Penn Foster's Michigan Electrical Apprenticeship program

DOL Office of Apprenticeship Approved

Course Title	Course Number	Course Duration
Year 1:		
Working Safely with Electricity	*4400	10 hours
Basic Industrial Math	*Block X31	30 hours
Addition and Subtraction	*186303	(5 hours)
Multiplication and Division	*186304	(5 hours)
Fractions, Percents, Proportions, and Angles	*186305	(5 hours)
Metric System	*186306	(5 hours)
Formulas	*186307	(5 hours)
Introduction to Algebra	*186308	(5 hours)
Problem Solving and Troubleshooting	186073	10 hours
Electrical Equipment, Part 1	*006027	10 hours
Electrical Equipment, Part 2	*006028	10 hours
Conductors	006014	10 hours
Working With Conduit	006015	10 hours
Wiring Electrical Components, Part 1	*006029	10 hours
Wiring Electrical Components, Part 2	006030	10 hours
Working with Multimeters	006021	10 hours
DC Principles	*Block A31	30 hours
Nature of Electricity	*086112	(5 hours)
Circuit Analysis and Ohm's Law	*086113	(5 hours)
Capacitors and Inductors	*086114	(5 hours)
Magnetism and Electromagnetism	*086115	(5 hours)
Conductors, Insulators, and Batteries	*086116	(5 hours)
Year 2:		
DC Motors and Generator Theory	*086117	(5 hours)
AC Principles	*Block A32	40 hours
Alternating Current	*086118	(5 hours)
Alternating Current Circuits	*086119	(5 hours)
Inductors in AC Circuits	*086120	(5 hours)
Capacitors in AC Circuits	*086121	(5 hours)
Transformers	*086122	(5 hours)
Alternators	*086123	(5 hours)
Electrical Energy Distribution	*086124	(5 hours)
Rectification and Basic Electronic Devices	*086125	(5 hours)
Electrical Blueprint Reading	*006036	10 hours
Reading Electrical Schematic Diagrams	006022	10 hours
Electrical Equipment	*Block A24	60 hours
Conductors and Insulators in Industry	*086070	(5 hours)
Working with Conduit	*086071	(5 hours)
Electrical Boxes	*086072	(5 hours)
Industrial Enclosures and Raceways	*086073	(5 hours)
Connecting Electrical Equipment, Part 1	*086074	(5 hours)
Connecting Electrical Equipment, Part 2	*086075	(5 hours)
Industrial Fuses	*086076	(5 hours)
Industrial Circuit Breakers	*086077	(5 hours)
Plugs, Receptacles, and Lampholders	*086078	(5 hours)
Industrial Switches	*086079	(5 hours)

Industrial Relay Ladder Logic	*086080	(5 hours)
Industrial Relays, Contractors, and Solenoids	*086081	(5 hours)
Transformers	*4040	10 hours
Transformer Operation	*4041	10 hours
Distribution and Power Transformers	*4042	10 hours

Year 3:

Industrial DC Motors	*086051	10 hours
Industrial AC Motors	*086052	10 hours
Controlling Industrial Motors	*086053	10 hours
National Electrical Code (Text/Course)	*5177EM	60 hours
Michigan Rules & Regulations, Parts 1 & 2	*MAA8A	15 hours
Fire Alarm Systems	*MAA8B	15 hours
Alternating Current Motors	*4032	10 hours
Industrial Motor Applications	*4341	10 hours
Motor Control Fundamentals (for PLC's)	*006010	10 hours

Year 4:

Industrial Motor Controls, Part 1 - 3	*6699A-C	30 hours
Industrial Motor Control (for PLC's), Part 1	*006011	10 hours
Industrial Motor Control (for PLC's), Part 2	*006012	10 hours
Protective Relaying, Parts 1 & 2	*6538A-B	20 hours
Electrical Grounding	*086E01	25 hours
Electrical Wiring Practices	*086E02	20 hours
Control Technology for Technicians	*286M04	45 hours

Duration: 610 hours: Year 1 = 145 hours; Year 2 = 155 hours; Year 3 = 150 hours; Year 4 = 160 hours

To learn about **costs**, how to get your electrical apprenticeship program **registered** and your apprentices **enrolled** contact:

Rick Bruno
518-894-5125
rick.bruno@pennfoster.edu

Course descriptions for all Penn Foster Electrical Courses

186001
Trades Safety: Getting Started

Duration:
5 hours (includes 1 test)

What Students Learn:
Preview
A thorough knowledge of safe practices is an important part of working in any industrial setting. Every industrial worker should be familiar with accident prevention techniques, fire safety mehods, and the use of personal protective equipment.
Injuries in the workplace cost many millions of dollars in medical costs, lost wages, and production losses each year. Many injuries can be prevented by understanding how accidents and injuries can occur. This study unit is designed to help trainees understand why safety is so important, and to present students with information about safety that goes beyond common sense.

Objectives
When a student completes this study unit, he and she will be able to:

- Name the agencies that make and enforce safety regulations and explain an employee's responsibilities under those regulations.
- List the physical hazards associated with chemicals and describe how to avoid those hazards.
- Name several electrical shock hazards and the techniques used to prevent shocks.
- List the steps in a lock-out / tag-out procedure.
- Explain the importance of machine guarding and name several types of machine guards.
- Name the four classes of fire and how to extinguish each of them.
- Describe the proper technique used to lift a heavy load.
- Explain how to avoid hand injuries when using hand and power tools.
- List some of the hazards involved in welding and hot cutting operations and how to prevent them.
- Explain how job analysis and the science of ergonomics are used to improve the workplace.
- Explain the importance of personal protective equipment and name several types of PPE.

Contents
Introduction; Safety Regulations; Key safety Issues; Protecting Yourself and Your Co-workers.

4400
Working Safely with Electricity

Duration:
10 hours (includes 1 test)

What Students Learn:
Electrician Categories and Classifications; Electrical Safety Standards and Codes, including OSHA, NEC, and NESC; Materials Standards; Listing and Labeling by Testing Laboratories; Electric Shock; Safety Precautions; First Aid for Electric Shock; Protective Clothing.

006025
Getting Started as an Electrician

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X31)

What Students Learn:
Introduction to the Entire Electric System, including the Generation, Transmission, Distribution, and Utilization of Electric Power; Types of Residential Branch Circuits; Service Entrance; Practical Wiring Examples; Required Subjects an Electrician Should Know.

Special Notes:

- This updated course replaces, Getting Started as an Electrician, course 4410.
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006026
Electricians' Tools

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Electrical Wiring Practices (086E02)

What Students Learn:

Electricians' Equipment: Basic Hand Tools; Wire-Working Tools; Conduit-Working Tools; Power Tools; Knowledge as a Tool with Basic Introduction to the Metric System; Units of Electricity; Static Electricity; Electric Current, Measuring Instruments, and the Symbols and Terminology Used by Electricians.

Special Notes:
- This updated course replaces, Electricians' Tools, course 4401.
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

Block X31
Basic Industrial Math

Duration:
30 hours (includes 6 tests)

What Students Learn:
This module of six study units offers the trainee arithmetic and basic mathematics, metric measurement, and calculator fundamentals. The Metric System is an introductory unit which includes metric conversions. Problem exercises and examples in this module are presented in on-the-job scenarios with applications drawn from the industrial context.

Special Notes:
This updated course replaces lessons contained within Practical Math and Measurements, Block X01. Each study unit contains a progress examination.

Components:
Addition and Subtraction (186303)
Multiplication and Division (186304)
Fractions, Percents, Proportions, and Angles (186305)
Metric System (186306)
Formulas (186307)
Introduction to Algebra (186308)

186303
Addition and Subtraction

Objectives:
- Define the terms: whole number, numeral, digit, decimal, place value, addend, sum, minuend, subtrahend, and difference.
- Explain the significance of the digit zero in a number.
- Differentiate between concrete and abstract numbers.
- Properly prepare numbers for addition and subtraction.
- Perform addition and subtraction on numbers.
- How to check your answers to both addition and subtraction problems.
- How to use a calculator to add and subtract numbers.

186304
Multiplication and Division

Objectives:
- Define the terms: factor, multiplicand, multiplier, partial product, dividend, divisor, quotient, and remainder.
- Recognize the various signs used for multiplication and division.
- Properly prepare numbers for multiplication and division.
- Perform multiplication and division on whole numbers and decimals.
- How to check your answers to both multiplication and division problems.
- How to find the average of a group of numbers.
- How to use a calculator to multiply and divide numbers.

186305
Fractions, Percents, Proportions, and Angles

Objectives:
- Define the terms: fraction, proper fraction, improper fraction, lowest common denominator, percent, ratio, and proportion.
- How to add, subtract, multiply, and divide fractions and decimals.
- How to change fractions to decimals and decimals to fractions.
- Solve problems involving percent.
- How to use a protractor to measure angles.
- Lay out templates for checking angles.
- How to use a calculator to solve percent problems and to convert fractions to decimals.

186306
Metric System

Objectives:
- Name the base units most commonly used in the metric system.
- Identify metric prefixes and their values.
- Apply conversion factors to increase or decrease metric base units.
- Estimate lengths in metric units.
- Express temperature in degrees Celsius.

- Define the terms: mass, density, force, torque, and pressure. Identify the metric units used to measure each one.
- How to use a calculator to convert one metric unit to another.

186307
Formulas

Objectives:
- Explain the use of letters in formulas.
- Prepare and use formulas to solve problems.
- The use of formulas to calculate the perimeter of a triangle and rectangle, distance, area of a triangle, rectangle, and circle, volume of a pyramid, current in a circuit, and volume of a sphere.
- How to use a calculator to find square root and solve formulas.
- Transform and solve an equation.
- Perform basic arithmetic operations with signed terms.
- Substitute given numerical values for letters in a formula and find the unknown quantity.

186308
Introduction to Algebra

Objectives:
- Define the terms: term, constant, coefficient, exponent, monomial, trinomial, and polynomial.
- Identify and combine like terms in an expression.
- Multiply and divide terms containing exponents.
- Remove parentheses from an expression and simplify the expression.
- Perform basic arithmetic operations with signed terms.

Block X32
Practical Measurements

Duration:
25 hours (includes 5 tests)

What Students Learn:
The five lessons in this block present the trainee with a broad overview of measurements found in an industrial setting. In addition to the basic measurements of length, temperature, energy, force, and power, the trainee will learn how materials are measured and handled in bulk quantities. Fluid measurements include the measuring of fluid flow, fluid pressure, and fluid level. All lessons include the metric conversions in addition to the English units.

Special Notes:

This updated course replaces the X0105 to X0109 lessons found in Practical Math and Measurements, Block X01. Each study unit contains a progress examination.

Components:
Linear and Distance Measurement (186125)
Bulk Measurement (186126)
Temperature Measurement (186127)
Energy, Force, and Power (186128)
Fluid Measurement (186129)

186125
Linear and Distance Measurement

Objectives:
- Recognize the difference between English and metric units of length.
- Find the perimeter of rectangular, square, or triangular areas or objects, such as rooms or machine bases, after measuring the sides.
- Calculate the circumference of circular objects like pipes of tanks after measuring the diameter.
- Measure lengths with the aid of rigid and flexible rules, thickness gauges and screw pitch gauges.
- Read a typical vernier scale and micrometer to take precise measurements.

