Electrical Maintenance

Addition and Subtraction

Objectives:

- Define the following terms: whole number, numeral, digit, decimal, place value, addend, sum, minuend, subtrahend, and difference
- Properly place commas in large numbers
- 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
- Check your answers to both addition and subtraction problems
- Use a calculator to add and subtract numbers

Multiplication and Division

Objectives:

- Define the following terms: factor, multiplicand, multiplier, partial product, 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, decimal numbers, and mixed decimal numbers Check your answers to both multiplication and division problems
- Find the average of a group of numbers
- Use a calculator to multiply and divide numbers

Fractions, Percents, Proportions, and Angles

Objectives:

- Define the following terms: fraction, proper fraction, improper fraction, lowest common denominator, percent, ratio, and proportion
- Add, subtract, multiply, and divide fractions
- Change fractions to decimals and decimals to fractions
- Solve problems involving percent
- Work with ratios and equivalent ratios
- Solve proportion problems
- Use a protractor to measure angles
- Lay out templates for checking angles
- Use a calculator to solve percent problems, to convert fractions to decimals, and to calculate missing terms in proportions

Metric System

Objectives:

- Name the base units most commonly used in the metric system and identify what they're used to measure
- Identify metric prefixes and their values
- Apply conversion factors to create a unit that's larger or smaller than the base unit
- Estimate lengths in metric units
- Express temperature in degrees Celsius
- Define the terms mass, density, force, torque, and pressure, and identify the metric units used to measure each one
- Use a conversion table to convert metric units to English units and English units to metric units
- Use a calculator to perform metric conversions

Formulas

Objectives:

- Explain the use of variables in formulas
- Prepare and use formulas to solve problems
- Use formulas to calculate the perimeter of a triangle and a rectangle, and the area of a triangle, a rectangle, and a circle
- Use formulas to calculate distance, current in a circuit, and the volume of a pyramid and a sphere
- Use a calculator to find square roots and solve formulas
- Substitute given numerical values for letters in a formula and find the unknown quantity
- Transform and solve equations and formulas

Introduction to Algebra

Objectives:

- Explain the difference between positive and negative numbers and their uses
- Perform basic arithmetic operations with signed numbers
- Raise a number to any power
- Use the order of operations for solving problems involving multiple operations
- Define the following words: term, constant, coefficient, exponent, monomial, trinomial, and polynomial Identify and combine like terms in an expression
- Perform basic arithmetic operations with signed terms
- Multiply and divide terms containing exponents
- Remove parentheses from an expression and simplify the expression

Linear Distance and Measurement

Objectives:

- Measure using both English and metric (SI) units of length
- Calculate the perimeters of rectangles, squares, and triangles
- Calculate the areas of objects such as rooms or machine bases
- Calculate the circumference of circular objects such as pipes or tanks
- Measure distances using rigid and flexible rules, thickness gages, and screw pitch gages
- Make precise measurements using vernier calipers and micrometers

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 mass 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

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

Energy, Force, and Power

Objectives:

- Distinguish among the concepts of energy, force, and power
- Explain what the term work means and how it's 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

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 tube pressure gages
- Measure the flow rate of fluids using different types of flowmeters

Trades Safety: Getting Started

Objectives:

- Name the agencies and organizations 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 and tag 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 tools 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 using personal protective equipment (PPE) and name several types of PPE

Working Safely with Chemicals

Objectives:

- Recognize the six different ways in which a chemical can cause you physical injury
- Name the routes or paths of entry by which chemicals can enter the body
- Describe the basic types of injuries caused by chemicals
- Identify potential chemical dangers in your workplace
- Describe how to identify, store, and label hazardous chemicals
- List several methods used to prevent chemical accidents
- Explain why proper training is important to chemical handling
- Describe the types of personal protective equipment used and worn when handling chemicals
- Explain the role of governmental agencies in enforcing chemical regulations

Fire Safety

Objectives:

- Describe the types of property losses and injuries associated with fires
- Explain how fires are ignited
- Identify the four classes of fire
- Describe the primary fire hazards found in the workplace
- Explain the various ways in which fires can be prevented
- Describe the operation of several different fixed fire protection systems
- Identify the proper type of portable fire extinguisher to use on a fire
- Describe the operation of several different types of fire extinguishers
- Explain how to defend yourself and others in a fire situation
- Describe how to safely evacuate a burning building

Safe Handling of Pressurized Gases and Welding

Objectives:

- Identify common welding gases and understand how they're used in welding operations
- Point out the hazards associated with welding gases
- Safely handle and store different types of gas cylinders
- Safely operate a basic gas welding setup
- Recognize the safety considerations involved in the setup and operation of electric arc-welding equipment
- Identify welding equipment malfunctions and take corrective action
- Utilize fire prevention and protection methods specific to welding operations
- Discuss the importance of the hot-work-permit program in your facility
- Explain the correct use of protective clothing and equipment for welding
- Utilize proper ventilation when welding
- Effectively deal with confined spaces when performing welding operations

