operated on one circuit?

PERFORMANCE OBJECTIVE V-TECS 104 (Continued)

Answers:

1. Window switch, motion detector, infrared detector
2. Battery
3. 20

PERFORMANCE GUIDE:

1. From layout of system, determine location of master control unit and points to be monitored.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Run low voltage wiring from each point to be monitored back to central location of master unit.
6. Install window foil, window switch, door switch, mat switches, smoke detector, fire detector, etc., in each room to be monitored.
7. Run 110 volt wiring circuit from main service panel to alarm system and control station.
8. Check rough in wiring for shorts and open circuits.
9. Connect detectors.
10. Connect master control unit.
11. Turn power on.
12. Assure required operation of system by activating each detector.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 105

TASK: Connect/install four wire 220 volt receptacles.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using materials and conductors suitable for conditions encountered. Receptacle must be supplied with correct voltage and must have required polarity.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Power source
2. Previously roughed in wiring
3. The basic tool kit
4. The installation/electrical materials
5. The electrical plan or other instructions to locate point of installation.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:

National Electrical Code, 1984, Articles 200-10, Articles 210-21.
Mullin, **Electrical Wiring (Commercial),** pp. 61-62.

TEACHING ACTIVITIES:
1. Read and discuss the National Electrical Code requirements for 220 volt receptacle installation.
2. Explain the location requirements for receptacle installation.
3. Show how to connect wiring for 220 volt receptacle.
4. Discuss wiring procedures for 220 volt receptacles.
5. Demonstrate how to check voltage after turning power on.

CRITERION REFERENCED MEASURE:

Questions:
1. List four types of ampere ratings for four wire 220 volt receptacles.
2. 'NEMA' has developed standards for the physical appearance of locking and nonlocking plugs and receptacles. What does the word 'NEMA' represent?
3. List two types of four wire 220 volt receptacles.

Answers:
1. 20, 30, 40, 50
2. National Electrical Manufacturers Association
3. Locking and nonlocking

PRACTICAL APPLICATION:

Connect/install four wire 220-volt receptacles following the National Electrical Code Standard.

PERFORMANCE OBJECTIVE V-TECS 105 (Continued)

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 105 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductors at wall box to leave six inches of free conductor.
6. Remove approximately three fourths inch insulation from each conductor.
7. Connect grounding conductor (green or bare) to grounding terminal.
8. Connect one line conductor to one of brass or gold colored terminal.
9. Connect remaining line conductor.
10. Connect white conductor to identified neutral terminal.
11. Attach receptacle to wall box.
12. Install cover plate.
13. Turn power on.
14. Check for required polarity.
15. Check for required voltage.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 105 EVALUATION

PERFORMANCE TEST FOR CONNECTING/INSTALLING FOUR WIRE 220 VOLT RECEPTACLES

Student's Name ______________________ Date ______

DIRECTIONS TO STUDENT: Connect/install four wire 220-volt receptacles following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	Prepared conductors for connection to device.	______	______
2.	Selected correct device.	______	______
3.	Prepared device for connections.	______	______
4.	Proper connections performed.	______	______
5.	Checked device for proper operation.	______	______
6.	Performed proper troubleshooting techniques.	______	______
7.	Made a list of materials used.	______	______
8.	Cleaned up work area.	______	______
9.	Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ Date ______

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 106

TASK: Install/connect ground fault interrupting device.

STANDARD OF PERFORMANCE OF TASK: Ground fault interrupting device must be installed according to manufacturer's instructions. Ground fault interrupting device must function to open circuit when tested as per manufacturer's instructions. The installation/connection of the ground fault interrupting device must meet the requirements as outlined by the National Electrical Code (Article 210, Section B, and Article 680) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 31-32, 560-574.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Ground fault interrupting device
2. Power source
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 210-8.
Mullin, **Electrical Wiring (Commercial),** pp. 63-64.

TEACHING ACTIVITIES:
1. Read and discuss the National Electrical Code requirements for groundfault interrupting device.
2. Explain the location requirements for receptacle installation.
3. Show how to connect wiring for GFCI receptacle and circuit breaker.
4. Discuss wiring procedures for GFCI devices.
5. Demonstrate the operation of GFCI devices.

CRITERION REFERENCED MEASURE:
Questions:
1. The underwriters laboratories require that Class A GFCI's trip on ground-fault currents of _______ to _______ milliamperes.
2. Name two locations where GFCI devices are required in a residence.
3. List two types of GFCI devices.

Answers:
1. 4,6
2. Bathrooms and outside receptacles
3. Circuit breaker and receptacle types

PERFORMANCE OBJECTIVE V-TECS 106 (Continued)

PRACTICAL APPLICATION:

Install/connect a ground fault interrupting device following the National Electrical Code Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 106 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. If circuit breaker type device, snap or bolt breaker in a breaker panel.
6. Locate circuit conductors to be protected for ground fault interrupting device.
7. Remove approximately three fourths inch insulation from each conductor.
8. Connect grounding conductor to ground bar in breaker panel.
9. Connect white or neutral conductor to identified terminal of circuit breaker.
10. Connect free end of coiled white neutral conductor of lead attached to circuit breaker to neutral bar in breaker panel.
11. Connect black or circuit conductor to load terminal of circuit breaker.
12. If ground fault interrupting is of ground fault interrupting receptacle type, determine outlet box ground fault interrupting receptacle type device is to be mounted in.
    a. Fold wire end out of wall box.
    b. Remove approximately three fourths inch insulation from each conductor.
    c. Connect green or bare conductor to grounding terminal on ground fault interrupting device and to wall box if it is of metal.
    d. Connect white wire to silver colored terminal of receptacle.
    e. Connect black wire to brass or gold colored terminal.
    f. Attach ground fault interrupting device to wall box.
    g. Attach cover plate.
13. Turn power on.
14. Test units for correct operation as per manufacturer's instructions.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 106 EVALUATION

PERFORMANCE TEST FOR INSTALLING/CONNECTING GROUND FAULT INTERRUPTING DEVICE

Student's Name ______________________ Date ________

DIRECTIONS TO STUDENT: Install/connect a ground fault interrupting device following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	Prepared conductors for connection to device.	______	______
2.	Selected correct device.	______	______
3.	Prepared device for connections.	______	______
4.	Proper connections performed.	______	______
5.	Checked device for proper operation.	______	______
6.	Performed proper troubleshooting techniques.	______	______
7.	Made a list of materials used.	______	______
8.	Cleaned up work area.	______	______
9.	Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ Date ________

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 107

TASK: Install/connect hot water heater.

STANDARD OF PERFORMANCE OF TASK: Heater must be supplied with required voltage. Heater must be grounded and connections must be tight and insulated. The installation/connection of the water heater must meet the requirements as outlined by the National Electrical Code (Article 422, Section 14) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 285-286.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Water heater with plumbing connections made.
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Read and interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 220-32, Article 422-14.
Mullin, **Electrical Wiring (Residential),** pp. 167-171.

TEACHING ACTIVITIES:
1. Read and discuss the National Electrical Code requirements for wiring methods for water heaters.
2. Explain the location requirements for water heaters.
3. Show how to connect wiring for water heaters.
4. Discuss wiring procedures for water heaters.
5. Demonstrate the operation of the water heater system.

CRITERION REFERENCED MEASURE:
Questions:
1. Electric water heaters shall be equipped with a temperature limiting means in addition to its control thermostat to disconnect all ________ conductors.
2. Many heaters contain one or two magnesium anodes (rods) which are permanently submerged in the water. These rods help to reduce ________.
3. The heating elements are generally rated at ______ volts.

Answers:
1. Ungrounded
2. Corrosion
3. 236

PERFORMANCE OBJECTIVE V-TECS 107 (Continued)

PERFORMANCE GUIDE

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Install cable connector or conduit connector in junction box on water heater.
5. Connect cable or conduit to water heater.
6. Remove approximately three-fourths inch insulation from each conductor.
7. Connect wiring using method and materials suitable for conditions encountered.
8. Read water heater nameplate.
9. Determine that correct voltage is available at water heater.
10. Check to see that tank is full of water.
11. Turn power on.
12. Check power consumption using clamp on ampmeter.
13. Install cover plate.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 108

TASK: Connect/install humidity control device.

STANDARD OF PERFORMANCE OF TASK: Humidity control device must be connected using method and connector suitable for conditions encountered. Connections must be tight.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Humidity control device
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 422-20, Article 422-26.
Mullin, **Electrical Wiring (Residential),** pp. 201-202.