186126
Bulk Measurement

Objectives:
- Measure an angle by degrees.
- Find the areas of rectangles, triangles, and circles.
- Find the volumes of prisms, cylinders, and cones.
- Find the weight of material stored in a container.
- Determine the amount of material that can be stored or handled.
- Discuss the types and uses of conveyors and weighing systems.

186127
Temperature Measurement

Objectives:
- Change temperature units from one system to another.
- Discuss the use of the various types of thermometers.
- Select the type of thermometer to be used at certain temperatures.

186128
Energy, Force, and Power

Objectives:
- Distinguish between the concepts of energy, force, and power.
- Explain what the term "work" means, and how it is measured.
- Know by sight the basic machines, lever, inclined plane, wedge, wheel and axle, and screw.
- Solve simple problems that involve levers, mechanical advantage, and machine efficiency.
- List the forms of energy that have important industrial applications, and the instruments used for measuring energy.

186129
Fluid Measurement

Objectives:
- Understand the properties of fluids.
- Determine the density, specific gravity, and viscosity of fluids.
- Express pressure in three different units.
- Measure the pressure of fluids using manometers and Bourdon tubs pressure gages.
- Measure the flow rate of fluids using different types of flowmeters.

186073
Problem Solving and Troubleshooting

Duration:
10 hours (includes 1 test)

What Students Learn:
What Students Learn:
Basics of problem solving, troubleshooting, and critical thinking
Applying a logical procedure in solving problems and troubleshooting systems
Selecting and using the right troubleshooting tools
Focusing on andcollecting information related to the problem at hand
"Using what you know" to understand complex systems

186052
Common Hand Tools, Part 1

Duration:
5 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
Practical Measurements (Block X22)
Trades Safety: Getting Started (186001)

What Students Learn:
Preview
In the first part of a students introduction to hand tools, you'll learn about various types of tools as well as how to use them safely. You'll also learn how workpieces are held in place, the manner in which workpieces are marked prior to actually starting a given job, and how to make the most of a workbench's many useful features.

Next, students will be introduced to a group of hand tools which most technicians use on a daily basis -- wrenches, pliers, screwdrivers, and hammers. Again, you'll learn the correct ways to safely use and take care of these tools. Equally important, students will learn how not to use these tools and the results of their improper use.

Objectives
When a student completes this study unit, he and she will be able to:
- Identify common hand tools and their function.
- Explain how to safely use common hand tools.
- Maintain most types of hand tools.
- Describe the benefits of several special features available for some hand tools.

Contents
Working with Hand Tools; Wrenches; Pliers; Screwdrivers; Striking Tools; Tool Storage and Benchwork.

186053
Common Hand Tools, Part 2

Duration:
5 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
Practical Measurements (Block X22)
Trades Safety: Getting Started (186001)

What Students Learn:
Preview
In this study unit, we'll continue the discussion of hand tools commonly used by technicians. While a broad range of technicians use many of the tools discussed here, such as chisels and punches, many others are more specialized and are commonly used by maintenance and machine trades technicians.

Students will learn how to choose the correct chisel or punch for the job, how to care for it, and use it safely.

Next, you'll learn about the variety of different cutting tools such as snips, knives, and hacksaws. Another important group of tools is shaping tools, such as files. Students will learn the different types of files, and again, how to care for them, and use them safely.

Also discussed in this unit are various specialized maintenance tools. These are tools used for specific types of maintenance jobs such as pulling or prying objects from machines, safely inspecting machines, and retrieving objects in areas that aren't easily accessible to the technician.

Objectives
When a student completes this study unit, he and she will be able to:

- Identify and use various chisels and punches safely.
- Use and care for cutting tools.
- Understand the need for specialized maintenance tools.
- Correctly use threading and other precision tools.

Contents
Struck Tools; Cutting Tools; Sheet Metal Tools; Shaping Hand Tools; Hand Tools for Threading and other Precision Work; Specialized Maintenance Hand Tools.

186054
Electric Drilling and Grinding Tools

Duration:
5 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
Practical Measurements (Block X22)
Trades Safety: Getting Started (186001)

What Students Learn:
Preview
The electric drill is one of the most widely used power tools. It has many uses and is simple to operate. Electric drills can be found in a variety of shapes and sizes, from a light household duty to the heavy-duty industrial grade hand drill and drill press. One variation of the electric drill is the hammer drill or rotary hammer. The hammer drill is a tool used for making holes in concrete and masonry.

Grinders are commonly used for shaping and finishing metal and other materials. Hand grinders are available in sizes ranging from those designed to do the intricate work of the die grinder to that of the 7-inch heavy-duty disc grinder. Bench grinders are standard equipment in most shops, ranging from a 6-inch bench model to the heavy-duty 12-inch pedestal grinder.

Objectives
When a student completes this study unit, he and she will be able to:

- Safely set up and operate a portable electric drill, electric drill press, and electric hammer.
- Choose the proper drill bit for many drilling applications.
- Set up and use a variety of hand and bench grinders.
- Safely use the proper grinder for various jobs.
- Follow the necessary steps for proper tool maintenance.
- Purchase the proper drilling tool for your application.

Contents
Electric Drills; Drill Presses; Drill Bits; Hammer Drills and Rotary Hammers; Electric Grinders; Abrasives.

006027 - 006028
Electrical Equipment

Duration:
20 hours (includes 2 tests)

Course Prerequisites:
Electrical Wiring Practices (086E02)

What Students Learn:
PART 1 (006027). This study unit will teach students about the different types of equipment and hardware that are required to mechanically support or complete interrupted electric circuits. This equipment is needed at the many locations in a wiring run where the wiring is interrupted. In particular, this study unit deals with receptacles, switches, lampholders, boxes, and fittings.

When students complete this study unit, you will be able to:

- Recognize several common types of wiring equipment.
- Define the important terms that apply to electrical equipment.
- Recognize the electrical symbols that relate to electrical equipment.
- Explain when and where boxes, cabinets, and panels are used in electrical installations.
- Describe how to properly install boxes, cabinets, and panels.

- Explain when and where cable and conductor fittings and conduit fittings are used in electrical installations.
- Describe how to properly install boxes, cabinets, and panels.
- Explain when and where cable and conductor fittings and conduit fittings are used in electrical installations.
- Describe how to install cable and conductor fittings and conduit fittings.

PART 2 (006028). In Electrical Equipment, Part 1, students learned about boxes and fittings of various types that are used at the many locations in a wiring run where the wiring is interrupted. In this study unit, the student will learn about the equipment and hardware that are needed at these locations where the wiring has stopped and must be connected to loads or devices.

When students complete this study unit, you will be able to:

- Recognize and identify various types of control devices, including hand operated switches, automatic switches, magnetically controlled devices, and remote control systems.
- Explain how to install various types of control devices.
- Identify various types of protective devices, including fuses, circuit breakers, and ground fault circuit interrupters.
- Describe the installation of various protective devices.
- Classify and define various types of electrical loads.

Special Notes:
- This updated course replaces, Electrical Equipment, course 4403A-B.
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006014
Conductors

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Electrical Wiring Practices (086E02)

What Students Learn:
Electrical circuits rely on conductors to carry current from one point to another. All electricians deal with some form of conductors every day.

In this study unit, you will learn about conductor characteristics that are important to the electrician. Understanding how to select the appropriate conductors for a job and how to install conductors properly is described in this study unit.

When students complete this study unit, you will be able to:

• Identify the physical properties and characteristics of conductors.
• Identify electrical properties and characteristics.
• Work with tables that define conductor characteristics.
• Install and connect wires and cables in residential circuits.
• Size conductors to match circuit requirements.

Special Notes:
• This updated course replaces, Conductors, course 4402B.
• This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006015
Working With Conduit

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Electrical Wiring Practices (086E02)

What Students Learn:
This study unit focuses on what the electrician needs to know about conduit. It begins by explaining the characteristics of commonly used types of conduit. Next, the study unit covers conduit installation, including fittings, supports, and conduit sizing considerations. When installing conduit, you frequently have to make bends in the conduit. These bends must be made with the proper tools using specific techniques which are described in this study unit. The study unit concludes with a discussion on why and how specific conductors are installed in conduit.

When students complete this study unit, you will be able to:

- Identify and define the types and characteristics of conduit.
- Describe and install various types of conduit fittings and supports.
- Identify the tools needed to bend conduit and use those tools correctly.
- Determine conductor and conduit sizing when given a particular wiring job.

Special Notes:

- This updated course replaces, Conduit, course 4402A.
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006029
Wiring Electrical Components, Part 1

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Electrical Wiring Practices (086E02)

What Students Learn:
Electrical equipment, devices, and conductors are wired together to form circuits. In this study unit, you will learn how to combine what you know about electrical equipment and conductors in order to wire typical new residential circuits. You will also learn many of the features of electrical systems.

When students complete this study unit, you will be able to:

- Identify the function of various electrical components.
- Recognize and work with various types of electrical systems.
- Describe the function of grounding wires and connect them properly.
- Select the correct terminals on electrical equipment and properly connect them to circuit conductors.
- Select the proper switches, receptacles, and device boxes needed for given applications and describe how they are wired.
- Identify the terminals on light fixtures and how they are wired.

Special Notes:
- This updated course replaces, Conduit, course 4402A and Wiring Electical Components, Part 1, course 4404A.
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006030
Wiring Electrical Components, Part 2

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Electrical Wiring Practices (086E02)

What Students Learn:
Students now understand how to wire a new electrical system. Specifically, you have learned how to install wiring from one point to another and how to install and wire the boxes and devices at those points where the wiring is interrupted. In this study unit, you will learn how to apply this knowledge to old work situations. While much of the old work task involves the same skills you will use when doing new work, there are additional things students will need to know. This unit also discusses certain special wiring situations that are commonly encountered but not part of every job. It also explains how electricians use circuit measurement techniques to troubleshoot problems.

When students complete this study unit, you will be able to:

• Explain how old work differs from electrical jobs for new construction.
• Identify several ways to run wire in existing structures.
• Describe the steps to take when installing new electrical devices in existing structures.
• Outline the acceptable procedure for adapting existing aluminum wire for use with modern devices.
• Explain how electricians rely on electrical measurements to troubleshoot an existing circuit.

Special Notes:
• This updated course replaces, Conductors, course 4402B and Wiring Electrical Components, Part 2, course 4404B.
• This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006021
Working with Multimeters

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Electrical Safety for the Trades (186005)
AC Principles (Block A22)

What Students Learn:

When an electrician is asked to identify the source of a circuit or locate a fault in a machine, the first tool normally selected to help with this task is a multimeter. The multimeter can be used quickly to identify circuits, troubleshoot both AC and DC power supply problems, and find circuit breaker problems. In this study unit, trainees will learn how to use digital multimeters and their special features and capabilities. As is the case when working with any electrical equipment, encompassing live circuits and power supplies, safety considerations should be foremost in the workers' mind at all times.

When students complete this study unit, you will be able to:

- Define the terms voltage, current and resistance, and explain their relationship in a circuit.
- Discuss how voltage, current and resistance are measured with a multimeter.
- Discuss some of the most important safety precautions to take when working with a multimeter.
- Describe the purpose of a continuity test.
- Perform tests for short circuits.
- Perform resistance tests on resistors, switches and transformers.
- Measure current by using a direct series connection.
- Measure the output voltage of a DC power supply.

