



Montgomery County
CONSTRUCTION TRADES FOUNDATION

Construction Electricity

The Montgomery County Students Construction Trades Foundation, Inc has developed a comprehensive construction technology program designed to prepare students for a rewarding career in the construction industry. Students master a variety of construction skills by applying knowledge through their participation in a “student design-built” house project. In addition, each program area has articulation agreements with an apprenticeship program as well as Montgomery College.

The apprenticeship program is aligned with the National Center for Construction Education and Research (NCCER) standards. The NCCER is a not-for-profit education foundation created to help address the critical workforce shortage facing the construction industry and to develop industry driven standardized craft training program with portable credentials. For each module, students must score a minimum of 70% on module tests and complete 100% of the Competency Profiles in order to receive NCCER credit. Parentheses indicate the approximate classroom hours spent on each module. Students who enroll in the construction program beyond 2 semesters may have an opportunity to complete optional modules in Level 2 of the NCCER curriculum.

For students who earn a B grade or better, up to seven credits may be transferred to Montgomery College’s Building Trades Technology, A.A.S. or Building Trades Technology Certificate Programs.

The following describes the scope and sequence of instruction for Construction Electricity.

NCCER Modules-Semester 1	Unit(s)
Module 26101-08	Orientation to the Electrical Trade (2.5 hours)
Module 26102-08	Electrical Safety (10 hours)
Module 26105-08	Introduction to the National Electrical Code (7.5 hours)
Module 26109-08	Conductors and Cables (10 hours)
Module 26111-08	Residential Electrical Services (15 hours)
Module 26106-08	Device Boxes (10 hours)

NCCER Modules-Semester 2	Unit(s)
Module 26107-08	Hand Bending (10 hours)
Module 26108-08	Raceways and Fittings (20 hours)
Module 26112-08	Electrical Test Equipment (5 hours)
Module 26110-08	Basic Electrical Construction Drawings (7.5 hours)
Module 26103-08	Introduction to Electrical Circuits (7.5 hours)
Module 26104-08	Electrical Theory (7.5 hours)

NCCER Modules-Semester 3 (Optional)	Unit(s)
Module 26210-08	Circuit Breakers and Fuses (12.5 hours)
Module 26208-08	Conductor Terminations and Splices (7.5 hours)
Module 26206-08	Conductor Installations (10 hours)
Module 26209-08	Grounding and Bonding (15 hours)
Module 26211-08	Control Systems and Fundamental Concepts (12.5 hours)

NCCER Modules-Semester 4 (Optional)	Unit(s)
Module 26202-08	Motors: Theory and Application (20 hours)
Module 26203-08	Electric Lighting (15 hours)
Module 26201-08	Alternating Current (17.5 hours)
Module 26204-08	Conduit Bending (15 hours)
Module 26205-08	Pull and Junction Boxes (12.5 hours)
Module 26207-08	Cable Tray (7.5 hours)

LEVEL 1

MODULE 26101-05 ELECTRICAL SAFETY

1. Demonstrate safe working procedures in a construction environment.
2. Explain the purpose of OSHA and how it promotes safety on the job.
3. Identify electrical hazards and how to avoid or minimize them in the workplace.
4. Explain safety issues concerning lockout/tagout procedures, personal protection using assured grounding and isolation programs, confined space entry, respiratory protection, and fall protection systems.

MODULE 26107-05 INTRODUCTION TO THE NATIONAL ELECTRICAL CODE

1. Explain the purpose and history of the *National Electrical Code* (NEC).
2. Describe the layout of the NEC.
3. Explain how to navigate the NEC.
4. Describe the purpose of the National Electrical Manufacturers' Association (NEMA) and the National Fire Protection Association (NFPA).
5. Explain the role of testing laboratories.