TEACHING ACTIVITIES:
1. Read and discuss National Electrical Code requirements for wiring methods for humidity control device.
2. Explain the location requirements for humidity control.
3. Show how to connect wiring for humidity control device.
4. Discuss wiring procedures for humidity control devices.
5. Demonstrate the operation of the humidity control device.

CRITERION REFERENCED MEASURE:
Questions:
1. The electrician must check the maximum ________ and ________ ratings of a humidistat before the device is installed.
2. Some humidistats are low voltage devices and require a _________.
3. The disconnect must be within sight of a motor driven appliance where the motor is more than 1/8 HP. (True or False)

Answers:
1. Voltage, amperage
2. Transformer
3. False

PERFORMANCE OBJECTIVE V-TECS 108 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Connect wiring to humidity control device with connector suitable for conditions encountered. Be sure connections are tight.
6. Attach humidity control device to wall or to return air duct system depending on type of device being used.
7. Turn power on.
8. Assure required operation.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 109

TASK: Connect intercom system.

STANDARD OF PERFORMANCE OF TASK: Intercom system must be connected using method and connectors required by manufacturer. All connections must be tight.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Intercom system
2. Power source
3. Previously installed wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 800-1.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods for intercom system.
2. Explain the location requirements for intercom systems.
3. Show how to connect wiring for intercom system.
4. Discuss wiring procedures for intercom connections.
5. Demonstrate the operation of the intercom system from one location to another.

CRITERION REFERENCED MEASURE:
Questions:
1. The __________ must check the maximum number of stations the intercom system will handle before installation of wiring.
2. Some __________ have features that allow a person to call from any location.
3. The fuse protection for an intercom system must be in accordance with the __________.

Answers:
1. Electrician
2. Intercom
3. National Electrical Code

PERFORMANCE OBJECTIVE V-TECS 109 (Continued)

PERFORMANCE GUIDE:

1. Locate installation points.
2. Turn power off.
3. Determine that power is off by checking line conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Connect wiring to each intercom unit in system as per manufacturer's instructions and wiring diagram using connectors suitable for conditions encountered.
6. When all units of system have been connected, turn power on.
7. Check system for correct operations.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 110

TASK: Connect low-voltage lighting control.

STANDARD OF PERFORMANCE OF TASK: Connect low-voltage lighting control. Connections must be made using method and connectors required by manufacturer and the National Electrical Code.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Low-voltage lighting control
2. Power source
3. Previously installed wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:

National Electrical Code, 1984, Article 725.
Mullin, **Electrical Wiring (Residential),** pp. 268-274.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods for low-voltage lighting control.
2. Explain the location requirements for low-voltage control.
3. Show how to connect wiring for low-voltage lighting control.
4. Discuss wiring procedures for low-voltage lighting.
5. Demonstrate the operation of the low-voltage lighting system.

CRITERION REFERENCED MEASURE:

Questions:
1. What is the approximate voltage used on low-voltage, remote control system?
2. The low-voltage, remote control system uses a normally open, single pole, double throw __________ contact switch.
3. A number __________ AWG conductor is generally used for low-voltage, remote control systems.

Answers:
1. 24
2. Momentary
3. 18

PERFORMANCE OBJECTIVE V-TECS 110 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at points of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Connect power leads of low-voltage control devices to light fixture wiring using suitable connectors.
6. Connect low-voltage control lead to relays and control switches as required to complete the wiring of the low-voltage lighting control using suitable connector.
7. Turn power on.
8. Check for operation of control system.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS [illegible]

TASK: Connect moisture resistant receptacle.

STANDARD OF PERFORMANCE OF TASK: Receptacle must be connected using methods and connectors required by manufacturer and the National Electrical Code. Connections must be tight. Receptacle must be wired for correct polarity.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:

1. Moisture resistant cover plate and receptacle
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. The installation/electrical materials.

ENABLING OBJECTIVE(S):

1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:

National Electrical Code, 1984, Article 380-4, 410-57.
Mullin, **Electrical Wiring (Residential),** p. 128.

TEACHING ACTIVITIES:

1. Discuss National Electrical Code requirements for wiring methods for moisture resistant receptacle.
2. Explain the location requirements for moisture resistant receptacles.
3. Show how to connect wiring for receptacle operation.
4. Discuss wiring procedures for moisture resistant receptacles.
5. Demonstrate the operation of the receptacle.

CRITERION REFERENCED MEASURE:

Questions:

1. Receptacles located outdoors in damp locations such as porches and under canopies, or in wet locations directly exposed to the weather, must be __________ when the self closing cover of the receptacle is closed.
2. Fixtures located in wet or damp locations must be constructed so that ________ will not enter their wiring compartments or electrical parts.
3. Receptacles located on the outside of a building must be protected by a ______________ breaker.

Answers:

1. Waterproof
2. Water
3. GFIC

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PERFORMANCE OBJECTIVE V-TECS 111 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductors at point of connections with voltage tester.
4. Read manufacturer's installation instructions.
5. Remove insulation from each conductor to length suggested by manufacturer.
6. Connect white wire to silver colored terminal.
7. Connect black wire to gold or brown colored terminal.
8. Connect grounding conductor to green colored terminal.
9. Attach receptacle to receptacle housing. Be sure gaskets or other water proofing materials are in place.
10. Install protective covers or cover plates.
11. Turn power on.
12. Check for correct polarity.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 112

TASK: Install/connect photo-electric cell control.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using method and connectors required by manufacturer and the National Electrical Code. Connections must be tight. Device must be tested to assure required operation.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Photo-electric cell control
2. Power source
3. Previously installed wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:

National Electrical Code, 1984, Articles 410-4B, 240-4.
Buban, et al., **Understanding Electricity and Electronics,** pp. 198-199.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods for photo-electric cell control.
2. Explain the location requirements for photo-electric cell controls.
3. Show how to connect wiring for photo-electric cell.
4. Discuss wiring procedures for photo-electric cell.
5. Demonstrate the operation of the photo-electric cell control.

CRITERION REFERENCED MEASURE:

Questions:
1. A group of devices that convert one form of energy into another form of energy or into a variation of some electrical quantity are called __________.
2. ____________ cells cause a decrease in the resistance of the cells when light is present.
3. ____________ cells convert light energy into electric energy by generating a voltage.

Answers:
1. Transducers
2. Photoconductive
3. Photovoltaic

PERFORMANCE OBJECTIVE V-TECS 112 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Attach photo-electric cell to outlet box or light fixture as appropriate.
6. Make wiring connections per manufacturer's instruction using suitable connectors.
7. Install cover plates or rehang fixture.
8. Turn power on.
9. Assure required operation.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 113

TASK: Connect recessed fixture box in ceiling.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using methods and connectors required by manufacturer and the National Electrical Code. Polarity must be correct and fixture must be grounded.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Previously installed recessed fixture box
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Articles 410-65, 66, and 67.
Mullin, **Electrical Wiring (Commercial),** pp. 153-155.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods for recessed lighting fixture box.
2. Explain the location requirements for recessed lighting.
3. Show how to connect wiring for recessed lighting fixtures.
4. Discuss wiring procedures for junction boxes in attics.
5. Demonstrate the operation of the recessed lighting fixture.

CRITERION REFERENCED MEASURE:
Questions:
1. Flexible metal raceway to a recessed fixture must be more than ______ feet and less than ______ feet.
2. Flush, recessed fixtures having a solid lens, or ceiling mounted fluorescent fixtures, must be placed so that there is at least a ______ inch clearance between the fixture and the combustible material.
3. List four styles of recessed mounted luminaries.

Answers:
1. 4, 6
2. 6
3. Style F, G, H, J

PERFORMANCE OBJECTIVE V-TECS 113 (Continued)

PERFORMANCE GUIDE:

1. Locate previously installed box.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Remove approximately three-fourths inch insulation from the end of each conductor.
5. Make wiring connections in junction box, using correct connectors and methods and observing correct polarities.
6. Insulate all connections.
7. Fold wiring back into junction box.
8. Install cover on junction box.
9. Install lamp no greater than manufacturer's recommendation.
10. Install fixture trim.
11. Turn power on.
12. Assure required operation.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 114

TASK: Connect single pole switch.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using methods and connectors required by manufacturer and the National Electrical Code. Connections must be tight. The connections must meet the requirements as outlined by the National Electrical Code (Article 380) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 238-241.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Single pole switch
2. Previously roughed in wiring
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Articles 380-8, 14b.
Mullin, **Electrical Wiring (Residential)**, pp. 45-46.