Block A31
DC Principles

Duration:
30 hours (includes 6 tests)

Course Prerequisites:
Basic Industrial Math (Block X31)

What Students Learn:
In this block consisting of six study units, the trainee will learn the basics of electrical theory. These units introduce electrical terms, symbols, and the operation of simple circuits. Ohm's law receives extensive coverage including practical troubleshooting examples used to industry. A new unit specific to capacitors and inductors provides more in-depth coverage. Up-to-date information on conductors, insulation, and specialty batteries forms a revised study unit. Study units covering magnetism, electromagnetism, motors, and generators are included with industry related examples.

Special Notes:
This updated course replaces DC Principles, Block A01. Each study unit contains a progress examination.

Components:

Nature of Electricity (086112)
Circuit Analysis and Ohm's Law (086113)
Capacitors and Inductors (086114)
Magnetism and Electromagnetism (086115)
Conductors, Insulators, and Batteries (086116)
DC Motors and Generator Theory (086117)

086112
Nature of Electricity

Objectives:
- Explain the operation of a simple circuit.
- Define the terms: conductor, insulator, and resistor.
- Demonstrate that unlike charges attract and like charges repel.
- List the dangers and benefits of static electricity.
- Define the terms: volt, ampere, and ohm.
- Describe common notations and prefixes used to identify electrical and electronic values.
- Identify carbon resistors, potentiometers, and rheostats, and explain how they work.
- Identify the common electrical symbols used in schematic diagrams.
- Explain the difference between a series and parallel circuit.

086113
Circuit Analysis and Ohm's Law

Objectives:
- Find the total resistance in series, parallel, and series-parallel circuits.
- Use Ohm's law to calculate the current, voltage, or resistance in circuits.
- Calculate the amount of power supplied and dissipated in a DC circuit.
- List the steps for finding current, voltage, and resistance with a digital or analog meter.

086114
Capacitors and Inductors

Objectives:
- Explain how a capacitor holds a charge.
- Describe common types of capacitors.
- Identify common capacitor ratings.
- Calculate the total capacitance of a circuit containing capacitors in series or in parallel.
- Calculate the time constant of a resistance-capacitance or RC circuit.
- Explain how inductors are constructed.
- Describe the system used to rate inductors.
- Describe how an inductor regulates the flow of current in a DC circuit.

- Calculate the total inductance of series or parallel connected inductors.
- Calculate the time constant for a resistance-inductance or RL circuit.

086115
Magnetism and Electromagnetism

Objectives:
- Identify the north and south poles of permanent magnets and electromagnets.
- Name magnetic and nonmagnetic materials.
- Describe how to magnetize a piece of steel by induction.
- Explain the difference between simple, compound, and closed magnetic circuits.
- Locate the direction of magnetic lines of force around a conductor (if the direction of current is known).
- Use the right-hand rule to locate the poles of a solenoid.
- Describe the operation of simple electromagnetic relays, buzzers, and stepping switches.
- Explain how a DC motor operates.
- Give a simplified explanation for generator action and motor action with electromagnetic induction.

086116
Conductors, Insulators, and Batteries

Objectives:
- Describe the various types of conductors and discuss their conductivity.
- Explain the American Wire Gage System of sizing copper conductors.
- Determine the size of conductor needed for an application.
- Identify the various types of insulating materials and their temperature ratings.
- Explain the difference between a dry cell and a storage battery.
- How to connect cells together to obtain more voltage, more current, or more of both voltage and current.
- Describe the proper safety precautions used when working with storage batteries.
- Describe how to properly clean and care for storage batteries.
- Discuss the instruments used for testing storage batteries.
- Explain how NiCad, lithium, and other types of special batteries operate, and describe their ratings.

086117
DC Motors and Generator Theory

Objectives:
- Identify a series-, shunt-, and compound-wound motor and discuss their application.
- Explain how a permanent-magnet and stepper motor operate.
- List the steps to reversing a DC motor's direction.
- Discuss how the speed of a DC motor can be controlled.
- Explain the basic principle for generating a direct current.
- Name the factors that affect the strength of the induced voltage.
- Describe the purpose of a commutator and brush assembly.
- Discuss the difference between the field connections of series-, shunt-, and compound-wound machines.
- Give the reason for shifting brushes.
- Discuss the use of commutating poles and compensating windings for better generator operation.
- List the various types of machine losses.

Block A32
AC Principles

Duration:
40 hours (includes 8 tests)

Course Prerequisites:
Basic Industrial Math (Block X31)
DC Principles (Block A31)

What Students Learn:
Alternating current is the form of current most often used to furnish electrical energy. Students receive a complete introduction to AC terminology and basic AC circuit configurations. Individual study units on the uses of capacitors and inductors in AC circuits underlines the importance of these components in AC theory. The generation, control, and distribution of AC power are highlighted in study units on alternators, transformers, and energy distribution. How electricity is generated at a power plant and sent to consumers is covered. The student will also be introduced to basic electronics through a study unit on rectification and basic electronic components.

Special Notes:
This updated course replaces AC Principles and Components, Block A02. Each study unit contains a progress examination.

Components:
Alternating Current (086118)
Alternating Current Circuits (086119)
Inductors in AC Circuits (086120)
Capacitors in AC Circuits (086121)
Transformers (086122)
Alternators (086123)
Electrical Energy Distribution (086124)
Rectification and Basic Electronic Devices (086125)

086118
Alternating Current

Objectives:
- Draw a graph of an AC voltage and describe how AC voltage is created.
- Explain AC cycle terms: "alternation," "peak," "positive," and "negative."
- Define the time period of an AC voltage as expressed in degrees.
- List the characteristic values of an AC cycle and describe the relationship between the values.
- Define phase angle and describe how it relates to reactive circuits.
- Calculate power for single-phase and three-phase circuits.
- Describe how a 220 VAC single-phase circuit operates.
- Illustrate the phase relationship of three-phase wave forms.
- Determine real power by reading a power factor meter.
- Describe delta and wye three-phase circuit connections.

086119
Alternating Current Circuits

Objectives:
- Identify electric circuits in terms of their circuit characteristics.
- List several circuit characteristics that are used to describe a circuit for a particular load application.
- Connect electrical components in series and parallel circuits.
- Control loads from one or two switch points.
- Describe how delta- and wye-connected three phase circuits are different.
- Explain how grounding a circuit increases its safety.
- Recognize the difference between control circuits and power circuits.

086120
Inductors in AC Circuits

Objectives:
- Explain how an inductor is made and how it operates in a DC and AC circuit.
- Describe inductive reactance and impedance, and how AC frequency effects inductance.
- Use Ohm's law in an AC circuit that includes an inductor.
- Calculate the impedance of a series RL circuit.
- Calculate the impedance of a parallel RL circuit.

086121
Capacitors in AC Circuits

Objectives:
- Describe how a capacitor stores a charge and how series connected and parallel connected capacitance values are calculated.
- Discuss capacitive reactance and use Ohm's Law in AC circuits that contain a capacitor.
- Calculate the impedance of a series RC circuit.
- Explain how changing the frequency of an AC signal changes capacitive reactance.

086122
Transformers

Objectives:
- Explain what the main components of a transformer are.
- Tell how mutual inductance makes it possible to change an AC voltage from one value to another when using a transformer.
- Determine the turns ratio of a transformer when the primary and secondary voltages are known.
- Calculate primary or secondary voltages or current when either one of these and the turns ratio are known.
- Explain why transformers are laminated.
- Connect three single-phase transformers for three-phase operation.
- Calculate line current (if phase current is known) in delta-connected transformers.
- Explain the operating principles of an auto transformer.

086123
Alternators

Objectives:

- Explain how single- and three-phase alternators operate.
- List and describe the major components of an alternator.
- Discuss alternator ratings in terms of power, voltage, speed, and temperature.
- State the steps required for starting, stopping, and operating alternators.
- Describe the similarities and differences of the three main types of alternators.

086124
Electrical Energy Distribution

Objectives:
- Explain the difference between feeder and branch circuits.
- Describe the different types of systems available for distributing power within a plant.
- Recognize and identify utilization equipment.
- Discuss the use of transformers in energy distribution.
- Identify by name and describe the uses of various types of raceways.
- Distinguish between panel boards and switchboards.
- Describe the electrical system of a power utility.
- Describe how electricity is generated at a power station or utility.

086125
Rectification and Basic Electronic Devices

Objectives:
- Explain how diodes are used as rectifiers.
- Discuss the basic operation of a diode and a triode electron tube.
- Connect a PN junction for forward and reverse bias.
- Explain how a transistor operates as an amplifier.
- Recognize transistor input and output circuits.
- Compare rectifier circuits with and without filter circuits.
- Describe the operation of an SCR and a triac.
- Calculate the ripple frequency of a half-wave and full-wave single-phase and three-phase rectifier.

086013
Electrical Energy Distribution

Objectives:
- Explain the difference between feeder and branch circuits.
- Describe the different types of systems available for distributing power within a plant.
- Recognize and identify utilization equipment.
- Discuss the use of transformers in energy distribution.
- Identify by name and describe the uses of various types of raceways.
- Distinguish between panel boards and switchboards.
- Describe the electrical system of a power utility.
- Describe how electricity is generated at a power station or utility.

086014
Rectification and Basic Electronic Devices

Objectives:
- Explain how diodes are used as rectifiers.
- Discuss the basic operation of a diode and a triode electron tube.
- Connect a PN junction for forward and reverse bias.
- Explain how a transistor operates as an amplifier.
- Recognize transistor input and output circuits.
- Compare rectifier circuits with and without filter circuits.
- Describe the operation of an SCR and a triac.
- Calculate the ripple frequency of a half-wave and full-wave single-phase and three-phase rectifier.

186080
Introduction to Print Reading

Duration:
8 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)

What Students Learn:
• Describe the basic format for conveying technical information in a drawing
• Interpret the various drawing views used in technical drawings
• Extract information from notes and title blocks
• Recognize and interpret the different line types used in drawings
• Understand the concept of drawing scale and how it affects
information shown in the drawing
• Identify various types of building, electrical, and mechanical drawings.

186081

Print Reading Symbols and Abbreviations

Duration:
8 hours (includes 1 test)

Course Prerequisites:
Introduction to Print Reading (186080)

What Students Learn:
• Recognize, understand, and interpret the most common abbreviations
used on a wide range of drawing types used in construction and
maintenance trades
• Understand and interpret the various symbols and notations used on
drawings for electrical, architectural, mechanical, welding, fluid
power, and other types of applications
• Explain how.

186082
Dimensioning and Tolerancing

Duration:
8 hours (includes 1 test)

Course Prerequisites:
Introduction to Print Reading (186080)

What Students Learn:
• Recognize the international standards and conventions that apply to
drawings
• Explain how different numbering systems were developed and how
they are applied to prints
• Read and interpret various systems of dimensions and tolerances on
drawings
• Recognize and interpret common symbols and nomenclature used in
geometric dimensioning and tolerancing (GD&T) systems
• Understand how GD&T symbols describe the designer's intent to
those making or inspecting the part, eliminating misinterpretation of
the print.

186083
Print Reading Applications

Duration:
8 hours (includes 1 test)

Course Prerequisites:
Introduction to Print Reading (186080)
Print Reading Symbols and Abbreviations (186081)
Dimensioning and Tolerancing (186082)

What Students Learn:
Work with standard drawing formats to obtain information such as
part titles, part numbers, dimensional standards, revisions, and
materials
• Explain how various components shown on prints are connected or
related to each other
• Obtain information from a drawing about quantities, materials,
assembly processes, or dimensions
• Visualize the three-dimensional parts and assemblies represented by
two-dimensional drawings
• Effectively interpret electrical, architectural, mechanical, fluid power, and other types of prints.