MODULE 26109-05 CONDUCTORS

1. Explain the various sizes and gauges of wire in accordance with American Wire Gauge standards.
2. Identify insulation and jacket types according to conditions and applications.
3. Describe voltage ratings of conductors and cables.
4. Read and identify markings on conductors and cables.
5. Use the tables in the NEC to determine the ampacity of a conductor.
6. State the purpose of stranded wire.
7. State the purpose of compressed conductors.
8. Describe the different materials from which conductors are made.
9. Describe the different types of conductor insulation.
10. Describe the color coding of insulation.
11. Describe instrumentation control wiring.
12. Describe the equipment required for pulling wire through conduit.
13. Describe the procedure for pulling wire through conduit.
14. Install conductors in conduit.
15. Pull conductors in a conduit system.

MODULE 26112-05 WIRING: RESIDENTIAL

1. Describe how to determine electric service requirements for dwellings.
2. Explain the grounding requirements of a residential electric service.
3. Calculate and select service-entrance equipment.
4. Select the proper wiring methods for various types of residences.
5. Explain the role of the NEC in residential wiring.
6. Compute branch circuit loads and explain their installation requirements.
7. Explain the types and purposes of equipment grounding conductors.
8. Explain the purpose of ground fault circuit interrupters and tell where they must be installed.

9. Size outlet boxes and select the proper type for different wiring methods.
10. Describe rules for installing electric space heating and HVAC equipment.
11. Describe the installation rules for electrical systems around swimming pools, spas, and hot tubs.
12. Explain how wiring devices are selected and installed.
13. Describe the installation and control of lighting fixtures.

MODULE 26111-05 WIRING: COMMERCIAL AND INDUSTRIAL

1. Identify and state the functions and ratings of single-pole, double-pole, three-way, fourway, dimmer, special, and safety switches.
2. Explain NEMA classifications as they relate to switches and enclosures.
3. Explain the NEC requirements concerning wiring devices.
4. Identify and state the functions and ratings of straight blade, twist lock, and pin and sleeve receptacles.
5. Identify and define receptacle terminals and disconnects.
6. Identify and define ground fault circuit interrupters.
7. Explain the box mounting requirements in the NEC.
8. Use a wire stripper to strip insulation from a wire.
9. Use a solderless connector to splice wires together.
10. Identify and state the functions of limit switches and relays.
11. Identify and state the function of switchgear.

MODULE 26103-05 FASTENERS AND ANCHORS

1. Identify and explain the use of threaded fasteners.
2. Identify and explain the use of non-threaded fasteners.
3. Identify and explain the use of anchors.
4. Demonstrate the correct applications for fasteners and anchors.
5. Install fasteners and anchors.

MODULE 26102-05 HAND BENDING

1. Identify the methods of hand bending conduit.
2. Identify the various methods used to install conduit.
3. Use math formulas to determine conduit bends.
4. Make 90° bends, back-to-back bends, offsets, kicks, and saddle bends using a hand bender.
5. Cut, ream, and thread conduit.

MODULE 26108-05 RACEWAYS, BOXES, & FITTINGS

1. Describe various types of cable trays and raceways.
2. Identify and select various types and sizes of raceways.
3. Identify and select various types and sizes of cable trays.
4. Identify and select various types of raceway fittings.
5. Identify various methods used to install raceways.
6. Demonstrate knowledge of NEC raceway requirements.
7. Describe procedures for installing raceways and boxes on masonry surfaces.
8. Describe procedures for installing raceways and boxes on concrete surfaces.

9. Describe procedures for installing raceways and boxes in a metal stud environment.
10. Describe procedures for installing raceways and boxes in a wood frame environment.
11. Describe procedures for installing raceways and boxes on drywall surfaces.
12. Recognize safety precautions that must be followed when working with boxes and raceways.