TEACHING ACTIVITIES:
1. Discuss **National Electrical Code** requirements for wiring methods for single pole switches.
2. Explain the location requirements for single pole switches.
3. Show how to connect wiring for single pole switches.
4. Discuss wiring procedures for single pole switches.
5. Demonstrate the operation of the single pole switch.

CRITERION REFERENCED MEASURE:
Questions:
1. A single pole switch is used when a light or group of lights or other load is to be controlled from ______ switching point(s).
2. A single pole switch is identified by its two terminals and the toggle which is marked ________.
3. All switches and circuit breakers used as switches shall be so located that they may be operated from a readily __________ place. (Article 380-8).

Answers:
1. One
2. On/off
3. Accessible

PERFORMANCE OBJECTIVE V-TECS 114 (Continued)

PRACTICAL APPLICATION:

Connect a single pole switch following the National Electrical Code Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 114 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Remove approximately three-fourths inch insulation from the ends of each conductor.
5. Make wiring connection to switch using terminals or connectors provided. Be sure all connections are tight.
6. Attach switch to box with means provided.
7. Install cover plate.
8. Turn power on.
9. Assure required operation.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 114 EVALUATION

PERFORMANCE TEST FOR CONNECTING SINGLE POLE SWITCH

Student's Name **Date**

DIRECTIONS TO STUDENT: Connect a single pole switch following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	Prepared conductors for connection to device.	______	______
2.	Selected correct device.	______	______
3.	Prepared device for connections.	______	______
4.	Proper connections performed.	______	______
5.	Checked device for proper operation.	______	______
6.	Performed proper troubleshooting techniques.	______	______
7.	Made a list of materials used.	______	______
8.	Cleaned up work area.	______	______
9.	Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 115

TASK: Connect/install single pole switch with pilot light.

STANDARD OF PERFORMANCE OF TASK: The switch must control the intended device. The pilot light must indicate when the switch is in the on position.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Single pole switch with pilot light
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Articles 380-8, 14b.
Mullin, **Electrical Wiring (Residential),** pp. 45-46.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods for single pole switches with pilot light.
2. Explain the location requirements for single pole switches.
3. Show how to connect wiring for single pole switches with pilot lights.
4. Discuss wiring procedures for single pole switches with pilot lights.
5. Demonstrate the operation of the single pole switch with pilot light.

CRITERION REFERENCED MEASURE:
Questions:
1. A single pole switch with a pilot is used when a light or group of lights or other load is to be controlled from _________ switching point(s).
2. A single pole switch with a pilot is identified by its three terminals and the toggle which is marked ____________.
3. Snap switches shall not be grouped or ganged in outlet boxes unless they can be so arranged that the voltage between adjacent switches does not exceed __________.

Answers:
1. One
2. On/off
3. 300

PERFORMANCE OBJECTIVE V-TECS 115 (Continued)

PRACTICAL APPLICATION:
Connect/install a single pole switch with a pilot light.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for Performance Objective 115 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductor at wall box to leave six inches of free conductor.
6. Remove approximately three fourths inch insulation from each conductor.
7. Connect white or neutral conductor to white or silver terminal on pilot light.
8. Connect ungrounded conductors to identified line of lead conductors of switch.
9. Attach switch with pilot light to wall box.
10. Install cover plate.
11. Turn power on.
12. Turn switch on.
13. Assure required operation.
14. If device does not work or pilot light does not burn, recheck connections.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 115 EVALUATION

PERFORMANCE TEST FOR CONNECTING/INSTALLING SINGLE POLE SWITCH WITH PILOT LIGHT

Student's Name **Date**

DIRECTIONS TO STUDENT: Connect/install a single pole switch with a pilot light following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. Prepared conductors for connection to device.	______	______
2. Selected correct device.	______	______
3. Prepared device for connections.	______	______
4. Proper connections performed.	______	______
5. Checked device for proper operation.	______	______
6. Performed proper troubleshooting techniques.	______	______
7. Made a list of materials used.	______	______
8. Cleaned up work area.	______	______
9. Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 116

TASK: Connect split circuit duplex receptacle.

STANDARD OF PERFORMANCE OF TASK: Finished wiring must be supplied from two sources. The cover must be installed flush with wall, level across the top, and cover opening in the wall. Polarity must be correct.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Duplex receptacle that can be split wired
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:

National Electrical Code, 1984, Articles 210-7, 52.
Mullin, **Electrical Wiring (Residential),** pp. 108, 114-116.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods for split circuit duplex receptacles.
2. Explain the location requirements for receptacles.
3. Show how to connect wiring for split circuit duplex receptacle.
4. Discuss wiring procedures for split circuit duplex receptacles.
5. Demonstrate the operation of the split circuit duplex receptacle.

CRITERION REFERENCED MEASURE:

Questions:
1. For split circuit duplex receptacles, one part of the receptacle is ________ and the other is ________.
2. Split circuit duplex receptacles are most commonly used in the ________ of a residence.
3. Receptacle ratings shall conform to the values listed in table ________ of the NEC.

Answers:
1. Hot, switch controlled
2. Living room
3. 210-21 (b) (3)

PERFORMANCE OBJECTIVE V-TECS 116 (Continued)

PRACTICAL APPLICATION:

Connect a split circuit duplex receptacle following the National Electrical Code Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 116 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductor at wall box to leave six inches of free conductor.
6. Remove approximately three-fourths inch of insulation from each conductor.
7. Remove break off tab from line side of receptacle to cause it to be a split-wired receptacle.
8. Connect white or neutral conductor to silver or white terminal.
9. Connect one of the other supply conductor to one of the brass or gold terminals.
10. Connect the remaining supply conductor to the remaining brass or gold terminal.
11. Connect bare or green grounding conductor to green terminal and to wall box if it is a metal box.
12. Attach duplex receptacle to wall box.
13. Install cover plate.
14. Turn power on.
15. Check that the receptacle has been supplied from two sources by turning off one source.
16. Test for correct polarity.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 116 EVALUATION

PERFORMANCE TEST FOR CONNECTING SPLIT CIRCUIT DUPLEX RECEPTACLE

Student's Name **Date**

DIRECTIONS TO STUDENT: Connect a split circuit duplex receptacle following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. Prepared conductors for connection to device.	______	______
2. Selected correct device.	______	______
3. Prepared device for connections.	______	______
4. Proper connections performed.	______	______
5. Checked device for proper operation.	______	______
6. Performed proper troubleshooting techniques.	______	______
7. Made a list of materials used.	______	______
8. Cleaned up work area.	______	______
9. Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature **Date**

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 117

TASK: Connect/install three wire 220 volt receptacle.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using materials and conductors required by manufacturer and the National Electrical Code. Receptacle must be supplied with correct voltage and must have correct polarity.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Three wire 220 volt receptacle
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:

National Electrical Code, 1984, Articles 210-7, 52.
Mullin, **Electrical Wiring (Residential),** p. 108.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods for 220 volt receptacle.
2. Explain the location requirements for receptacles.
3. Show how to connect wiring for three wire 220 volt receptacle.
4. Discuss wiring procedures for 220 volt receptacle.
5. Demonstrate the operation of the three wire 220 volt receptacle.

CRITERION REFERENCED MEASURE:

Questions:
1. Section _________ of the National Electric Code states that a means must be provided to simultaneously disconnect both ungrounded conductors at the panelboard where the branch circuit originates.
2. A cable containing a black, white, and bare conductor may be used as a 220 volt circuit provided the ________ and ________ colors are used as the hot conductors.
3. In a cable containing a black, white, and red conductor, the ________ and ________ conductors are used as the hot conductors.

Answers:
1. 210-4
2. Black, white
3. Black, red

PERFORMANCE OBJECTIVE V-TECS 117 (Continued)

PRACTICAL APPLICATION:

Connect/install a three wire 220 volt receptacle following the National Electrical Code Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 117 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Determine that power has been turned off by checking each conductor with voltage tester.
6. Cut conductor at wall box to leave six inches of free conductor.
7. Remove approximately three-fourths inch insulation from each conductor.
8. Connect grounding conductor (green or bare) to grounding terminal.
9. Connect one line conductor to one of brass or gold colored terminal.
10. Connect remaining line conductor to other brass or gold colored terminal.
11. Attach receptacle to wall box.
12. Install cover plate.
13. Turn power on.
14. Check for correct polarity and voltage.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 117 EVALUATION

PERFORMANCE TEST FOR CONNECTING/INSTALLING THREE WIRE 220 VOLT RECEPTACLE

Student's Name _______________________________ **Date** __________

DIRECTIONS TO STUDENT: Connect/install a three wire 220 volt receptacle following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. Prepared conductors for connection to device.	______	______
2. Selected correct device.	______	______
3. Prepared device for connections.	______	______
4. Proper connections performed.	______	______
5. Checked device for proper operation.	______	______
6. Performed proper troubleshooting techniques.	______	______
7. Made a list of materials used.	______	______
8. Cleaned up work area.	______	______
9. Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature _______________________________ **Date** __________

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 118

TASK: Connect/install delayed action or time switch.