186043
Building Drawings

Duration:
8 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)

What Students Learn:
- Identify the various kinds of building drawings.
- Compare elevations, plans, and sections.
- Match the symbols used on drawings with the various building materials they stand for.
- Interpret the explanations and abbreviations used on building drawings.
- Read steel and concrete structural drawings.

186044
Electrical Drawings and Circuits

Duration:
8 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)

What Students Learn:
- Identify electrical construction drawings, schematics, and wiring diagrams.
- Interpret various electrical symbols.
- Read standard abbreviations used in electrical diagrams.

- Tell if a diagram is a block diagram, a schematic diagram, or a wiring diagram.
- Compare closed circuits, open circuits, grounded circuits, and short circuits.

006022
Reading Electrical Schematic Diagrams

Course Prerequisites:
DC Principles (Block A21)
AC Principles (Block A22)

What Students Learn:
Electrical Diagrams; Meaning of Schematic Diagrams; Schematic Diagrams of Basic Electric Equipment and Connections, such as Types of Circuits; Sources of DC Power; Sources of AC Power; Transformers; Rectifiers; Motors; Measuring Devices; Protection and Control Devices.
Schematic Diagrams of Lighting Circuits and Various Types of Motor Control Circuits; Typical Schematics Used in Generating Systems, Transmission Systems, and Distribution Systems.

Special Notes:
This updated course replaces, Electrical Schematic Diagrams, course 6634A-B.

006036
Electrical Blueprint Reading

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
AC Principles (Block A22)

What Students Learn:
In this study unit, you will learn to read several different types of electrical blueprints. Reading and understanding the information that appears on a blueprint will be emphasized, not the design details of a particular project. Engineers and designers use blueprints to present design information in a variety of ways. The general principles for preparing blueprints will also be covered. The skills you learn can be applied to reading blueprints for residential, commercial, manufacturing, and electric utility projects.

When students complete this study unit, you will be able to:

- Explain how blueprints are prepared.
- Discuss how and why blueprints are copies of original drawings.
- Talk about the relationship of electrical blueprints to the architectural drawings and drawings of other trades.
- Read and understand the information presented on blueprints.
- Identify the different methods of presenting information.
- Interpret the common symbols used on electrical blueprints.
- List the common abbreviations used on electrical blueprints.
- Trace a wiring diagram and understand it.

Special Notes:
This updated course replaces, Electrical Blueprint Reading, course 6635.

Block A33
Analog Circuit Measurement

Duration:
15 hours (includes 3 tests)

Course Prerequisites:
Basic Industrial Math (Block X31)
AC Principles (Block A32)

What Students Learn:
In this three unit block, trainees learn how to use electrical test instruments and measuring techniques. The instruments covered are multimeters, volt-ohm-milliameters (VOMs) and oscilloscopes. Students will learn how to measure voltage, resistance, and current valves is a circuit. Troubleshooting tests on both AC and DC systems including PLC input and output problems are emphasized.

Special Notes:
This updated course replaces Electrical Measurements and Instruments, Block A03. Each study unit contains a progress examination.

Components:
Basic Test Equipment (086126)
Troubleshooting with Volt-Ohm-Milliamp Meters (VOMs) (086127)
Using Basic Oscilloscopes (086128)

086126
Basic Test Equipment

Objectives:

- How to use the multimeter (also known as a volt-ohm-milliameter or VOM).
- Define the terms voltage, current and resistance, and explain their relationship in a circuit.
- Discuss how voltage, current and resistance is measured with a multimeter.
- Identify the schematic symbols used to represent various reactive devices.
- Describe the major features of analog and digital VOMs.
- Explain how to use both analog and digital VOMs to measure voltage, resistance and current in a circuit.
- Learn about the special probes used with a digital VOM.
- Discuss the important safety precautions you must take when using a multimeter.

086127
Troubleshooting with Volt-Ohm-Milliamp Meters (VOMs)

Objectives:

- Review the functions of a multimeter.
- Name the safe practices you should use when troubleshooting with a VOM.
- How to measure circuit resistance.
- Learn the purpose of, and how to perform, tests for continuity and short circuits.
- Perform resistance tests on resistors, fuses, solenoids, relays, switches, transformers, motors and semiconductors.
- How to take basic current measurements on power supplies, AC feeder lines and other such circuit areas.
- Measure current by using a direct series connection or by using a clamp-type ammeter.
- How to take basic voltage measurements on both AC and DC systems.
- Measure the output voltage of a DC power supply and the voltage of an AC feeder line.
- Measure voltage at disconnect switches, circuit breakers, contactors and transformers.
- Perform voltage tests on circuit boards, PLC systems and motor circuits.

086128
Using Basic Oscilloscopes

Objectives:

- An introduction to the basic controls and functions of an oscilloscope.
- Describe the component parts and features of a standard, dual-trace oscilloscope.
- How to use the front panel controls.
- How to connect an oscilloscope to a circuit.
- Learn how to perform low-voltage measurements on circuit boards.
- Measure the voltage output of a power supply and AC ripple.
- Describe how to perform measurements in SCR and TRIAC circuits.
- Test both DC and AC servo motor controller circuits and heater controller circuits.
- Perform basic scope measurements on digital circuits.
- Learn how to use an oscilloscope to troubleshoot industrial systems.

186005
Electrical Safety for the Trades

Duration:
5 hours (includes 1 test)

What Students Learn:
Preview
This study unit will introduce students to many workplace situations that require you to work safely with electricity. You will learn how and why electricity can be dangerous. Trainees will also learn about various methods used for protection. Safety begins with the careful installation of electrical components by means of approved wiring methods. You should use safety procedures and practices that insulate you from electricity's power anytime you work with, or near, electrical equipment and components.

Objectives
When a student completes this study unit, he and she will be able to:

- Explain how electricity can harm you and your property.
- Discuss the importance of properly using quality electrical components.
- Follow the basic methods of protection when wiring electrical installations.
- Tell why it is important to ground electrical equipment and systems.
- Select the type of electrical equipment to use in a hazardous location.
- List the safety practices required in an electrical work area.
- Talk about the importance of a clear working space around electrical equipment.
- Educate your own level of safety training to be sure it matches the electrical work you are performing.

Contents
Introduction to Electrical Safety; Using Proper Materials and Components; Equipment Grounding; Hazardous Locations; Safe Working Clearances; Safety Practices.

Block A24
Electrical Equipment

Duration:
60 hours (includes 12 tests)

Course Prerequisites:
Basic Industrial Math (Block X21)
Analog Circuit Measurement (Block A23)

What Students Learn:
The twelve study units in this block provide the student with the skills and knowledge needed to install basic industrial electrical equipment. In addition to learning the symbols for the various types of equipment, the student will learn how to safely install conductors and electrical fittings. The types of equipment discussed includes outlet boxes, panels, raceways, conduits, switches, fuses, circuit breakers, plugs, receptacles, and lampholders. The student will also learn how to calculate electrical loads, lay out circuits, and troubleshoot control circuits.

Special Notes:
This updated course replaces Electrical Equipment, Block A04. Each study unit contains a progress exam.

Components:
Conductors and Insulators in Industry (086070)
Working with Conduit (086071)
Electrical Boxes (086072)
Industrial Enclosures and Raceways (086073)
Connecting Electrical Equipment, Part 1 (086074)
Connecting Electrical Equipment, Part 2 (086075)
Industrial Fuses (086076)
Industrial Circuit Breakers (086077)
Plugs, Receptacles, and Lampholders (086078)
Industrial Switches (086079)
Industrial Relay Ladder Logic (086080)
Industrial Relays, Contractors, and Solenoids (086081)

086070
Conductors and Insulators in Industry

Objectives:
Preview

As an industrial electrician, students will work with various types of conductors and insulators. For instance, you may install a new service and have to pull conductors through conduit. Electricians will have to select the right size, type, and color of conductor to properly perform the installation. In another instance, you may troubleshoot a problem with an industrial circuit and find a faulty conductor. Your knowledge of the types of conductors and insulators can help you perform this task quickly and efficiently.

This study unit provides electricians with information on conductors and insulators that you will find in industry. This study unit covers a range of conductors from the standard plastic coated, copper conductors to the large, high-temperature conductors. Students will learn about the different types of insulators and how the type of insulator can influence the maximum temperature and current-carrying capability of the conductor. At the end of this study unit, students will learn how to troubleshoot and repair conductor and insulator problems.

Objectives
When students complete this study unit, he and she will be able to

- Identify the physical properties of various conductors.
- Describe the electrical properties of common conductor materials.
- Explain why conductors contain resistance, which causes voltage drops.
- Identify the common types of insulation materials that are used on industrial conductors.
- Explain how to repair faulty insulation on industrial conductors.
- Describe how to troubleshoot and repair conductor and insulation problems.

Contents
Physical Properties and Characteristics: Conductor Terminology; Wire Sizes; Wire Tables; Mil-Foot and the Effect of Temperature; Electrical Properties and Characteristics: Conductivity; Wire Resistance; Voltage Drop; Types of Industrial Insulation: The Definition of an Insulator; Natural Insulators; Synthetic Insulators; High-Temperature Insulators; Shrink Tubing; Tapes; Other Forms of Insulators; Problems with Conductors and Insulators: Effects of Too Much Current or Heat; Effects of Abrasion; Effects of Poor Conductor and Insulator Installation ;Effects of Aging on Conductors.

086071
Working with Conduit

Objectives:
Preview

This study unit focuses on what an electrician needs to know about conduit. First, you will study the characteristics of common types of conduit. Next, students will learn how to work with conduit. The course covers the types of fittings, conduit cutting and threading, and supporting conduit from walls and ceilings. When installing conduit, an electrician frequently has to make bends in the conduit. These bends must be made properly, using the right tools and techniques described in this study unit. Finally, you will study examples of large conduit installations and how to size and pull conductors through conduit.

Objectives
When a student completes this study unit, he and she will be able to:

- Define the characteristics of different types of conduit.
- Describe how to install various types of conduit fittings and support.
- Explain how to properly cut and thread conduit using manual and machine methods.
- Identify and use the proper tools for bending conduit.
- List the equipment used in installing large conduit and its conductors.
- Determine conduit sizing when given a particular wiring assignment.

Contents
Conduit Types and Characteristics: Rigid Metal Conduit Systems; Electrical Metallic Tubing (EMT);Intermediate Metallic Conduit (IMC);Flexible Metal Conduit; Other Types of Conduit; Conduit Procedures: EMT Conduit Fittings; Rigid and IMT Fittings; Cutting, Reaming, and Threading Conduit; Bonding Conduit; Supporting Conduit; Conduit Nipples and Elbows; Using Insulating Bushings; Bending Conduit: The Right Way ;Manually Operated Benders; Hydraulic Benders ;Radius of the Bend; Bending for a Given Rise; Back-to-Back Bends; Re-bending; Offsets; Saddle Bends; Conduit Run Requirements; Large Conduit Installations: Where Large Conduit Installations are Performed; Conduit Hangers; Using Pull Boxes; Installing Large Conduit Systems; Mating Conductors and Conduit: Derating for More Than Three Conductors; Basic Conductor Ampacity; Derating for More than Three Conductors; Derating for Ambient Temperature; Conductor cross sectional Area; Conductor Fill; Selection of Conduit Size; Combinations of Wire Sizes in Conduit; Fishing Wire through Conduit; Feeding Conductors into Conduit.