MODULE 26106-05 ELECTRICAL TEST EQUIPMENT

1. Explain the operation of and describe the following pieces of test equipment:
 - Ammeter • Voltmeter
 - Ohmmeter • Volt-ohm-milliammeter (VOM)
 - Wattmeter • Megohmmeter
 - Frequency meter • Power factor meter
 - Continuity tester • Voltage tester
 - Recording instruments • Cable-length meters
2. Explain how to read and convert from one scale to another using the above test equipment.
3. Explain the importance of proper meter polarity.
4. Define frequency and explain the use of a frequency meter.
5. Explain the difference between digital and analog meters.

MODULE 26110-05 INTRODUCTION TO ELECTRICAL BLUEPRINTS

1. Explain the basic layout of a blueprint.
2. Describe the information included in the title block of a blueprint.
3. Identify the types of lines used on blueprints.
4. Identify common symbols used on blueprints.
5. Understand the use of architect's and engineer's scales.
6. Interpret electrical drawings, including site plans, floor plans, and detail drawings.
7. Read equipment schedules found on electrical blueprints.
8. Describe the type of information included in electrical specifications.

MODULE 26104-05 ELECTRICAL THEORY ONE

1. Recognize what atoms are and how they are constructed.
2. Define voltage and identify the ways in which it can be produced.
3. Explain the difference between conductors and insulators.
4. Define the units of measurement that are used to measure the properties of electricity.
5. Explain how voltage, current, and resistance are related to each other.
6. Using the formula for Ohm's Law, calculate an unknown value.
7. Explain the different types of meters used to measure voltage, current, and resistance.
8. Using the power formula, calculate the amount of power used by a circuit.

MODULE 26105-05 ELECTRICAL THEORY TWO

1. Explain the basic characteristics of a series circuit.
2. Explain the basic characteristics of a parallel circuit.

3. Explain the basic characteristics of a series-parallel circuit.
4. Calculate, using Kirchoff's Voltage Law, the voltage drop in series, parallel, and series-parallel circuits.
5. Calculate, using Kirchoff's Current Law, the total current in parallel and series-parallel circuits.
6. Find the total amount of resistance in a series circuit.
7. Find the total amount of resistance in a parallel circuit.
8. Find the total amount of resistance in a series-parallel circuit.

LEVEL 2

MODULE 26209-05 INSTALLATION OF ELECTRIC SERVICES

1. Describe various types of electric services for commercial and industrial installations.
2. Read electrical blueprints and diagrams describing service installations.
3. Calculate and select service-entrance equipment.
4. Explain the role of the NEC in service installations.
5. Install main disconnect switches, panelboards, and overcurrent protection devices.
6. Identify the circuit loads, number of circuits required, and installation requirements for distribution panels.
7. Explain the types and purposes of service grounding.
8. Explain the purpose and required location(s) of ground fault circuit interrupters
9. Describe single-phase service connections.
10. Describe both wye- and delta-connected three-phase services.

MODULE 26210-05 CIRCUIT BREAKERS AND FUSES

1. Explain the necessity of overcurrent protection devices in electrical circuits.
2. Define the terms associated with fuses and circuit breakers.
3. Describe the operation of a circuit breaker.
4. Select the most suitable overcurrent device for the application.
5. Explain the role of the NEC in specifying overcurrent devices.
6. Describe the operation of single-element and time-delay fuses.
7. Explain how ground fault circuit interrupters (GFCIs) can save lives.
8. Calculate short circuit currents.
9. Describe troubleshooting and maintenance techniques for overcurrent devices.

MODULE 26208-05 CONDUCTOR TERMINATIONS AND SPLICES

1. Describe how to make a good conductor termination.
2. Prepare cable ends for terminations and splices.
3. Install lugs and connectors onto conductors.
4. Train cable at termination points.
5. Explain the role of the NEC in making cable terminations and splices.
6. Explain why mechanical stress should be avoided at cable termination points.
7. Describe the importance of using proper bolt torque when bolting lugs onto busbars.
8. Describe crimping techniques.
9. Select the proper lug or connector for the job.