STANDARD OF PERFORMANCE OF TASK: Switch must turn device it is controlling off within the prescribed time after it has been turned on. Connections must be made using method and connector required by manufacturer and the National Electrical Code.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Timed or delayed action switch
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Articles 380-8, 422-D.
Richter, **Practical Electrical Wiring,** p. 432.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods for time switches.
2. Explain the location requirements for switches.
3. Show how to connect wiring for time switch.
4. Discuss wiring procedures for time switches.
5. Demonstrate the operation of the time switch.

CRITERION REFERENCED MEASURE:
Questions:
1. ______ switches are used to control lighting for added convenience.
2. List two examples where time switches are used.
3. Poultry houses use times to control lights for additional lighting in the winter to ________ egg production.

Answers:
1. Time
2. Hot water heaters, outside lighting
3. Increase

PERFORMANCE OBJECTIVE V-TECS 118 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductor at wall box to leave six inches of free conductors.
6. Remove approximately three-fourths inch of insulation from each conductor.
7. Connect conductors to switch terminals.
8. Attach switch to wall box.
9. Install cover plate.
10. Turn power on.
11. Turn switch on.
12. Assure required operation of switch.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 119

TASK: Connect water pump motor.

STANDARD OF PERFORMANCE OF TASK: Connection must be made using method and connectors required by manufacturer and the National Electrical Code. Water pump motor must run in correct direction when power is supplied by its controller. The connections must meet appropriate codes according to motor manufacturer's wiring diagram and materials. All connections must be tight and the motor must be grounded if required. The connections must meet the requirements as outlined by the National Electrical Code (Article 430) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 311-347.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Water pump motor
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 430.
Mullin, **Electrical Wiring (Residential),** pp. 164-165.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods pump motors.
2. Explain the location requirements for water pump electrical disconnects.
3. Show how to connect wiring for water pumps.
4. Discuss wiring procedures for water pumps.
5. Demonstrate the operation of the water pump.

CRITERION REFERENCED MEASURE:
Questions:
1. Dual element, time delay fuses must be rated at not more than ________ percent of the full load current of the motor.
2. For a submersible pump the ________ contains the motor's starting relay, overload protection, starting and running capacitors, lightning arrester, and terminals for making the necessary electrical connections.
3. The ________ data and instructions furnished with the pump must be followed for proper wiring of the water pump.

PERFORMANCE OBJECTIVE V-TECS 119 (Continued)

Answers:

1. 125
2. Controller
3. Nameplate

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Connect motor leads to wiring previously roughed in from the pump controller using suitable connectors and methods for conditions encountered.
6. Replace covers on junction boxes or controller.
7. Turn power on for water pump circuit.
8. Turn pump controller on.
9. Check that pump motor runs when power has been applied to motor.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 120

TASK: Connect wires from junction box to appliance.

STANDARD OF PERFORMANCE OF TASK: Wiring must be connected using methods required by the manufacturer and the National Electrical Code. Polarity must be correct and appliance must be grounded. The appliance must operate when the power is turned on.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Junction box
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use e[illegible]trical tools for the task.
2. Interpret bluepri[illegible] drawings.

RESOURCES:
National Electrical Code, 1984, Articles 370-6, 18, 19, 430-145.
Mullin, **Electrical Wiring (Residential),** p. 8.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods used for junction boxes.
2. Explain the location requirements for junction boxes.
3. Show how to connect wiring for appliance using a junction box.
4. Discuss wiring procedures for junction boxes.
5. Demonstrate the operation of the appliance.

CRITERION REFERENCED MEASURE:

Questions:
1. _________ boxes are sometimes placed in a circuit for convenience in joining two or more cables or conduits.
2. The wiring contained in junction boxes shall be _________ without having to remove any part of the building.
3. All ________ entering a junction box are joined to other conductors entering the same box to form the proper hookups so that the circuit will operate in the manner intended.

Answers:
1. Junction
2. Accessible
3. Conductors

PERFORMANCE OBJECTIVE V-TECS 120 (Continued)

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductors at wall box to leave six inches of free conductor.
6. Run power cord from appliance to junction box through approved cord connector.
7. Remove approximately three-fourths inch of insulation from each conductor.
8. Make connections in junction box using correct connector and methods and observing correct polarity.
9. Install cover on junction box.
10. Turn power on for appliance circuit.
11. Turn appliance control switch on.
12. Assure required operation.
13. Turn appliance off.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 121

TASK: Connect/install three way switches.

STANDARD OF PERFORMANCE OF TASK: Light or other device must be controlled on or off from either switch location. Cover plate must be straight, cover the opening, and fit flush to the wall.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A pair of three way switches
2. Power source
3. Previously roughed in wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:

National Electrical Code, 1984, Article 380-8.
Mullin, **Electrical Wiring (Residential),** pp. 47-48.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods used for three way switches.
2. Explain the location requirements for switches and boxes.
3. Show how to connect wiring for three way switches.
4. Discuss wiring procedures for three way switches.
5. Demonstrate the operation of the three way switches.

CRITERION REFERENCED MEASURE:

Questions:
1. Three way switches are used to control a light or group of lights from ________ or more locations.
2. Three way switches contain ________ terminals for the conductors to be connected.
3. List the names of the conductors that are connected to the three way switches.

Answers:
1. Two
2. Three
3. Hot, switch leg, travelers (2)

PERFORMANCE OBJECTIVE V-TECS 121 (Continued)

PRACTICAL APPLIÇATION:
Connect/install a three way switch following the National Electrical Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for Performance Objective 121 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductor at wall box to leave six inches of free conductor.
6. Remove approximately three-fourths inch of insulation from each conductor.
7. Identify conductors.
8. Connect source or hot lead to identified switch terminal at one switch location.
9. Connect travelers to either of other two terminals on switch.
10. Connect switched leg to identified switch terminals at second switch location.
11. Connect traveler to either of other two terminals at second switch location.
12. Attach switches to wall boxes.
13. Install cover plates.
14. Turn power on.
15. Assure required operation of switch at both locations.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 121 EVALUATION

PERFORMANCE TEST FOR CONNECTING/INSTALLING THREE-WAY SWITCHES

Student's Name ______________________ **Date** ________

DIRECTIONS TO STUDENT: Connect/install a three way switch following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

	ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1.	Prepared conductors for connection to device.	______	______
2.	Selected correct device.	______	______
3.	Prepared device for connections.	______	______
4.	Proper connections performed.	______	______
5.	Checked device for proper operation.	______	______
6.	Performed proper troubleshooting techniques.	______	______
7.	Made a list of materials used.	______	______
8.	Cleaned up work area.	______	______
9.	Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ **Date** ________

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 122

TASK: Connect/install four way switches.

STANDARD OF PERFORMANCE OF TASK: Connections must be made using methods and connectors required by manufacturer and the National Electrical Code. Light or other device must be controlled on or off from either switch location. Cover plate must be straight, cover the opening, and fit flush to the wall.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Four way switch
2. Power source
3. Previously installed wiring
4. The basic tool kit
5. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 380-8.
Mullin, **Electrical Wiring (Residential),** pp. 48-49.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for wiring methods used for four way switches.
2. Explain the location requirements for switches and boxes.
3. Show how to connect wiring for four way switches.
4. Discuss wiring procedures for four way switches.
5. Demonstrate the operation of the four way switches.

CRITERION REFERENCED MEASURE:
Questions:
1. Four way switches are used to control a light or group of lights from _______ or more locations.
2. Four way switches contain ________ terminals for the conductors to be connected.
3. Conductors that are connected to the three way switches are called __________.