086072
Electrical Boxes

Objectives:

Preview
This study unit teaches electricians about a very important part of any electrical distribution or control cable wiring system. This important part is the electrical box. The electrical box may be a small component, such as a box for a light switch or receptacle. Or, the box may be a large junction box with many conductors entering and leaving the box.

This study unit provides you with information on the types of electrical boxes their covers, and discusses boxes for pulling and splicing. Students will learn how to select the proper sized box for a situation. You will also learn about the proper ways of installing electrical boxes.

Objectives
When a student completes this study unit, he and she will be able to:

- Describe the role of electrical boxes in an installation.
- Explain why circuits are interrupted.
- Explain when and where electrical boxes are used in installations.
- Describe how to properly install electrical boxes.
- Identify the types of electrical pulling and splicing boxes.
- Explain how to properly install conductors in a system with electrical boxes.

Contents
Equipment Defined: When Wiring is Interrupted; Material Standards; Common Wiring Terms; Wiring Symbols; The Parts of an Electrical System; Electrical Boxes and Covers: Outlet Boxes; Where Outlet Boxes are Used; Boxes and Their Associated Fittings; Types of Outlet Boxes; Non-Metallic Outlet Boxes; Outlet Box Knockouts; Brackets; Fittings for Outlet Boxes; Flush Plates and Covers; Industrial Electrical Boxes; Boxes used for Pulling and Splicing: Junction Boxes; Special Boxes; Conduit Bodies; Straight Pull Boxes; Right-Angle Pull Boxes; Knockouts and Circuit Grounding; Installing an Outlet Box: The Volume of the Box; Locating an Outlet Box; Mounting an Outlet Box; Lighting Fixtures and Exhaust Fans; Cleaning an Outlet Box; Wiring an Outlet Box.

086073
Industrial Enclosures and Raceways

Objectives:

Preview

Whenever a person walks through an industrial plant, you will notice many large electrical enclosures that serve as control cabinets. These enclosures house panelboards to which many control components, protection devices, recorders, and other equipment, connect. As an industrial electrician, it is important for students to know how industrial enclosures and the panelboards they contain are constructed, secured, and connected to the devices throughout the plant.

This study unit provides electricians with the information you will need to construct and install an industrial enclosure, and to connect the panelboard to the field devices through one or more kinds of raceways. Many different types of installations are encountered in industry, and you will be introduced to several of them. Students will also learn about raceway installation and grounding.

Objectives
When a student completes this study unit, he and she will be able to:

- Describe the basic construction of industrial control cabinets and similar enclosures.
- Explain how to connect conduit to enclosures.
- List the proper procedures for installing a disconnect switch or main breaker in an enclosure and the procedures for connecting conductors to the switch.
- Explain how to properly ground the enclosure.
- Describe how to properly install wireways, such as wiring troughs.
- Explain how plugs and receptacles can be used to prefabricate a system.

Contents

086074
Connecting Electrical Equipment, Part 1

Objectives:
Preview
Industrial systems are complex systems having many interconnections. All components work together to keep the system functioning properly. Every component must communicate with a main control panelboard or a main system controller, which, in turn, communicates with the other components of the system. Even a remote device like a single photoeye located on a distant conveyor plays an important role in a system's operation. That photoeye may communicate with the conveyor system controller and possibly the main assembly line controller.

This study unit provides trainees with information on how intermediate or main junction boxes are connected to the main system by means of raceway. Then, you will learn how devices are connected into a wireway, to a junction box, or to another location, using raceway or cabling and strain relief fittings. The next section discusses how connections are made inside control-panelboard enclosures. Students will be introduced to terminal block connections. You will also learn about connections to devices such as fuse holders, circuit breakers, and motor starters. The final section of this study unit covers connections to remote operator stations and remote control stations.

Objectives
When a student completes this study unit, he and she will be able to:

- Describe the use of flexible conduit, strain relief fittings, plug connections, and terminal blocks in industrial equipment.
- Discuss why there are often two raceways run in parallel in an industrial system.
- Explain when to run rigid conduit, EMT conduit, wireway, or open cords in a system.
- Describe how to make basic connections in industrial control-panelboard enclosures.
- Explain the different classes of remote station and operator station wiring.
- Discuss why various types of cables and conductors must be kept separated.
- Explain how to properly connect communications and controller cables in an industrial control cabinet.

Contents

Connecting Devices to Intermediate Boxes: A General Layout; The AC Wireway; Strain Relief Connections; Larger Systems; Using Receptacles and Plugs; Using Flexible Conduit; The DC Wireway; External Devices; Connections to Terminal Blocks; Connecting Devices to Raceways: Using Rigid Conduit; Using EMT Conduit; Using Flexible Conduit; Using Strain Relief Fittings; Connections in the Control Cabinet: Terminal Block Connections; Connections to Motor Starters and Circuit Breakers; Connections to Fuses; Connecting Signal Cables for Electronic Equipment; Remote Operator Stations: Voltage Levels in Modern Remote Operator Stations; Grounding of Remote Operator Stations; Separating Signal and Control Cables; Broadband and Communication Circuits.

086075
Connecting Electrical Equipment, Part 2

Objectives:

Preview

As an industrial electrician, you will spend a lot of time selecting electrical connectors and making electrical connections. You may perform these activities as part of a new installation or as a repair task. A good electrical connection is critical. A poorly made connection may cause a failure, which can cost thousands of dollars because of downtime in a plant, and possible injury caused by electrical shock.

In this study unit, students will learn how to make good electrical connections using the proper type of electrical connector. This study unit covers solderless terminals, wire nuts, and butt splices. You will learn about larger compression-type connectors and about connections made to smaller devices.

Objectives

When a student completes this study unit, he and she will be able to:

- Describe types of solderless connectors.
- Explain the use of hand-operated and hydraulic crimping tools to make good electrical connections.
- Identify the proper size of wire nut or butt splice for splicing conductors.
- Describe how to make good connections with wire nuts and butt splices.
- Explain how to use large compression connectors, including solderless lugs and split-bolt connectors.
- Describe the installation of wires on terminal blocks, plugs and receptacles, and push-pin style terminals.

Contents

086076
Industrial Fuses

Objectives:

Preview

All electrical and electronic circuits, from the small ones in our homes to the large ones in industry, need to have circuit protection. This protection guards against too much current flowing in the circuit. Too much current in a circuit can cause serious damage. There are two different methods of protecting a circuit: fuses or circuit breakers. This study unit focuses on fuses.

First, this study unit discusses the need for overcurrent protection in modern industrial circuits. There are many reasons why the system wiring, control circuits, and load devices must be protected. Next, fuse ratings and specifications are covered. This section discusses the selection of the correct type and size of fuse in a system.

The following section focuses on typical fuse holders. There are a wide range of fuse holders, from fuses soldered onto a circuit board to those that are clamped into large disconnect switches. Many problems can occur on a fuse holder. This study unit shows how to address the problem until the fuse holder can be replaced. Finally, the unit ends with a discussion of how to safely test and replace fuses in their fuse holders.

Objectives

When a student completes this study unit, he and she will be able to:

- Discuss the purpose of fuses in industrial electrical and electronic circuits.
- Explain the numbering and lettering system for classifying a fuse's shape, size, or circuit protection capabilities.
- Identify various types of fuse holders.
- Locate common failure points on different fuse holders.
- Explain how to properly test and replace a fuse.
- Describe common methods for repairing fuse holders.

Contents

The Purposes of Fuses: Protecting Electrical Wiring; Protecting Circuit Devices; Protecting Control Circuits; Protecting Output Devices; Fuse Ratings and Classifications: Current and Voltage Ratings; Time and Temperature Considerations; Interrupt Current Rating; Fuse Categories and Classifications; Sizes and Shapes of Fuses; Fuse Classifications: Glass and Ceramic Fuse Types; Class RK5 Fuses ;Class RK1 Fuses; Class CC Fuses; Class L Fuses; Class J Fuses; One Time Fuses; Class G Fuses; Class T Fuses; Midget Fuses; Specialty Fuses; Using Fuse Catalogs; Fuse Holders: Holders for Small Glass and Ceramic Fuses; Larger Fuse Holders; Blade Fuse Holders; Open Fuse Installation; Changing Fuses and Maintaining Fuse Holders: Removing Power; Testing the Fuses; Checking for a Short Circuit; Checking Fuse Holder Contacts; Cleaning Fuse Holder Contacts; Maintaining Fuse Holders.

086077
Industrial Circuit Breakers

Objectives:

Preview

As an electrician, one of the most common devices you will see is a overcurrent protection device (OCD). This may be a fuse or a circuit breaker, and every industrial cabinet will usually contain at least one OCD.

The Industrial Fuses study unit covered the various types of fuses. Here the second kind of protective device, the circuit breaker will be examined.

Most people are familiar with the molded-case circuit breakers used in our homes. The home load center will normally contain a main circuit breaker that protects the entire load center for the home, and smaller circuit breakers that protect the various branch circuits.

An industrial control panel is not much different from a home's load center. A large circuit breaker or fuse system is usually located at the main disconnect that supplies the control panel. Each circuit will then contain a smaller circuit breaker or fuse system to protect the branch circuits inside and outside the panel.

This study unit will look at the types of circuit breakers that are commonly used in industry; how they are designed and how they work. We will also look at typical branch circuits for single-phase and three-phase loads. Finally, the study unit will discuss ground fault circuit breakers and outlets, and how to safely work with circuit breakers.

Objectives

When a student completes this study unit, he and she will be able to:

- Explain the thermal and magnetic operation of a circuit breaker.
- Explain how a combination circuit breaker operates.
- Identify an electronic circuit breaker and its operation.
- List the various types of industrial circuit breakers.
- Describe the various types of circuit that single-pole and multiple-pole circuit breakers will be used in.
- Explain how to troubleshoot a circuit in which a circuit breaker has tripped.
- Describe the operation of a ground fault circuit breaker.

Contents

The Operation of a Circuit Breaker: An Automatic Switch; Thermal Circuit Breaker Operation; Magnetic Circuit Breaker Operation; Combination Circuit Breaker Operation; Circuit Breaker Accessories; Electronic Circuit Breakers; Current-Limiting Circuit Breakers; Circuit Breaker Time of Operation; Current Ratings and Interruption Current; Types of Industrial Circuit Breakers: Small Single Phase Breakers; Molded-Case Circuit Breakers; Adjustable Current and Time Delay Circuit Breakers; Air Circuit Breakers; Circuit Breaker Circuits: Protecting Single-Phase Circuits; Protecting Three-Phase Circuits; Alarm Circuit Contacts; Circuit Breaker Auxiliary Circuits; Working with Circuit Breakers: Finding A Replacement Circuit Breaker; Installing Circuit Breakers; Resetting Circuit Breakers; Checking Circuit Breakers; Causes for False Trips; Earth Leakage (Ground Fault) Circuit Interrupters: Terms used for Earth Leakage or Ground Fault Protection Devices; Tripping Current; GFCI Operation; Types of GFCIs; Testing GFCI Circuit Breakers and Outlets.