Electrical Safety

Objectives:

- 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's 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're performing

Material-Handling Safety

Objectives:

- Recognize the hazards associated with handling materials
- Know the types of injuries that can be caused by these hazards
- Understand how to effectively use safe material-handling practices
- Know how to avoid physical injury when handling loads
- Know and follow the rules for safe operation of powered industrial material-handling equipment
- Understand and respect the limits and restrictions placed on powered material-handling mechanisms

Machine Safety

Objectives:

- Recognize the basic machine motions that can present a hazard to you
- Recognize the types of machinery most likely to be hazardous to you
- Understand the types of injuries caused by accidents commonly associated with unsafe machine-operating procedures
- Discuss the importance of machine guarding and how to incorporate methods of guarding to avoid physical injury
- Recognize the four basic types of machine guards commonly used in industry
- Control various forms of hazardous machine energy through the use of lockout/tagout procedures
- Understand how and why to properly use personal protective equipment for added protection when using industrial equipment

Common Hand Tools, Part 1

Objectives:

- 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

Common Hand Tools, Part 2

Objectives:

- 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

Precision Measuring Instruments, Part 1

Objectives:

- Explain the difference between accuracy and precision
- Define standard, the Rule of 10, and traceability
- Describe Abbe's error
- Describe how to use a number of tools for measuring dimensions
- Read a vernier scale
- Demonstrate the skill to work with both English and metric systems and with their abbreviations
- Convert between millimeters and inches

Electric Drilling and Grinding Tools

Objectives:

- Safely set up and operate a portable electric drill, drill press, and electric hammer
- Choose the proper drill bit for many drilling applications
- Select the proper drilling tool for an application
- 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

Power Cutting Tools

Objectives:

- Identify the most common portable and stationary power saws
- Identify the various parts of a saw and explain how they work
- Discuss the types of cuts made by each type of saw
- List the various safety precautions you should follow when using power saws
- Choose the most appropriate saw and blade for the type of work being done

Pneumatic Tools

Objectives:

- Describe the various pneumatic tools used for plant maintenance
- Identify and describe the safe use of impact, cutting, and grinding tools
- Explain how pneumatic hammers, nailers, and staplers are selected and used in a safe manner
- Describe the use of pneumatic assembly tools such as grinders, sanders, screwdrivers, and drills and how other types of production tools are selected and used
- Identify the proper procedures for pneumatic tool and system care
- List procedures for safely using pneumatic tools
- Understand how vibration and excess noise can cause bodily injury

Plumbing and Pipe-fitting Tools

Objectives:

- Explain the importance of safety on the job
- Identify the rules of job safety and tool safety
- Apply the rules of job safety and tool safety to workplace situations
- Identify the various tools available to perform layout, cutting, and boring tasks
- Determine when and how to use layout, cutting, and boring tools
- Identify the tools available to join and assemble pipes of various materials
- Determine when and how to use pipe-joint assembly tools
- Identify the tools needed for testing and maintaining piping systems
- Determine when and how to use finishing, testing, and maintenance tools for piping systems

Electricians' Tools

Objectives:

- Explain how various hand tools are used by an electrician
- Discuss the safe use of hand tools and power tools
- Perform basic calculations and measurement conversions using the metric system
- Use Ohm's law to explain the relationship among current, voltage, and resistance in a circuit
- Explain how electrical measuring instruments are used to measure current, voltage, and resistance
- Define many of the basic electrical terms that electricians use every day
- Identify the basic symbols used in electrical schematic drawings

Tool Grinding and Sharpening

Objectives:

- Use a grinding machine, following all safety procedures
- Hone, or whet, tools with an oilstone
- Explain the procedures for grinding metal stock
- Compare the methods used in grinding screwdrivers, snips, chisels, plane irons, and twist drills

Woodworking Hand Tools

Objectives:

- Distinguish between the types of hand saws, and use them correctly
- Bore and drill holes wood
- Explain the differences between planes, and use planes effectively
- Use abrasive tools correctly

Routers, Power Planers, and Sanders

Objectives:

- Operate (with practice) the portable router
- Outline the procedures for using a portable power planer
- Recognize by sight the common stationary power sanders, and compare their operation
- Choose the right portable power sander for a given job, and operate (with practice) the portable belt sander

Jacks, Hoists, and Pullers

Objectives:

- Identify the many forms of jacks and hoists
- Safely operate jacks and hoists
- Understand the construction details of fiber ropes, wire ropes, and chains
- Properly use and maintain fiber-rope, wire-rope, and chain slings
- Properly use jaw and push pullers

Applied Geometry

Objectives:

- Identify properties and types of angles and figures
- Distinguish between common geometric solids
- Use the Pythagorean theorem to solve triangles
- Calculate the perimeter and area of polygons, circles, and ellipses
- Determine the surface area and volume of commonly encountered geometric solids

Practical Trigonometry

Objectives:

- Define and compute the value of trigonometric functions such as cosine, sine, tangent, and others
- Use trigonometric functions to find the lengths of sides and angles in right and oblique triangles
- Understand trigonometric functions as they relate to waves
- Solve practical problems using trigonometry

Introduction to Print Reading

Objectives:

- Describe the basic format for conveying technical information in a drawing
- Identify and interpret the various drawing views used in technical drawings
- Understand how information is organized in notes and title blocks
- Interpret the different line types used in drawings
- Understand the concept of the drawing scale and how it affects information shown in the drawing

Print Reading Symbols and Abbreviations

Objectives:

- Interpret the most common abbreviations used on drawings
- Understand and interpret the various symbols and notations used on drawings for electrical, architectural, mechanical, and other types of applications
- Recognize how symbols are used to show standard materials, parts, and assemblies
- Interpret thread specifications
- Understand some common symbols used in machining prints
- Recognize common symbols found on hydraulic and pneumatic prints

Dimensioning and Tolerancing

Objectives:

- Know the international standards and conventions that apply to drawings
- Understand how different numbering systems were developed and how they're applied to prints and drawings
- Understand dimensions and tolerances on drawings that describe geometries of parts and assemblies
- Recognize and interpret common symbols and nomenclature used in geometric dimensioning and tolerancing (GD&T)
- Understand how GD&T uses symbols to explain and describe the designer's intent, and eliminate misinterpretation of the print

Print Reading Applications

Objectives:

- Understand standard drawing formats that give information about part titles, part numbers, dimensional standards, revisions, and materials
- Explain how various components shown on prints are connected or related to each other
- Obtain important information from a drawing about quantities, materials, assembly processes, or dimensions
- Visualize the three-dimensional parts and assemblies represented by two-dimensional drawings

Building Drawings

Objectives:

- Identify the various kinds of building drawings
- Compare elevation, plans, and section
- 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

Electrical Drawings and Circuits

Objectives:

- 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

Electronics Drawings

Objectives:

- Identify and interpret the various electronics symbols used on drawings
- Identify and interpret the various types of drawings used in the electronics field

Hydraulic and Pneumatic Drawings

Objectives:

- Graphic symbols for lines, flows, and reservoirs
- Pump and valve symbols
- Fluid circuit and air circuit components
- Graphical, circuit, cutaway, pictorial, and combined diagrams

Piping: Drawings, Materials, and Parts

Objectives:

- Define the term ‘’piping drawings”
- Recognize on sight plans, elevations, and sectional views
- Identify a view by its placement on a drawing
- List what working drawings include
- Evaluate whether or not a freehand sketch serves its intended purpose
- Interpret the standard symbols and abbreviations used on piping drawings and diagrams
- “Read” the color coding on piping in industrial and power plants
- Interpret dimensions marked on piping drawings
- Define piping plans, diagrams, plot plans, general arrangements, and details, and state the use of each
- List the various materials used for pipe and give the characteristics of pipe of each material
- Classify pipe by material, construction, end condition, strength, and size
- Recognize the various types of valves and identify their use and construction
- List and identify various kinds of pipe hangers and supports and other piping accessories

Welding Symbols

Objectives:

- Identify by name the welding processes commonly used in plant maintenance work
- Name the best welding processes for a given welding job
- Identify by sight the basic joint and groove designs used in welding
- Identify by sight the basic types of welds, and describe their uses
- Interpret the weld symbols most often found in the drawings used in plant maintenance work

Sheet Metal Basics

Objectives:

- Identify sheet metal of known material and thickness by gage and weight
- Figure allowances for bends, circumferences, seams, locks, and edges
- Know when and where to cut relief radii
- Catalog and identify by sight the various seams, locks, and edges
- Name and describe the major tools and machines used in sheet metal working
- Explain how large fittings can be constructed
- List the characteristics of PVC and PVF sheet and laminates

Sketching

Objectives:

- Use the right techniques for sketching straight and curved lines, and circles and arcs
- Make, with practice, multiview sketches of simple objects that accurately show all the details of the objects
- Dimension sketches of simple machine parts with enough detail that parts can be made
- Draw, with practice, realistic picturelike sketches of objects that have simple rectangular and circular shapes

The 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 some of the dangers and benefits of static electricity
- Define the terms volt, ampere, and ohm
- Describe some common notations and prefixes used to identify electrical and electronic values
- Identify carbon resistors, potentiometers, rheostats, and relays, and explain how they work
- Identify some of the electrical symbols used in schematic diagrams
- Explain the difference between a series and a parallel circuit