Answers:
1. Two
2. Four
3. Travelers

PERFORMANCE OBJECTIVE V-TECS 122 (Continued)

PRACTICAL APPLICATION:

Connect/install a four way switch following the National Electrical Code Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 122 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Read manufacturer's installation instructions.
5. Cut conductor at wall box to leave six inches of free conductor.
6. Remove outer sheath leaving approximately one-half inch protruding to remains in box.
7. Remove approximately three-fourths inch of insulation from each conductor.
8. Identify conductors (at least four).
9. Connect conductors to appropriate terminal on switch as per diagram supplied by switch manufacturer.
10. Attach switch to wall box.
11. Install cover plate.
12. Turn power on.
13. Operate switch at each location to determine if circuit can be turned on and off.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 122 EVALUATION

PERFORMANCE TEST FOR CONNECTING/INSTALLING FOUR WAY SWITCHES

Student's Name ____________________ **Date** ________

DIRECTIONS TO STUDENT: Connect/install a four way switch following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. Prepared conductors for connection to device.	______	______
2. Selected correct device.	______	______
3. Prepared device for connections.	______	______
4. Proper connections performed.	______	______
5. Checked device for proper operation.	______	______
6. Performed proper troubleshooting techniques.	______	______
7. Made a list of materials used.	______	______
8. Cleaned up work area.	______	______
9. Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ____________________ **Date** ________

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 123

TASK: Install surface raceway.

STANDARD OF PERFORMANCE OF TASK: Surface raceway must be securely attached to the building structure using clips or straps designed for the system being installed. The installation of the surface raceway must meet the requirements as outlined by the National Electrical Code (Article 352) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 208-210.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Surface raceway
2. Power source
3. The basic tool kit
4. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Articles 348, 352.
Mullin, **Electrical Wiring (Commercial),** pp. 91-93, 119-120.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for installing surface raceway.
2. Explain the location requirements for surface raceways.
3. Show how to connect raceway (emt, wiremold) using connectors, couplings, and straps.
4. Discuss installation procedures for surface raceway.
5. Demonstrate the installation of the surface raceway.
6. Show how to pull conductors in raceway.

CRITERION REFERENCED MEASURE:
Questions:
1. Electrical metallic tubing shall be strapped within every ______ feet and within _______ of a junction box.
2. A run of emt between outlets shall not exceed the equivalency of _______ degrees in bends.
3. The number of conductors permitted in emt shall not exceed the percentage fill specified in Table _______, Chapter _______ of the NEC.

PERFORMANCE OBJECTIVE V-TECS 123 (Continued)

Answers:
1. Ten, three
2. 360
3. 1, 9

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at point of connection(s) with voltage tester.
4. Read manufacturer's instructions.
5. Attach junction box to cable or conduit that is going to supply surface raceway.
6. Attach junction box to building structure.
7. Attach lengths of surface raceway to building structure enough to complete desired circuit using clips, clamps, coupling, etc., designed for sighting being installed.
8. Install circuit conductor in raceway.
9. Make wiring connections using terminals or connectors suitable for conditions encountered.
10. Install all cover plates.
11. Turn power on.

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 124

TASK: Connect 120/240 circuits to circuit breaker panel using nonmetallic cable.

STANDARD OF PERFORMANCE OF TASK: Cables must enter panel through approved type connectors. Circuit conductors must be attached to correct size breaker.

SOURCE OF STANDARD: Tennessee Writing Team.

CONDITIONS FOR PERFORMANCE OF TASK:
1. Cables in circuit breaker panel for 120/240 bolt circuits
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 240.
Mullin, **Electrical Wiring (Residential),** pp. 254-255.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for connecting 120/240 volt circuits to circuit breaker.
2. Explain the location requirements for circuit breakers.
3. Show how to connect conductors to circuit breakers.
4. Discuss installation procedures for circuit breakers.
5. Demonstrate the installation of the circuit breaker.

CRITERION REFERENCED MEASURE:
Questions:
1. Installations in dwellings normally use _________ circuit breakers.
2. Circuit breakers shall be trip free so that even if the handle is held in the ON position, the internal mechanism will trip to the ______ position.
3. ________ single pole breaker(s) or _______ double breaker(s) is(are) used to control a 240 volt circuit.

Answers:
1. Thermalmagnetic
2. OFF
3. 2, 1

PRACTICAL APPLICATION:
Connect 120/240 circuits to circuit breaker panel using nonmetallic cable following the National Electrical Code Standard.

PERFORMANCE OBJECTIVE V-TECS 124 (Continued)

METHOD OF EVALUATING PRACTICAL APPLICATION:

Use the Checklist for Performance Objective 124 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:

1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductors at points of connection(s) with voltage tester.
4. Determine that cables have entered box through approved connector.
5. Remove outer jacket from each cable back to point just inside box where cable enters box.
6. Identify each cable as to circuit it is to serve.
7. Identify conductors in each cable. In two wire cables that are to serve 240 volt circuits, the white wire must be taped or painted some other color, usually red.
8. Connect all bare or green grounding conductors to grounding terminal bar.
9. For 120 volt circuits, connect white conductors to neutral bar.
10. Connect all 120 volt circuits to single pole breaker of the correct ampacity.
11. Connect all 240 volt circuits to double pole breaker of the correct ampacity.
12. Using multimeter, check each circuit for shorts and grounds.
13. If all circuits have been connected, attach cover to panel.
14. Turn power on.
15. Check each circuit.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 124 EVALUATION

PERFORMANCE TEST FOR CONNECTING 120/240 CIRCUITS TO CIRCUIT BREAKER PANEL USING NONMETALLIC CABLE

Student's Name ____________________ **Date** __________

DIRECTIONS TO STUDENT: Connect 120/240 circuits to circuit breaker panel using a nonmetallic cable. Follow the National Electrical Code Standard and use the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. Prepared conductors for connection to breaker.	______	______
2. Selected correct size breaker and type.	______	______
3. Prepared breaker for connections.	______	______
4. Proper connections performed.	______	______
5. Checked breaker for proper operation.	______	______
6. Performed proper troubleshooting techniques.	______	______
7. Made a list of materials used.	______	______
8. Cleaned up work area.	______	______
9. Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ____________________ **Date** __________

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 125

TASK: Make fixture splice.

STANDARD OF PERFORMANCE OF TASK: Splice must be made in outlet box using connectors or other means suitable for the fixtures being installed. Splice must be mechanically strong and insulated electrically to withstand applied voltage. The splice must meet the requirements as outlined by the National Electrical Code (Article 410-11, 410-23, and 410-32) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 269, 274.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A power source
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 402.
Mullin, **Electrical Wiring (Residential),** p. 9.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for connecting wiring for light fixtures.
2. Explain the difference in the neutral and the hot conductors.
3. Show how to connect conductors to the fixture.
4. Discuss installation procedures for the fixture.
5. Demonstrate the installation of the light fixture.

CRITERION REFERENCED MEASURE:
Questions:
1. Fixture wires shall be of the type listed in Table _____ of the National Electrical Code.
2. Fixture wires shall not be smaller than Number ________.
3. The fixture wire that is intended to be used as a grounded conductor shall be identified by means of _________ or colored insulation.

Answers:
1. 402-3
2. 18
3. Stripes

DUTY: TRIMMING OUT (FINISHING) ELECTRICAL DEVICES AND APPLIANCES

PERFORMANCE OBJECTIVE V-TECS 125

TASK: Make fixture splice.

STANDARD OF PERFORMANCE OF TASK: Splice must be made in outlet box using connectors or other means suitable for the fixtures being installed. Splice must be mechanically strong and insulated electrically to withstand applied voltage. The splice must meet the requirements as outlined by the National Electrical Code (Article 410-11, 410-23, and 410-32) and the local authority having jurisdiction.

SOURCE OF STANDARD:
Tennessee Writing Team.
National Electrical Code, pp. 269, 274.

CONDITIONS FOR PERFORMANCE OF TASK:
1. A power source
2. The basic tool kit
3. Installation/electrical materials.

ENABLING OBJECTIVE(S):
1. Select and use electrical tools for the task.
2. Interpret blueprint drawings.

RESOURCES:
National Electrical Code, 1984, Article 402.
Mullin, **Electrical Wiring (Residential),** p. 9.

TEACHING ACTIVITIES:
1. Discuss National Electrical Code requirements for connecting wiring for light fixtures.
2. Explain the difference in the neutral and the hot conductors.
3. Show how to connect conductors to the fixture.
4. Discuss installation procedures for the fixture.
5. Demonstrate the installation of the light fixture.

CRITERION REFERENCED MEASURE:
Questions:
1. Fixture wires shall be of the type listed in Table _____ of the National Electrical Code.
2. Fixture wires shall not be smaller than Number _________.
3. The fixture wire that is intended to be used as a grounded conductor shall be identified by means of _________ or colored insulation.

Answers:
1. 402-3
2. 18
3. Stripes

PERFORMANCE OBJECTIVE V-TECS 125 (Continued)

PRACTICAL APPLICATION:
Make a fixture splice following the National Electrical Code Standard.