086078
Plugs, Receptacles, and Lampholders

Objectives:

Preview

Industrial equipment is rarely connected to a control system or to other equipment using direct wiring methods. Instead the power and signal cables are often hooked to the equipment using plugs and receptacles. Trainees will find a wide variety of plugs and receptacles used in industry.

In many cases, an entire work cell or area of a plant is designed and built in a factory, separate from where the equipment will be installed. The machines will interconnect to each other and to the main control system using one of a number of plug and receptacle systems. This study unit will introduce you to those industrial plug and receptacles.

This study unit will begin with information on the common 120 VAC plug and duplex receptacle systems used in both residential and industrial locations. Next students will see the various types of plugs and receptacles used in single phase and three-phase AC power systems. Information on various types of signal plugs and receptacles that are used in industry is covered. Finally, this study unit will conclude with information on various types of lampholders.

Objectives
When a student completes this study unit, he and she will be able to:

- Describe various types of convenience receptacles and their special features.
- Explain how to properly wire a convenience receptacle.
- Describe the operation and installation of a ground-fault circuit interrupter receptacle.
- Identify various types of straight-blade plugs and their installation.
- Discuss how locking receptacles and plugs are different from straight-blade devices.
- Explain how to pick the proper locking plug and receptacle for various currents, voltages, and circuit types.
- Discuss the use and installation of various types of industrial signal and power plugs and receptacles.
- Describe various types of industrial lamps and lamp holders.

Contents

086079
Industrial Switches

Objectives:
Preview
In the maze of wiring, controls, and equipment in most industrial locations, switches are among the most overlooked devices. Yet switches can cause the most problems when they do not work properly. There are many kinds of switches. When troubleshooting, some can be diagnosed simply by looking at their contacts or actuators. But many more switches consist of intricate, sometimes solid-state circuitry, and use component properties such as inductance, capacitance, and magnetism.

These types of switches are found in the basic electrical circuits and in the control rooms of industrial facilities. They also are used in the regulation of such process-line variables as flow, level, temperature, and pressure.

This study unit will introduce electricians to the many designs and technologies of industrial switches, and provide insight into their operation and applications.

Objectives
When a student completes this study unit, he and she will be able to:

- Identify switch symbols on electrical drawings.
- Have a basic understanding of the process control hierarchy.
- Identify the various types of industrial switches.
- Identify components of various types of industrial switches.
- Discuss applications for various types of industrial switches.

Contents

086080
Industrial Relay Ladder Logic

Objectives:
Preview

Control circuitry in industrial applications is the brain behind the brawn of motorized power. Motors require one element to perform the work they are designed to do: power. How they get the power is not a concern of the motor, but it is a major concern to the developers of control systems.

Industries, especially those involving sequential operations such as mills, refineries, chemical plants, manufacturing conveyor systems, and any of the processes that require certain events to happen at certain times, require well-designed control systems.

To properly provide sequential operation of these events, a control system designer must start with what is referred to as logic, or sequential events. A ladder diagram is the main tool used by control systems designers to design a control system that causes certain events to happen at certain times.

Once the design is developed, it is up to the electrician or technician to install the system and, later, to maintain it.

Objectives
When a student completes this study unit, he and she will be able to:

- Describe the fundamentals of relay ladder logic.
- Identify the different types of relays used in ladder logic.
- Identify the symbols for input and output elements used in ladder logic.
- Understand the principles such as power, current flow, rules of reading, numbering systems, and component interconnections applied in relay ladder logic.
- Interpret simple and complex ladder logic by applying the fundamentals learned.

Contents

086081
Industrial Relays, Contractors, and Solenoids

Objectives:
Preview
In the Industrial Relay Ladder Logic study unit, we learned that an electromagnetic relay is an electromechanical switch made up of an electromagnet and a set or sets of contacts.

An electromagnet is created by passing electrical current through a wire, causing a magnetic field to form around the outside of the wire. A ferrous metal, which is a metal that contains iron and can be magnetized, will be pulled toward the magnetic field being emitted by the energized coil. If the ferrous metal is shaped into a rod or plunger and is inserted in the middle of the coil, the magnetic field will pull it into the coil's core, and the rod or plunger will try to align itself in the center of the field. If the bar or plunger is mechanically connected to a contact bar, the device is a relay, starter, or contactor. If the plunger in a coil is mechanically connected to a valve or other operating mechanism, the device is a solenoid.

The magnetic field will pull the contact or mechanical device with it, and cause a movable contact to either make contact or break contact with a stationary contact (in the case of a relay), or cause a mechanical action (in the case of a solenoid).

This study unit will delve deeper into the various types of industrial control relays, magnetic starters, contactors, and solenoids, covering their operating principles, construction, components, and applications.

Objectives
When a student completes this study unit, he and she will be able to:

- Distinguish between types of control relays, contactors, magnetic starters, and solenoids.
- Describe how each type operates.
- Identify the part of each type.
- Identify specific applications for each type.

Contents

006031
Electric Lamps, Part 1

Duration:
10 hours (includes 1 test)

Course Prerequisites:
AC Principles (Block A22)

What Students Learn:
This study unit is designed to provide basic information on the fundamentals of lamp operation. First, students will learn about the concept of light and how it is measured. You will also learn about basic lamp types. The main body of the study unit will provide students with a thorough introduction to the incandescent lamp.

When students complete this study unit, you will be able to:

- Describe the concept of light.
- Define several important photometry terms.
- Name the three major lamp types.
- Explain the term lamp efficacy.
- Calculate the lumen depreciation of a lamp.
- Explain the importance of a lamp's chromaticity and color rendition index (CRI).
- Describe the differences between incandescent lamps and discharge-type lamps.
- List the basic components of an incandescent lamp.
- Explain how a halogen lamp differs from an incandescent lamp.
- Use catalog ordering codes to determine incandescent lamp shapes, bases, and wattages.

Special Notes:
- This updated course replaces, Electric Lamps, course 6682A.
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006032
Electric Lamps, Part 2

Duration:
10 hours (includes 1 test)

Course Prerequisites:
AC Principles (Block A22)

What Students Learn:
This study unit is the second part of learning about lamps. This course describes the components of discharge lamps and what they are used for. Fluorescent and high intensity discharge (HID) lamps are the two major lamp groups that will be covered.

When students complete this study unit, you will be able to:

- Understand the advantages and disadvantages of each lamp.
- Recognize the different characteristics of each lamp.
- Recognize the proper application of these lamps.
- Specify or read specifications of discharge lamps.
- Understand the basic manufacturer's ordering codes.
- Carefully recognize problems before changing a lamp.
- Realize some of the complications that may occur in an electrician's work.

Special Notes:
- This updated course replaces, Electric Lamps, course 6682B.
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006033
Lighting Control

Duration:
10 hours (includes 1 test)

Course Prerequisites:
AC Principles (Block A22)

What Students Learn:
Electrical lamps are available in a wide range of different styles and can be used for lighting any type of area. In previous study units, you learned about the different types of lamps and fixtures, and the controlling devices. This study unit is designed to teach you about combining these items to design different types of lighting control systems. It will also teach you how to apply the different systems efficiently and conveniently.

When students complete this study unit, you will be able to:

- Combine natural light and dimming devices efficiently.
- Use multi-level lighting with fluorescent lamps.
- Divide an area into different zones for different lighting needs.
- Place switches in convenient areas.
- Apply sensors and timers in lighting control systems.

Special Notes:
- This updated course replaces, Lighting Control, course 4305.
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006016
Interior and Exterior Lighting Practices

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Electric Lamps, Part 1 (006031)
Electric Lamps, Part 2 (006032)

What Students Learn:
The purpose of this study unit is to familiarize yourself with lighting fixtures, known as luminaires, and their applications. It is important to understand the relationship of the components in lighting fixtures and their enhancements and limitations. Knowing the terminology used to describe the fixtures will expedite your work and enable you to communicate effectively with your associates.

An electrician must knowing the electrical codes before the installation of lighting fixtures. Many of the codes have been established to prevent fires or electric shock.

When students complete this study unit, you will be able to:

• Describe a lighting fixture in detail and where they are used.
• Know any precautions to take while installing them.
• Know the effects of temperature on recessed lighting.
• Know the difference between prewired and non-prewired fixtures.
• Know the difference between a "wet niche" and a "dry niche" pool light

Special Notes:
This updated course replaces, Interior Lighting Practice, course 6685, and Exterior Lighting Practice, course 5513.
• This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006034
Electric Heating

Duration:
10 hours (includes 1 test)

Course Prerequisites:
AC Principles (Block A22)

What Students Learn:
The use of electricity in an ever increasing number of applications has become an accepted pattern over the years. The microwave and range were originally regarded as luxury items. Today, however, they're viewed by many as necessities, along with dozens of other electric devices, ranging from computers to hair dryers. The acceptance of these devices as necessary for our convenience and comfort has paralleled the rise in our standard of living. Therefore, it is not surprising that electric heating has also been accepted in our homes, schools, offices, and industrial plants.

When students complete this study unit, you will be able to:

• Identify the way and the how of the electric-heating market; its growth and present trends.

• Compare heating sources and list some of the benefits of electric heating.
• Define the basic terms used in electric heating.
• Describe the basics of heat loss and how insulation, ventilation, and other controls affect heat loss calculations.
• Understand how heating requirements for buildings are estimated using the degree day method of calculation.
• Identify and compare the major selections of heating equipment.
• Discuss the relationship of heat, current, resistance, and voltage.
• Describe the main types of electric thermal-storage systems available, including the advantages of each.
• Identify and describe the various heating controls available.
• Compare and select electric heating systems for residential applications.
• Choose the proper heating system for a particular type of building.
• Discuss the various methods for recovering lighting energy for space heating.
• Determine which of the electric systems studied apply to industrial buildings.

Special Notes:
• This updated course replaces, Electric Heating, course 4310, and Electric Space Heating, course 4312.
• This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

006035
Controls for Air Conditioning

Duration:
10 hours (includes 1 test)

What Students Learn:
Students will begin their study with an introduction to building heating, ventilating, and air conditioning systems. This introduction discusses the typical arrangement of components, basic system operation, and power requirements. Students then learn the fundamentals of automatic control systems. Also covered are pneumatic, electric, and electronic controls, along with elementary and complete control systems.

When students complete of this study unit, you will be able to:

• Describe the function of common components within a building's HVAC system.
• Understand the purpose and function of common components within a pneumatic automatic control system.
• Comprehend the purpose and function of common components within an electric automatic control system.
• Explain the operation of an electric automatic control system using ladder logic diagrams.
• Describe the purpose and function of common components within an electronic automatic control system.
• Understand the operation of an automatic control system for a heating, ventilating, and air conditioning system based on ladder logic and schematic diagrams.

Special Notes:
This updated course replaces, Controls for Air Conditioning, course 6636.

006037
Wiring Electrical Circuits

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Electrical Wiring Practices (086E02)

What Students Learn:
All electrical systems -- whether for industrial plants, office buildings or houses -- have one thing in common: they must be properly connected. To assure the proper connection and maintenance of electrical systems, schematic diagrams and wiring plans are a must. As an electrician, students will need to know the common wiring terms and symbols used on these diagrams and plans. This study unit will prepare you for a better understanding of these electrical "road maps."

Although most of the branch circuits and panel board equipment discussed in this study unit are based on residential electrical use, they apply as well to many commercial and industrial applications.