10. Describe splicing techniques.
11. Explain how to use hand and power crimping tools.

MODULE 26206-05 CONDUCTOR INSTALLATIONS

1. Describe the various methods of installing conductors in conduit.
2. Plan and set up for a cable pull.
3. Understand the importance of selecting the proper location for cable pulls.
4. Describe how cable reels are transported to the pulling site.
5. Set up reel stands and spindles for a wire-pulling installation.
6. Explain how mandrels, swabs, and brushes are used to prepare conduit for conductors.
7. Properly install a pull line for a cable-pulling operation.
8. Explain the operation of power fish tape systems.
9. Prepare the ends of conductors for pulling.
10. Describe the types of cable pullers.
11. Describe the process of high-force cable pulling.
12. Explain how to support conductors in vertical conduit runs.
13. Describe the installation of cables in cable trays.
14. Explain the importance of communication during a cable-pulling operation.
15. Calculate the probable stress or tension in cable pulls.

MODULE 26203-05 GROUNDING

1. Explain the purpose of grounding and the scope of *NEC Article 250*.
2. Distinguish between a short circuit and a ground fault.
3. Define the NEC ground-related terms.
4. Distinguish between system grounding and equipment grounding.
5. Use *NEC Table 250.66* to size the grounding electrode conductor for various AC systems.
6. Explain the NEC requirements for the installation and physical protection of grounding electrode conductors.
7. Explain the function of the grounding electrode system and determine which grounding electrodes must be used.
8. Define *electrodes* and explain the resistance requirements for electrodes *using NEC Section 250.56*.
9. Use *NEC Table 250.122* to size the equipment grounding conductor for raceways and equipment.
10. Explain the function of the main bonding jumper in the grounding system and size the main bonding jumper for various applications.
11. Size the main bonding jumper for a service utilizing multiple service disconnecting means.
12. Explain the NEC requirements for bonding of enclosures and equipment.
13. Explain the NEC requirements for grounding of enclosures and equipment.
14. Explain *effectively grounded* and its importance in clearing ground faults and short circuits.
15. Explain the purposes of the grounded conductor (neutral) in the operation of overcurrent devices.
16. Explain the NEC requirements for grounding separately-derived systems, including transformers and generators.

17. Explain the NEC requirements for grounding at more than one building.
18. Explain the NEC grounding requirements for systems over 600 volts.

MODULE 26211-05 CONTACTORS AND RELAYS

1. Describe the operating principles of contactors and relays.
2. Select contactors and relays for use in specific electrical systems.
3. Explain how mechanical contactors operate.
4. Explain how solid-state contactors operate.
5. Install contactors and relays according to the NEC requirements.
6. Select and install contactors and relays for lighting control.
7. Read wiring diagrams involving contactors and relays.
8. Describe how overload relays operate.
9. Connect a simple control circuit.
10. Test control circuits

MODULE 26202-05 MOTORS: THEORY AND APPLICATION

1. Define the following terms:
 - Ampacity • NEMA design letter
 - Branch circuit • Nonautomatic
 - Circuit breaker • Overcurrent
 - Controller • Overload
 - Duty • Power factor
 - Equipment • Rated full-load speed
 - Full-load amps • Rated horsepower
 - Remote control circuit • Ground fault circuit interrupter

 - Interrupting rating • Service factor
 - Motor circuit switch • Thermal cutout
 - Thermal protector
2. Describe the various types of motor enclosures.
3. Describe how the rated voltage of a motor differs from the system voltage.
4. Describe the basic construction and components of a three-phase squirrel cage induction motor.
5. Explain the relationships among speed, frequency, and the number of poles in a three phase induction motor.
6. Describe how torque is developed in an induction motor.
7. Explain how and why torque varies with rotor reactance and slip.
8. Define percent slip and speed regulation.
9. Explain how the direction of a three-phase motor is reversed.
10. Describe the component parts and operating characteristics of a three-phase wound rotor induction motor.
11. Describe the component parts and operating characteristics of a three-phase synchronous motor.
12. Define torque, starting current, and armature reaction as they apply to DC motors.
13. Explain how the direction of rotation of a DC motor is changed.
14. Describe the design and characteristics of a DC shunt, series, and compound motor.
15. Describe dual-voltage motors and their applications.