METHOD OF EVALUATING PRACTICAL APPLICATION:
Use the Checklist for Performance Objective 125 to determine if the assignment was completed with at least an 80 percent accuracy.

PERFORMANCE GUIDE:
1. Locate installation point.
2. Turn power off.
3. Determine that power is off by checking conductor(s) at the point of connection(s) with voltage tester.
4. Determine wiring connection to be made observing polarity.
5. Remove approximately three-fourths inch of insulation from each conductor.
6. Connect fixture wires to circuit conductors using wire nut or other approved connector.
7. Check connection for mechanical strength by pulling on each conductor.
8. Tape or otherwise insulate connection to withstand applied voltage.

CHECKLIST FOR PERFORMANCE OBJECTIVE V-TECS 125 EVALUATION

PERFORMANCE TEST FOR MAKING A FIXTURE SPLICE

Student's Name ______________________ **Date** ______________

DIRECTIONS TO STUDENT: Make a fixture splice following the National Electrical Code Standard using the checklist below.

DIRECTIONS TO EVALUATOR: Observe the student. Pay close attention to the items to be evaluated. The student is to complete the task in a reasonable amount of time as would be required on the job. Mastery will be determined with an 80 percent proficiency level on the checklist.

ITEMS TO BE EVALUATED	Satisfactory	Unsatisfactory
1. Prepared conductors for connection to fixture.	______	______
2. Selected correct size wire nuts to join conductors together.	______	______
3. Prepared fixture for installation.	______	______
4. Proper connections performed.	______	______
5. Checked fixture for proper operation.	______	______
6. Performed proper troubleshooting techniques.	______	______
7. Made a list of materials used.	______	______
8. Cleaned up work area.	______	______
9. Followed all safety procedures.	______	______

APPROVED: Yes _____ No _____

Evaluator's Signature ______________________ Date ______________

APPENDICES

APPENDIX A

CROSS-REFERENCE OF DUTIES, TASKS AND PERFORMANCE OBJECTIVES

APPENDIX A

CROSS-REFERENCE TABLE OF DUTIES, TASKS, AND PERFORMANCE OBJECTIVES

The purpose of this table is to cross-reference changes made since compiling the original task inventory and completing the survey of incumbent workers. The information contained in the Cross-Reference Table is described below. The information is intended primarily for use in computerizing the catalog of performance objectives and performance guides for retrieval by various educational audiences.

1. * By a Task Number, indicates a performance objective was not written; however, stanine values appear under the Dictionary of Occupational Titles 4th ed. (DOT) code. (See No. 4 below regarding stanine value(s).)

2. (XXX) With Task Numbers indicate tasks that were combined to generate a performance objective. Example: A3 (A4). All combined tasks must be common to the same DOT code.

3. Duties, tasks, and stanine values by DOT to be included in the Cross-Reference Table of Duties, Tasks, and Performance Objectives are to be taken from the Task Worksheets.

4. Stanine values are assigned by individual DOTs to indicate the relative amount of time spent performing the tasks which were converted to objectives. Stanine values range from nine (most amount of time spent) to one (least amount of time spent). Percentages of tasks by time spent which correspond to each stanine value are as follows:

	Cumulative Percent of Total Tasks	Stanine Values
	4.0 (Upper)	9
	7.0	8
	12.0	7
	17.0	6
	20.0 (Middle)	5
	17.0	4
	12.0	3
	7.0	2
	4.0 (Lower)	1
Total Percent	100.00	

CROSS-REFERENCE TABLE OF DUTIES, TASKS, AND PERFORMANCE OBJECTIVES

Project Code:	3111	
OE Code:	17.102	Electricity
DOT Code:	824.261-010	Electrician (E)
	829.684-022	Electrician Helper (EH)

85 Respondents

	Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
A.	Computing service loads			
01	**Balance** the **total load** per phase. (Balance the total load per leg).	1/10	5	4
02	Calculate **individual circuit load.** (Calculate individual circuit loads).	2/12	6	4
03	Compute the **size of service entrance** conductors.	3/14	5	4
04	Determine how many convenience and **appliance outlets** should be on each separate circuit.	4/16	6	5
B.	Installing electrical environmental control components.			
01	Connect/install **baseboard** heat unit. (Connect baseboard heat unit).	5/19	5	6
02	Connect **ceiling** heat cable to thermostat. (Connect ceiling heating cable).	6/22	4	4
03	Connect **central electric** heat.	7/24	6	6
04	Connect **furnace motor.** (Connect furnace motors).	8/27	5	4
05	Connect/install **gas** or oil **fired heating** unit. (Connect gas fired heating units).	9/30	5	4

Duty/Task		P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty B continued				
06	Connect **line voltage** thermostat. (Connect line voltage thermostat).	10/33	5	5
07	Connect **low voltage** thermostat.	11/36	5	5
08	Connect/install **wall heater.** (Connect wall heater).	12/39	5	6
09	Install ceiling **heat cable.** (Install ceiling heating cable).	13/42	3	5
C.	Installing lighting fixtures.			
01	Install/connect **fan** controlled by switch. (Connect fan controlled by switch).	14/46	7	8
02	Connect/install **flood lights.** (Connect flood lights).	15/49	6	6
03	Connect/install **lighting dimmer** system. (Connect fluorescent lighting fixture dimmer).	16/52	5	4
04	Install/connect **heat-a-vent light** (connect heat-a-vent light).	17/55	6	6
05	Connect/install **light fixture.** (Connect light fixtures).	18/58	9	9
06	Install/connect **photo-electric control** on a light. (Connect photo-electric control on a light).	19/61	7	5
07	Connect/install **post lights.** (Connect post lights).	20/64	6	5
08	Install/connect **power failure** lighting. (Connect power failure lighting).	21/67	5	7

Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty C continued			
09 Install/connect **moisture resistant fixtures.** (Install moisture resistant fixtures).	22/70	5	7
10 Install/connect **pilot light** to show when appliance is on. (Install pilot light).	23/73	4	5
D. Installing service entrance			
01 Ground **service entrance** equipment.	24/77	7	6
02 Install **circuit breakers** in panel.	25/79	9	9
03 Install **main service panel.** (Install distribution panel board).	26/81	9	7
04 Install **mast-type** (through the roof) **service entrance.**	27/83	7	6
05 Install **main service disconnect.** (Install master switch).	28/85	6	5
06 Install/connect **mobile home service.** (Install mobile home service).	29/87	5	4
07 Install service **entrance cable** to service drop. (Install service entrance cables to service drop).	30/89	5	5
08 Install **temporary service entrance.**	31/91	6	6
09 Install **underground service entrance.**	32/95	6	5
E. Installing switch boxes and outlet boxes			
01 Install (bar-hanger) **mounted box.**	33/98	6	7

Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty E continued			
02 Install **flush mount junction box.**	34/101	7	9
03 Install **flush mount switch** and outlet box in a drywall, lath or plaster wall, or paneled wall. (Install flush mount switch and outlet box in a drywall).	35/103	8	9
04 Install **flush mount switch** and outlet boxes in a masonry wall.	36/106	9	9
05 Install **gangable boxes.**	37/109	7	7
06 Install **octagon outlet box.**	38/111	8	8
07 Install **outlet boxes** for receptacles and switches in existing wall. (Install receptacles and switches in old wall).	39/113	7	8
08 Install **recessed fixture housing** in ceiling. (Install recessed fixture box in ceiling).	40/116	8	7
09 Install **surface mount junction box.**	41/118	8	8
10 Install **underground**, watertight, cast iron box. (Install watertight, cast iron box underground).	42/120	5	4
F. Maintaining existing wiring.			
01 Diagnose/repair **fluorescent fixture.** (Repair fluorescent fixture).	43/123	7	8
02 Diagnose and repair/replace **lights.** (Repair lights).	44/126	8	8
03 Repair/replace **relays and timers.** (Repair relays and timers).	45/129	5	4

	Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty F continued				
04	Repair **water heater**. (Repair water heaters).	46/131	5	5
05	Install and maintain **emergency lighting**. (Repair/replace emergency lighting).	47/135	4	4
06	Repair or replace **frayed service cords**. (Repair/replace frayed service cords).	48/137	4	6
07	Replace existing **interior load center** (Replace an existing interior load center).	49/139	6	5
08	Replace **cable**.	50/141	6	5
09	Replace **circuit breakers**.	51/143	7	8
10	Replace existing **receptacle** or switch. (Replace existing receptacle and switch).	52/145	8	8
11	Replace **fuses**.	53/147	6	8
12	Replace **grounding electrode conductor**.	54/149	4	4
13	Replace **pilot light bulb**.	55/151	4	4
14	Replace **service entrance**.	56/153	7	5
15	Replace **transformer**. (Replace transformers).	57/157	4	6
16	Service **electric motors**.	58/159	4	4
17	Test for correct **voltage**.	59/161	6	6
18	Troubleshoot a **branch circuit**.	60/162	8	6
G.	Operating business			
01	Develop employee work **schedules**.	61/166	3	2
02	Develop/maintain **filing system**.	62/168	2	2

Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty G continued			
03 Establish and record **pay scale** and benefits for employees. (Establish and record pay scale and benefits for workers).	63/170	2	1
04 Estimate **cost of** job.	64/172	4	1
05 **Terminate** employee. (Fire workers).	65/174	2	2
06 **Hire** employee. (Hire workers).	66/176	2	1
07 Maintain **time records.**	67/178	3	3
08 Negotiate **credit.**	68/180	3	1
09 Obtain **insurance.**	69/182	3	2
10 Prepare **payroll records.**	70/184	2	2
11 Take **inventory** of materials and tools. (Take inventory of material and tools).	71/186	4	3
H. Roughing in feeders, branch circuit cables, and circuits.			
01 Rough in **120 or 240 volt circuits** to distribution panel using non-metallic sheathed cable, (N.M.C.). (Connect 120 volt circuits to circuit breaker panel using non-metallic sheathed cable).	72/189	7	7
02 Rough in **armored cable** to outlet box. (Install armored cable to outlet box).	73/191	4	6
03 Rough in cable between an **existing box** and newly installed box. (Install cable between an existing box and newly installed box).	74/194	6	7

Duty/Task	P.O./ Page Number	E.H. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty H continued			
04 Rough in cable or conduit for **branch circuits.** (Install cable or conduit for branch circuits).	75/197	9	7
05 Rough in the circuit for a **device controlled by two three-way switches** with feed to the switch box. (Install device controlled by two three way switches with feed to the switch box).	76/200	8	6
06 Rough in the **circuit** for a device controlled by **two three-way switches** with feed to the device outlet box. ((Install device controlled by two three-way switches with feed to the light box).	77/203	7	6
07 Rough in the **circuit** for a device controlled by **two three-way switches** and **one four way switch** (with feed to a three-way switch). Install device controlled by two three way switches and one four way switch with feed to a 3-way switch).	78/206	6	5
08 Rough in the **circuit** for a device controlled by **two three way switches** and one **four way switch** with feed to the device. (Install device controlled by two three-way switches and one four way switch with feed to the light).	79/209	5	5
09 Rough in the **circuit** for a device controlled by **two three-way switches** and two **four way switches** with feed to a three-way switch. (Install device controlled by two three way switches and two four way switches with feed to a 3-way switch).	80/212	5	5

Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty H continued			
10 Rough in the **circuit for door chime** system. (Install door chime system).	81/215	6	6
11 Rough in the **circuit for intercom system.** (Install intercom system).	82/218	5	4
12 Rough in **line voltage thermostat** wiring. (Install line voltage thermostat wiring).	83/220	5	5
13 Rough in **low-voltage thermostat** wiring. (Install low-voltage thermostat wiring).	84/223	5	5
14 Rough in **non-metallic cable** in outlet boxes. (Install non-metallic cables in outlet boxes).	85/225	6	6
15 Rough in **duplex receptacles circuits** with two three way switches controlling one-half of each of two duplex receptacles. (Install receptacles with two-three way switches controlling one half of two receptacles.)	86/228	5	5
16 Rough in **cables** for **single pole switch** controlling one or more lights or devices with feed to a switch box. (Install single pole switch controlling one or more lights/devices with feed to a switch box).	87/231	7	6
17 Rough in **cables** for **single pole switch** controlling one or more lights /devices with a feed to the light/device box. (Install single pole switch controlling one or more lights/devices with a feed to the light box).	88/234	7	7

Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty H continued			
18 Rough in circuit for a single pole switch controlling three lights or devices with feed to the end light device box. (Install single pole switch controlling three lights or devices with a feed to the end light box).	89/237	6	5
19 Rough in a circuit for a split circuit duplex receptacle. (Install split circuit duplex receptacle).	90/240	5	5
20 Rough in circuit for two three-way switches controlling one device using conduit and 4" square boxes with plaster rings. (Install two three way switches controlling one device using conduit and 4" square boxes with plaster rings circuitry and boxes).	91/242	6	5
21 Install conduit underground. (Install underground conduit).	92/244	9	9
22 Rough in direct burial cable. (Install underground direct burial cable).	93/246	6	5
23 Make joint using crimp type connectors (splices). Make joints using crimp type connectors (splices).	94/249	5	6
24 Make pigtail splice (joint).	95/251	6	8
25 Make splices using mechanical-type connectors (split bolt connectors, lugs, and wire nuts).	96/253	9	9
26 Rough in a single pole switch circuit. (Rough in a single pole switch).	97/255	8	8

Duty/Task	P.O/ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty H continued			
27 Run **feeder cable** from main service panel to auxiliary panel. (Run feeder cable from main panel to auxiliary panel).	98/258	7	6
I. Trimming out (finishing) electrical devices and appliances.			
01 Install/connect **automatic garage door operator.** (Connect automatic garage door operator).	99/262	5	4
02 Connect **de-icing equipment.**	100/264	2	3
03 Connect **door chime system.**	101/266	5	6
04. Connect/install **duplex receptacle** outlets. (Connect duplex receptacles).	102/268	8	9
05 Connect/install **electric fence charger.** (Connect electric fence charger).	103/271	2	2
06. Connect/install **emergency warning system** (burglar or fire). (Connect emergency warning system, burglar or fire).	104/273	5	6
07 Connect/install **four wire 220 volt receptacle.** (Connect four wire 220 V receptacles).	105/275	5	6
08 Install/connect **ground fault interrupting device.** (Connect ground fault interrupting device).	106/278	7	7
09 Install/connect **hot water heater.** (Connect hot water heater).	107/281	8	7
10 Connect/install **humidity control device.** (Connect humidity control device).	108/283	4	3
11 Connect intercom system.	109/285	5	4

	Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H.I. Stanine Values Time Spent
Duty I continued				
12	Connect **low-voltage lighting control.** (Connect low voltage lighting controls).	110/287	4	4
13	Connect **moisture resistant** receptacle.	111/289	5	5
14	Install/connect **photo-electric cell control.** (Connect photo-electric cell control).	112/291	6	5
15	Connect **recessed fixture box** in ceiling.	113/293	8	7
16	Connect **single pole switch.**	114/295	9	8
17	Connect/install **single pole switch** with pilot light. (Connect single pole switch with pilot light).	115/298	5	5
18	Connect **split circuit duplex** receptacle.	116/301	5	5
19	Connect/install **three wire 220 volt receptacle.** (Connect three wire 220 V receptacles).	117/304	7	6
20	Connect/install delayed action or **time switch.** (Connect timer or delayed switch).	118/307	5	4
21	Connect **water pump motor.**	119/309	4	4
22	Connect **wires** from junction box to appliance.	120/311	6	7
23	Connect/install **three way switches.** (Connect 3-way switches).	121/313	8	6
24	Connect/install **four way switches.** (Connect 4-way switches).	122/316	6	6

	Duty/Task	P.O./ Page Number	E. Stanine Values Time Spent	E.H. Stanine Values Time Spent
Duty I continued				
25	Install **surface raceway.** (Install surface raceways).	123/319		
26	Connect **120/240 circuits** to circuit breaker panel using non-metallic cable. (Install 120 volt circuits to circuit breaker panel using non-metallic sheathed cable).	124/321	7	5
27	Make **fixture splice.**	125/324	7	5

APPENDIX B

DEFINITION OF TERMS

APPENDIX B

DEFINITION OF TERMS

Basic Tool Kit: A collection of tools developed from the occupational inventory equipment and tool list. Refer to Appendix A.

Catalog: A comprehensive collection of performance objectives, performance guides, and related data organized by a job structure or career ladder within a domain of interest.

Consortium: A group of state agencies, institutions, or other entities which have been legally constituted through letters of commitment, agreements, or by assignment of higher authorities to work together toward the solution of problems in education.

Domain: A group of related job titles.

D.O.T. Code: A nine-digit number assigned in the Dictionary of Occupational Titles, U. S. Department of Labor, and used to identify a specific job within a given domain.

Duty: A major segment of work comprising related tasks.

Job: A group of tasks performed by a job incumbent.