When students complete this study unit, you will be able to:

- Differentiate between feeder and branch circuits.
- Select the correct type of general and special purpose circuit when given a list of circuit descriptions.
- Describe how wiring is installed for branch circuits in a residence, given particular situations.
- Select the correct electrical components for wiring a residence.
- Differentiate between portable, fixed and stationary appliances and describe how each type is wired.
- Select the components needed for an electric circuit.
- Calculate the current in a neutral conductor.

Special Notes:
This updated course replaces, Wiring Electrical Circuits, course 4405.

4040
Transformers

Duration:
10 hours (includes 1 test)

Course Prerequisites:
AC Principles (Block A22)

What Students Learn:
Essential Transformer Properties; Operation Under Load and Without Load; Losses; Voltage Regulation; Rating; Types of Core and Windings; Insulation; Bushings; Tap Changers; Polarity; Single-Phase and Polyphase Transformers; Delta, Star, Open-Delta, and Scott Connections; Special Transformers, Autotransformers, Reactors, Step-Voltage Regulators; Instrument Transformers; Maintenance of Transformers; Design of Small Low-Voltage Transformers.

4041
Transformer Operation

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Introduction to Algebra, Geometry, and Trigonometry (Block X02)
AC Principles (Block A22)
Transformers (4040)

What Students Learn:
Calculations Pertaining to Transformer Operation; Phasor Diagrams; Equivalent Circuits; Losses; Efficiency; Three-Phase Transformer Connections; Harmonic Currents and Voltages; Parallel Operation of Transformers; Phase Transformation; Regulation of Voltage with Tap Changers and Separate Units; Operation of Autotransformers and Three-Winding Transformers; Testing of Transformers.

4042
Distribution and Power Transformers

Duration:
10 hours (includes 1 test)

Course Prerequisites:
AC Principles (Block A22)
Transformers (4040)

What Students Learn:
Distribution Transformer: Core-Form and Shell-Form Transformers; Insulation, Connections, Protective Devices; Types of Distribution Transformers; Air-Core and Iron-Core Reactors, Furnace and Neon-Sign Transformers; Rectifiers, Transformers, and Test Transformers; Power Transformers: Rating, Core Construction, Coil Forms, Bushings, Protection and Temperature Control, Cooling Methods, Oil Protection, Maintenance.

006038
Local Distribution of Electrical Power

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
AC Principles (Block A22)
Transformers (4040)

What Students Learn:
The distribution of electrical power is comprised of a total system, starting with the production of electricity and ending with the consumption of electricity. This process includes the planned generation of power based on demand, the long distance transmission system, the local distribution system, and the customer's electrical wiring system. Each of these components includes equipment, material, and many devices that function as individual elements in the successful distribution of usable electrical energy.

In this study unit, students take a tour of the distribution of electrical energy, starting with the various methods of generation, through transmission systems, into the rural and urban substations, and ending at the customer's service entrance.

When students complete this study unit, you will be able to:

- Identify the three classes of power demands and the trends associated with them.
- Identify the various methods used in the production of electricity.
- List the generation, transmission, subtransmission, distribution, and secondary voltage levels.
- Describe the conductors used in primary distribution systems.
- Identify the components used in the protection of primary distribution systems.
- List the clearance requirements associated with secondary distribution.
- Recognize methods of metering consumer usage of electricity.

- List the NEC minimum requirements associated with installing services.

Special Notes:
This updated course replaces, Local Distribution of Electrical Power, course 6686.

006039
Underground Power Systems

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
AC Principles (Block A22)

What Students Learn:
Students learned in a previous study unit that the delivery of power includes several systems of components, including the generating plant, transmission system, subtransmission system, and the distribution system. The most visible method of delivering electricity is overhead transmission and distribution. However, an alternative method of getting electricity from the power plant to the customer is underground, both in the transmission and distribution systems.

This study unit examines methods and equipment associated with the underground primary transmission and distribution, and the secondary distribution, of electricity to the customer.

When students complete this study unit, you will be able to:

- List some advantages and disadvantages of underground electrical installations.
- Identify, cables, ducts, enclosures, and equipment used in underground primary systems.
- Describe some of the requirements and methods used in the installation of underground secondary electrical service.
- Describe some of the methods used in the secondary distribution of power in high rise buildings.

Special Notes:
This updated course replaces, Underground Power Systems, course 5959A-B.

006018
Troubleshooting Electrical Systems

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Analog Circuit Measurement (Block A23)

What Students Learn:
Electricians must deal with the problems and failures that occur in residential, commercial and industrial electrical systems. While faults do not occur in every system, they must be quickly and properly addressed. In this study unit, students will learn about the types of problems that often occur in electrical systems. Students will also learn the basic steps followed by all effective troubleshooters, and will be exposed to several real world troubleshooting situations.

Special Notes:
This study unit is primarily appropriate for residential and commercial electricians and electrical contractors

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5177EM
National Electrical Code (2014 Code and Textbook Course)

Duration:
60 hours (includes 5 tests)

Course Prerequisites:
Basic Industrial Math (Block X21)
Practical Measurements (Block X22)
AC Principles (Block A22)

What Students Learn:
This course provides students with the ability to understand what the National Electrical Code (NEC) requires, how to read the Code and to apply the rules. The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity. The Code is one of the electrical standards accepted by OSHA.
Definitions and Explanation of Code; History of the Code and the NFPA; Code Changes; Understanding the terms and theories; Layout of the NEC; Understanding a Code Section; How to use and find information in the NEC. Understanding the Scope and Attitude of the Code; NEC NFPA 70; Article 90 Purpose, Scope, Enforcement, Explanation, and Safety Summary.
Wiring Design and Protection; Wiring Methods and Materials; Use and Identification of Grounded Conductors; Branch circuits, feeders, service calculations, overcurrent protection, grounding and bonding; Equipment for General Use; Special Occupancies; Special Equipment; Special Conditions; Communication Systems; Construction Specifications; Tables; Diagrams and Examples.

Special Notes:

- The 2014 NEC course package consists of: the 2014 National Electrical Code text; a study guide; course

supplement, Understanding the NEC; and a NEC graded project, which is optional for course study.
- The project calls for the student to design a residential wiring plan. The project guide is shipped with all course orders. Being graded, it is considered as the sixth test in the course. If the company program coordinator and/or the student determine that the project is not essential to the training program, be sure to notify the Customer Service department to adjust the student record with an excused or omit grade for stock number 006017.

086051
Industrial DC Motors

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
DC Principles (Block A21)

What Students Learn:
Advantages and Operating Characteristics of DC Motors that make them widely used in industrial applications; Function of each component of a DC Motor; Operation of a Single-Coil Armature Motor; Troubleshooting DC Motors; How a DC Motor Controller Operates; Identify and list applications for various types of DC Motors including Universal, Stepper, PM, Servo and Brushless Motors.

Special Notes:
This new course replaces, DC Generators and Motors, course 6687.

086052
Industrial AC Motors

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
AC Principles (Block A22)

What Students Learn:
Construction and Operation of Single- and Three-Phase AC Motors; Principles of Electromagnetic Induction; Identify and work with Starter Systems for Single- and Ploy-Phase Motors including Shaded-Pole, Split-Phase Capacitor, and Repulsion-Induction Motors; Troubleshoot Polyphase Motor Systems.

Special Notes:
This new course replaces, AC Motors, Generators and Rectifiers, course 6698.

086053
Controlling Industrial Motors

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
AC Principles (Block A22)
Industrial DC Motors (086051)
Industrial AC Motors (086052)

What Students Learn:
How Stepper Motors are Electronically Controlled; Steps to follow when Troubleshooting Stepper Motor Controls; Explain how AC Line Frequency sets Motor Speed; How Frequency Inverters Control Motor Speed in Three-Phase Installations; Describe how Servo Motors are Controlled; Explain how Brushless Motors Work and how their Shafts are precisely Positioned: List the steps to follow when Troubleshooting Brushless Motor Controller Systems.

Special Notes:
This new course, in conjunction with courses 006010, 006011 and 006012 covering Industrial Motor Control for PLCs, replaces Industrial Motor Control, course 6699A-C.

4032
Alternating Current Motors

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Introduction to Algebra, Geometry, and Trigonometry (Block X02)
AC Principles (Block A22)

What Students Learn:

Principles of Operation of Induction Motors; Polyphase Primaries and Polyphase Secondaries; Squirrel-Cage Rotor, Phase-Wound Rotors; Starting Induction Motors; Squirrel-Cage Motors, Phase-Wound Motors; Performance and Speed Control: Adjustable-Speed Induction Motors; Synchronous Motors; Types, Operation, Theory, and Application; Single-Phase Motors: Types, Operating Characteristics.

Special Notes:
Covers subject at an advanced, in-depth level.

4341
Industrial Motor Applications

Duration:
10 hours (includes 1 test)

Course Prerequisites:
AC Principles (Block A22)
Industrial DC Motors (086051)
Industrial AC Motors (086052)

What Students Learn:
Motor Torque; Inertia of Loads; Motor Types and Characteristics; Power-Supply Factors; Types of Drives; Braking of Motors; Intermittent Service; Mechanical Connecting Devices; Motor-Driven Power Pumps; Fans and Blowers; Reciprocating, Rotary, and Centrifugal Compressors.

6699A-C
Industrial Motor Control

Duration:
30 hours (includes 3 tests)

Course Prerequisites:
Basic Industrial Math (Block X21)
AC Principles (Block A22)
DC Generators and Motors (6687)
AC Motors, Generators, and Rectifiers (6698)

What Students Learn:
PART 1 (6699A). Principles of Motor Control; Manual Motor Control; Manual Starters for Squirrel-Cage and Wound-Rotor Induction Motors; Manual Starters for DC Motors; Magnetic Control Components, such as Magnetic Contactors, Relays, Interlocks and Brakes, Master Switches, Resistors, Motors, Circuit Protective Devices, and Control Panel.
PART 2 (6699B). Control Circuits of Line Starters, Reduced-Voltage Magnetic Starters for AC Motors; Control Systems for Wound-Rotor Motors; Control System for Synchronous Motors; Constant-Voltage Controllers for DC Motors; Adjustable-Voltage Controllers for DC Motors; Voltage, Speed, and Current Regulators; Static Regulators.
PART 3 (6699C). Common Drive Systems; Symbols; Semiconductor Principles: Semiconductor Characteristics of Diodes, Zener Diodes, Transistors, Unijunction Transistors, and Silicon-Controlled Rectifiers; Basic Drive Systems; SCRs as AC to DC Converters; Types of Converters; Protection of Converters; Power Ratings; Use of Semiconductor Amplifiers in Converters; Acceleration and Deceleration Circuits; Block Diagrams; Application, Construction, Installation, and Maintenance of Drive Systems.

006010
Motor Control Fundamentals (for Programmable Logic Controllers)

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Basic Industrial Math (Block X21)
AC Principles (Block A22)
Industrial AC Motors (086052)

What Students Learn:
Motor Control Standards; Operating Characteristics of Motors motor starters, NEMA and IEC Starters, reversing and multi-speed starters; Motor Control Fundamentals; Interpreting Control Devices and Circuits using Control Diagrams automatic and manual signaling devices, capacitive and inductive switches; Enclosures.

Special Notes:
This new series of Motor Control texts (006010-11-12) provides current electronics technology not covered in Industrial Motor Control (6699A-C).