16. Describe the methods for determining various motor connections.
17. Describe general motor protection requirements as delineated in the NEC.

MODULE 26212-05 ELECTRIC LIGHTING

1. Explain how the human eye works.
2. Describe the characteristics of light.
3. Recognize the different kinds of lamps and explain the advantages and disadvantages of each type:
 - Incandescent • Halogen
 - Fluorescent • High-intensity discharge (HID)
4. Properly select and install lamps into lighting fixtures.
5. Recognize and install various types of lighting fixtures:
 - Surface-mounted • Recessed
 - Suspended • Track-mounted

MODULE 26201-05 ALTERNATING CURRENT

1. Calculate the peak and effective voltage or current values for an AC waveform.
2. Calculate the phase relationship between two AC waveforms.
3. Describe the voltage and current phase relationship in a resistive AC circuit.
4. Describe the voltage and current transients that occur in an inductive circuit.
5. Define *inductive reactance* and state how it is affected by frequency.
6. Describe the voltage and current transients that occur in a capacitive circuit.
7. Define *capacitive reactance* and state how it is affected by frequency.
8. Explain the relationship between voltage and current in the following types of AC circuits:
 - RL circuit • RC circuit
 - LC circuit • RLC circuit
9. Describe the effect that resonant frequency has on impedance and current flow in a series or parallel resonant circuit.
10. Define bandwidth and describe how it is affected by resistance in a series or parallel resonant circuit.
11. Explain the following terms as they relate to AC circuits:
 - True power • Apparent power
 - Reactive power • Power factor
12. Explain basic transformer action.

MODULE 26204-05 CONDUIT BENDING

1. Describe the process of conduit bending using power tools.
2. Identify all parts of popular electric and hydraulic benders.
3. Avoid excessive waste when working with conduit systems.
4. Bend offsets, kicks, saddles, segmented, and parallel bends.
5. Explain the requirements of the NEC for bending conduit.
6. Compute the radius, degrees in bend, developed length, and gain for conduit up to six inches.
7. Explain how to correct damaged conduit and modify existing bends.

MODULE 26205-05**BOXES AND FITTINGS**

1. Describe the different types of nonmetallic and metallic boxes.
2. Understand the NEC requirements for box fill.
3. Calculate the required box size for any number and size of conductors.
4. Explain the NEC regulations for volume required per conductor in outlet boxes.
5. Properly locate, install, and support boxes of all types.
6. Describe the NEC regulations governing pull and junction boxes.
7. Explain the radius rule when installing conductors in pull boxes.
8. Understand the NEC requirements for boxes supporting lighting fixtures.
9. Describe the purpose of conduit bodies and Type FS boxes.
10. Install the different types of fittings used in conjunction with boxes.
11. Describe the installation rules for installing boxes and fittings in hazardous areas.
12. Explain how boxes and fittings are selected and installed.
13. Describe the various types of box supports.

MODULE 26207-05**CABLE TRAY**

1. Describe the components that make up a cable tray assembly.
2. Explain the methods used to hang and secure cable tray.
3. Describe how cable enters and exits cable tray.
4. Select the proper cable tray fitting for the situation.
5. Explain the NEMA standards for cable tray installations.
6. Explain the NEC requirements for cable tray installations.
7. Select the required fittings to ensure equipment grounding continuity in cable tray systems.
8. Interpret electrical working drawings showing cable tray fittings.
9. Size cable tray for the number and type of conductors contained in the system.
10. Select rollers and sheaves for pulling cable in specific cable tray situations.
11. Designate the required locations of rollers and sheaves for a specific cable pull.