Occupational Area: A group of jobs that are related on the basis of required skills and knowledge.

Occupational Inventory (Task Inventory Booklet): A survey instrument containing tasks performed by job incumbents with D.O.T.s, complete with background information and a list of tools and equipment.

Occupational Survey: The procedure for collecting data to identify the duties and tasks that comprise one or more jobs, job types, or career field ladders, for the collection and analysis of information concerning such duties.

Performance-Based Instruction: Instruction which, when properly designed and applied, results in the learner's demonstration of certain abilities. The desired abilities are selected before the instruction is designed and are clearly defined as observable performance objectives. In V-TECS catalogs, the abilities are primarily psychomotor but might also include cognitive and affective behaviors. This type of instruction is also referred to as competency-based instruction.

Performance Guide (PG): A series of steps, arranged in a sequence ordinarily followed which, when completed, may result in the performance of a task.

Performance Objective (PO): A statement in precise, measurable terms of a particular behavior to be exhibited by a learner under specified conditions.

Project: An occupational domain area selected by a V-TECS member state for catalog development based upon the U. S. Department of Labor's Dictionary of Occupational Titles (D.O.T.).

Stanine Values: The stanine is a rating scale of 1 - 9 which provides for a distribution of items across a numerical range assigned to the items. Stanine values are computed using the following calculations:

Stanine Value	Percentage
9	4 Top
8	7
7	12
6	17
5	20 Middle
4	17
3	12
2	7
1	4 Bottom
Range 1 - 9	100% Total

State-of-the-Art (SOA) Study: Research conducted to determine the current status of performance-based instructional materials and practices in the domain area under study and to obtain other information that might be useful in catalog development.

Target Population (as applied to dissemination activities): The sub-set(s) of a system or systems for whom an improved product or process is designed for purposes of adoption.

A. Primary Target Population — The principal users of an improved product or products.

B. Secondary Target Population - All the other sub-sets of a system who would not be classified as principal users but who would be directly involved in the dissemination or diffusion/adoption process.

Task: A unit of work activity which constitutes logical and necessary steps in the performance of a duty. A task has a definite beginning and ending point in its accomplishments and generally consists of two or more definite steps.

Task Analysis: The process of reviewing elements of a job for the purpose of improving training program content across program levels of vocational-technical education.

Task Time-Spent Index: An index of relative time-spent on each task within a domain of interest and appearing on a task list. The task time-spent index is computed from scientifically selected samples of incumbent workers who respond to task listings.

Writing Team: A team of people representing instructors with subject matter expertise, local or state supervisors in the domain being developed, workers, and supervisors of incumbent workers whose function is to analyze occupational data and develop performance objective for specific D.O.T. areas.

APPENDIX C

EQUIPMENT

APPENDIX C

EQUIPMENT BY PERCENTAGE RATING

Equipment Description	Percentage of Members Using	Number of Members Using
Saw, hack	100.00	85.
Screwdriver, Phillips	100.00	85.
Drill, electric	98.82	84.
Extension cord	98.82	84.
Flashlight	98.82	84.
Knife, electrician	98.82	84.
Ladder, step	98.82	84.
Screwdriver, flat	98.82	84.
Wire strippers	98.82	84.
Conduit bender, electrical Metallic tubing	97.65	83.
Ladder, extension	97.65	83.
Wrench set, allen	97.65	83.
Bit, masonry	96.47	82.
Cutters, knockout	96.47	82.
Cutters, wire	96.47	82.
Pliers, needle nose	96.47	82.
Anchor set	94.12	80.
Level, small	94.12	80.
Saw, keyhole	94.12	80.
Socket set	94.12	80.
Tool pouch and belt	94.12	80.
Conduit bender, rigid	92.94	79.
Cutters, cable	92.94	79.
Tape reel and puller, steel fish	92.94	79.
Code book	91.76	78.
Drill, star	91.76	78.
Hammer, sledge	90.59	77.
Pliers, diagonal	89.41	76.
Pliers, lineman	89.41	76.
Rule, extension tape	89.41	76.
Rule, folding	89.41	76.
Bit, hole saw	88.24	75.
Chisel, cold	88.24	75.
Conduit, threading set	88.24	75.
File, flat	88.24	75.
Scaffolds	87.06	74.
Ammeter	85.88	73.
Extension light	85.88	73.
Hammer, claw	85.88	73.
Nut driver	85.88	73.
Wrench, pipe	84.71	72.
Hammer, power rotary	83.53	71.
Punch, knockout	83.53	71

EQUIPMENT BY PERCENTAGE RATING

Equipment Description	Percentage of Members Using	Number of Members Using
Wrench, combination open-end set	83.53	71.
Cutter, pipe	82.35	70.
Punch, center	82.35	70.
Vise, pipe	80.00	68.
Cutter, tinsnips	77.65	66.
Hat, hard	77.65	66.
Chalkline	76.47	65.
Crimper, terminal	76.47	65.
Bit, twist	75.29	64.
Chisel, wood	74.12	63.
Crimper, Splicecap	71.76	61.
Screwdriver, self-holding	71.76	61.
Hammer tool, drive pins	70.59	60.
Threader, portable power	70.59	60.
Reamer, pipe	69.41	59.
Tap, bolt	69.41	59,
File, rattail	68.24	58.
Cutter, bolt	67.06	57.
Goggles, safety	67.06	57.
Hammer, ball peen	67.06	57.
Tap and die	67.06	57.
Bit, extension	65.88	56.
Gage, American Standard wire	63.53	54.
Multimeter	63.53	54.
Pliers, visegrip	62.35	53.
Awl, metal	61.18	52.
Brace	61.18	52.
Hammer, electrician	61.18	52.
Hammer, 5 lb. shop	61.18	52.
Plumb bob	61.18	52.
Vise, regular	61.18	52.
Bit, screwdriver	60.00	51.
Pliers, high leverage end cutting	60.00	51.
Saw, reciprocating	60.00	51.
Shears, sheet metal	60.00	51.
Soldering torch	60.00	51.
Pliers, chain nose	58.82	50.
Puller, fuse	58.82	50.
Wire brush	58.82	50.
Bit, single-twist	55.29	47.
Saw, hand	55.29	47.
Tap, pipe	55.29	47.
Staple gun	52.94	45.
Bit, ship-auger	51.76	44.
Chisel, cape	50.59	43.
Wrecking bar	50.59	43.
Wrench, wire nut	50.59	43.

EQUIPMENT BY PERCENTAGE RATING

Equipment Description	Percentage of Member Using	Number of Members Using
Square, combination	49.41	42.
Cutter, armored-cable	47.06	40.
Reamer, tapered	47.06	40.
Wrench, lever jaw	45.88	39.
Awl, wood	44.71	38.
Bit, expansive	43.53	37.
Bit, spade-type	43.53	37.
Blow torch	41.18	35.
Pliers, combination or gas	40.00	34.
Auger, rafting	38.82	33.
Fixture, joist-drilling	36.47	31.
Ground fault interrupter, portable	35.29	30.
Chisel, utility	34.12	29.
Bit, solid-center carborundum	32.94	28.
Ripper, cable	32.94	28.
Bit, machine spur	25.88	22.
Bit, bellhanger drill	24.71	21.
Chisel, diamond point	24.71	21.
Chisel, framing	23.53	20.
Bit, uni-spur	21.18	18.
Bit, multi-spur pipe	20.00	17.

APPENDIX D

TOOLS

APPENDIX D
BASIC TOOL KIT

Allen wrench set, large
Awl, metal
Bolt cutter, small
Chisel, wood
Crimper, terminal
Drill, ½" electric
Drill, 3/4" or 1" electric
File, rattail
Hack saw
Hammer, claw
Hat, Hard
Hole saw set
Knife, electrician
Level - torpedo (pocket) 8"
Multimeter - volt ohm, rpm's.
Nut driver
Pliers - slip joint 10"
Pliers, diagonal
Pliers, lineman
Pliers, needle nose
Puller, fuse
Rule, folding
Screwdriver, flat - 4", 6", 8", 12" - plastic handle
Screwdriver, Phillips - 4" and 6"
Tool pouch and belt
Wire strippers
Wrench, adjustable 8" and 2-16" pipe

APPENDIX E

SOURCES OF STANDARDS

APPENDIX E

SOURCES OF STANDARDS

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APPENDIX F

STATE-OF-THE-ART-LITERATURE

APPENDIX F

STATE OF THE ART LITERATURE

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APPENDIX G

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APPENDIX G

BIBLIOGRAPHY COMPILED BY THE SOUTH CAROLINA WRITING TEAM

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