006011
Industrial Motor Control (for Programmable Logic Controllers), Part 1

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Motor Control Fundamentals (for Programmable Logic Controllers) (006010)

What Students Learn:
History and concepts of programmable logic controllers (PLC's); number systems, The Central Processing Unit (CPU); CPU scan, analog and discrete signals, types of PLC memory; The Input/Output System (I/O); Special Function I/O; Elements of a Relay Ladder Logic Program; Operation of Timers and Counters.

Special Notes:
This new series of Motor Control texts (006010-11-12) provides current electronics technology not covered in Industrial Motor Control (6699A-C).

006012
Industrial Motor Control (for Programmable Logic Controllers), Part 2

Duration:
10 hours (includes 1 test)

Course Prerequisites:
Industrial Motor Control (for Programmable Logic Controllers), Part 1 (006011)

What Students Learn:
Programmable Logic Controllers (PLC's) Fundamentals; contacts, coils, ladder logic terminology and symbology, scanning and solving ladder logic programs, application/troubleshooting exercise one; The Pick and Place Robot, application/troubleshooting exercise two; The Mixing Vat; application/troubleshooting exercise three, The Paper Roll Stand, troubleshooting skills using LED indicators and programming console procedures; PLC's in Motor Speed Control; PLC System Troubleshooting and Repair.

Special Notes:
This new series of Motor Control texts (006010-11-12) provides current electronics technology not covered in Industrial Motor Control (6699A-C)

086E02
Electrical Wiring Practices

Duration:
20 hours (includes 4 tests)

Course Prerequisites:
Basic Industrial Math (Block X21)
DC Principles (Block A21)
AC Principles (Block A22)
Electrical Equipment (Block A24)

What Students Learn:
Lesson 1 - High Voltage Applications

- Working with Site Plans and Symbols; Unit Substations; Transformer and Overcurrent Protection; Transformer Fuse Sizing; High-voltage Metering Equipment; Feeder Bus Systems; Panelboards and Protective Devices; Trolley Busways.

Lesson 2 - Wiring Motors, Controllers and Signaling Systems:

- Using Wire Tables and Sizing Conductors; Wiring Signaling Systems; Motor Types, Characteristics and Installation; Wiring DC, Single, Double and Triple Phase Motors.

Lesson 3 - Wiring of Special Equipment and for System Protection.

- Working with Power and Motor Power Factors; Installing and Testing Capacitors; Wiring HVAC System Controls; Circuit Breakers and Wiring for System Protection; Lightning Protection.

Lesson 4 - Wiring for Hazardous Locations

- Safe Circuits and Equipment; Panels, Seals, Fixtures, Controls and Other Equipment for Hazardous Locations; Wiring of PLC's and Site Lighting.

Special Notes:
- This course consists of a textbook and supplemental study guide.
- This updated course replaces course 4300A-C.
- This study unit is primarily appropriate for plant electricians and industrial maintenance training.

6538A-B
Protective Relaying

Duration:
20 hours (includes 2 tests)

Course Prerequisites:
AC Principles (Block A22)

What Students Learn:
PART 1 (6538A). Purpose of Protective Relays; Classification of Relays; Methods of Protection; Symbols and Diagrams in Protective Relaying; Power Circuit Breakers and Their Control Circuits; Relaying Accuracy of Current Transformers; Potential Transformers; Protective Relay Units, such as Induction Disk, Induction-Cylinder, Plunger, Polarized DC, Moving Coil, and Clapper Relays; Auxiliary Protective Equipment for Relaying; Testing of Relays by Test Plugs; Testing Procedures.
PART 2 (6538B). Principles of Relay Applications; Protective Relaying of Generators, Motors, Transformers, and Buses.

086E16
Data, Voice, and Video Cabling

Duration:
20 hours (includes 4 tests)

Course Prerequisites:
Electrical Equipment (Block A24)

What Students Learn:
What Students Learn:
Lesson 1 – Communication Cabling Systems:
• Early wired and wireless technologies; Planning the wiring installation; Applicable standards organizations; UTP cabling.
Lesson 2 – Copper Wiring for Telephone, Video, and Network Systems:
• Details of cable installation; Assess quality of work performed; Materials required; Handling cable without damage; Workplace security and safety.
Lesson 3 – Terminating and Testing Communication Wiring:
• Advantages and disadvantages of wireless networking; Installing wireless access points; Site testing of wireless networks; Cableworking and testing tools; Recognizing common cable problems; Terminating popular types of coaxial and copper-cable connectors.
Lesson 4 – Working with Fiber Optics:
• Principles of optical fiber transmission; Different types of fiber-optic cabling; Optical fiber connections, terminations, and splices; Pulling, cleaving, connecting, and polishing optical fiber cables; Testing fiber optic connections; Allowable tolerances for loss in fiber-optic connections; Safe practices.

Special Notes:
This course consists of a textbook and a supplemental study guide.

086E01
Electrical Grounding

Duration:
25 hours (includes 5 tests)

Course Prerequisites:
Basic Industrial Math (Block X21)
DC Principles (Block A21)
AC Principles (Block A22)

What Students Learn:
Lesson 1 - Principles of Grounding
- Understanding National Electric Code Grounding Requirements (article 250); Grounding for Safety; Fault Detection; Grounding Electrode Systems and Types.

Lesson 2 - Grounding Systems:
- Grounding Electrode Conductor (AC and DC) Material, Types and Sizing; Circuit Grounding; System Grounding; Grounded Conductor Installation, Sizing and Identification; Main Bonding Jumper Locations, Sizing and Connections.

Lesson 3 - Equipment and Enclosure Bonding and Grounding: Part 1:
- Understanding Effective Ground Paths; Equipment Grounding Conductor Types, Installation, and Sizing; Equipment Grounding Conductor Raceways, Connections and Boxes; Using Earth as an Equipment Grounding Conductor; Bonding Service Equipment; Working with Bonding Jumpers.

Lesson 4 - Equipment and Enclosure Bonding and Grounding: Part 2:
- Grounding Panelboards, Receptacles, Towers and Computers; Ground-Fault Protective Equipment; GFCI's.

Lesson 5 - High Voltage Grounding Applications:
- System and Circuit Grounding for 1kV and Over; Separately Derived Systems; Dedicated Five-Wire Systems; Grounding Two or More Buildings; Calculating Fault Currents and Grounding Conductor Withstand Ratings.

Special Notes:
- This course consists of a textbook and supplemental study guide.
- This study unit is primarily appropriate for plant electricians and industrial maintenance training.

086E04
Electrical Estimating

Duration:
15 hours (includes 1 test)

What Students Learn:
This course offers students an introduction to electrical estimating, which consists of the estimate of the projected cost to complete an electrical job or project within a stated period of time. Students learn that an estimate is comprised of factors such as methods used to install equipment, man hours worked, cost of material and overhead, and doing the job right the first time. Bid price and profit are also covered. Discussion includes what it takes to be a successful estimator, what methods are used in estimating, and when to use specific methods.

Students will learn about the unit of measurement referred to as a labor unit, consisting of the approximate time required to install an electrical product, component, or equipment.

The course will cover the basics of the electrical estimating process, including the available resources, such as labor, supervision, equipment, and buying power. Also covered will be the take off. This is the counting of symbols and measuring the conduits and conductors drawn on the blueprints to determine a bill of materials, which consists of the devices, components, equipment, conduit and conductors to complete a job.

Students will learn to prepare an estimate summary, which shows totals for material cost and labor hours, which will be transferred to the summary worksheet, which details costs such as labor, material, direct job costs, and job overhead, to determine a job's break even cost as well as the bid price. Common errors for bids, such as forgetting to include major part items, miscalculation of all work and costs included, are also covered.

The manual method of estimating in detail, as well as computer-based estimating and bid proposal software, are covered. Completing a specification checklist will also be discussed.

Special Notes:

- This new course consists of Electrical Estimating textbook, stock number (TB0310), and a study guide, stock number(006019).
- This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.

286M04
Control Technology for Technicians

Duration:
45 hours (includes 9 tests)

Course Prerequisites:
Basic Industrial Math (Block X21)
Practical Measurements (Block X22)
Introduction to Algebra, Geometry, and Trigonometry (Block X02)

What Students Learn:
This course introduces the fundamentals of control system components and operation. Students will learn how a control system works and how its operating characteristics can be interpreted from schematics and ladder logic diagrams. The course will explain how mechanical, hydraulic, pneumatic, electrical, and electronic components used in control systems measure parameters. These measurements are then converted into useful data or the appropriate control system response. The course discusses the use of feedback loops and their applications in real-world control systems. The student will understand how electronic systems are combined to deliver their acceptable data "signals" to computers. In conclusion, the student will learn how PLCs are used throughout industry to control complex systems.

Part 1 (286076) . Lesson 1 - Introduction to Control Systems

- Represent a control system with a block diagram.
- Recognize various control system types including open loop, closed loop, analog, and digital.
- Describe how servomechanisms work.

Lesson 2 - Op Amps and Signal Conditioning

- Explain how microprocessors are integrated into, and interface with, control systems.
- Evaluate and design op-amp and related signal conditioning circuits to be used in control systems.

Lesson 3 - Control System Switching Devices

- Describe the operating principles of, and applications for, relays, transistors, rectifiers, triacs and other switching devices.

Lesson 4 - Mechanical Control Systems

- Explain how mechanical components are designed into, and operate within, control systems.

Lesson 5 - Control System Sensors

- Evaluate the function of sensors in a given control system.
- Understand how sensors work to provide data in control systems.

Part 2 (286077). Lesson 6 - DC and Stepper Motors in Control Systems

- Explain how DC motors operate.
- Select a motor based on mechanical and performance requirements.
- Describe how DC motor control systems work.
- Understand how stepper motors and their driver circuits work.

Lesson 7 - AC Motors in Control Systems

- Explain how AC motors operate.
- Select a motor based on mechanical and performance requirements.
- Describe how AC motor control systems work.

Lesson 8 - Control System Actuators and Feedback Principles

- Recognize the applications for, and operating characteristics of, electric, hydraulic, and pneumatic linear actuators.
- Describe the operating principles of control valves and other components in hydraulic and pneumatic systems.
- Differentiate between proportional, integral, differential, and fuzzy logic control systems.

Lesson 9 - Relay Logic and PLCs

- Explain how to tune a process control system.
- Understand how analog and digital control circuits work.
- Explain the operation of relays, counters, and sequencers.
- Understand how PLCs work.
- Interpret ladder logic diagrams.

Special Notes:

This course consists of a textbook and two supplemental study guides. We recommend the course be purchased in its entirety. However, if needed due to targeted training, study guides (Parts 1 & 2) can be purchased separately, with or without the textbook. Note that the textbook is required for the Part 1 study guide. Call Customer Service for pricing and ordering information.

006020
The Business of Electrical Contracting

Duration:
10 hours (includes 1 test)

What Students Learn:
Some working electricians often consider starting an electrical contracting business. This study unit is written for electricians who want to own and manage their own electrical contracting business. The course is not intended to provide a complete guideline to starting and managing a successful electrical contracting business, but it will provide helpful information for electricians contemplating a career in electrical contracting.

When students complete this study unit, you will be able to:

- Recognize the important considerations of starting an electrical contracting business, including the advantages, disadvantages, skills required, and finances.
- Describe the very basic requirements and some suggested actions one might take when opening a business.
- Understand some of the preliminary management responsibilities and challenges associated with owning any electrical contracting business.

Special Notes:
This study unit is primarily appropriate for residential and commercial electricians and electrical contractors.