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 amount of current, voltage, or resistance in circuits
- Calculate the amount of power supplied and dissipated in a DC circuit
- List the steps for reading current, voltage, and resistance with a meter

Capacitors and Inductors

Objectives:

- Explain how a capacitor holds a charge
- Describe common types of capacitors
- Identify capacitor ratings
- Calculate the total capacitance of a circuit containing capacitors connected in series or in parallel
- Calculate the time constant of a resistance-capacitance (RC) circuit
- Explain how inductors are constructed and describe their rating system
- Describe how an inductor can regulate the flow of current in a DC circuit
- Calculate the total inductance of a circuit containing inductors connected in series or parallel
- Calculate the time constant of a resistance-inductance (RL) circuit

Magnetism and Electromagnetism

Objectives:

- Identify the north and south poles of permanent magnets and electromagnets
- List several magnetic and nonmagnetic materials
- Describe how to magnetize a piece of steel by induction
- Explain the difference between simple, compound, and closed magnetic circuits
- Determine the direction of magnetic lines of force around a conductor (if the direction of the 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
- Explain the generator action and motor action of electromagnetic induction in simple terms

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 list their temperature ratings
- Explain the difference between a dry cell and a storage battery
- 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

DC Motor and Generator Theory

Objectives:

- Describe the function of a commutator and brush assembly in a DC motor
- Explain how permanent magnet DC motors and stepper motors operate
- Identify series-wound, shunt-wound, and compound-wound motors and discuss their applications
- List the steps used to reverse a DC motor's direction
- Describe how the speed of a DC motor is controlled
- Explain the basic principle used to generate direct current
- List the factors that affect the strength of an induced voltage
- Explain how the field connections of series-wound, shunt-wound, and compound-wound generators differ
- Explain why it's necessary to shift brushes in a DC generator
- Discuss how interpoles and compensating windings can produce better generator operation
- List the various types of machine losses and calculate machine efficiency

Alternating Current

Objectives:

- Draw a graph of an AC voltage and describe how AC voltage is created
- Explain what an AC cycle is using the terms alternation, peak, positive, and negative
- Express the time period of an AC cycle 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
- Calculate the phase and line voltages of multiphase wave forms
- Determine real power by reading a power factor meter
- Describe delta-connected and wye-connected three-phase circuit connections

Alternating Current Circuits

Objectives:

- Identify electric circuits in terms of their characteristics
- List several circuit characteristics used to describe a circuit for a particular load application
- Identify electrical components wired as series and parallel circuits
- Describe how to control loads from one or two switch locations
- Describe how current flows in a three-wire circuit
- Describe how current flows in delta- and wye-connected circuits
- Calculate the line-to-line and line-to-neutral voltage in a wye-connected circuit

Inductors in AC Circuits

Objectives:

- Explain how an inductor is made and how it operates in DC and AC circuits
- Define inductive reactance and impedance
- Describe how AC frequency affects impedance
- Apply Ohm's law when calculating the current in an AC circuit that includes an inductor
- Calculate the impedance of a series RL circuit
- Calculate the impedance of a parallel RL circuit

Capacitors in AC Circuits

Objectives:

- Describe how a capacitor stores a charge and how series-connected and parallel-connected capacitance values are calculated
- Define capacitive reactance
- Apply Ohm's law in AC circuits that contain a capacitor
- Calculate the impedance of a series RC circuit
- Calculate the impedance of a parallel RC circuit
- Explain how changing the frequency of an AC signal changes capacitive reactance
- Calculate the resonant frequency of an RCL circuit

Transformers

Objectives:

- Explain what the main parts of a transformer are
- Explain how mutual inductance makes it possible to change an AC (alternating current) voltage or current from one value to another
- Determine the turns ratio when the primary and secondary voltages or currents are known
- Calculate primary or secondary voltage or current when either one of these and the turns ratio are known
- Explain why transformer cores are laminated (layered)
- Connect three single-phase transformers for three-phase operation
- Calculate line current (if phase current is known) in delta-connected transformers
- Explain the principle of operation of an autotransformer

Alternators

Objectives:

- Explain how single and three-phase alternators operate
- List and describe the major parts 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 among the three main types of alternators

Electrical Energy Distributors

Objectives:

- Explain the difference between feeder and branch circuits
- Describe the different types of systems for distributing power within a plant
- Identify utilization equipment by name and look
- Discuss the use of transformers
- Identify names and uses of various types of raceways
- Distinguish between panel boards and switchboards
- Discuss the electrical system of a power utility
- Describe how electricity is generated

Rectification and Basic Electronic Devices

Objectives:

- Explain how diodes are manufactured
- Explain how diodes are used as rectifiers
- Identify the correct PN junction connection for forward and reverse bias
- Describe the characteristics of different diode types
- Interpret diode specifications as they would appear on a data sheet
- Explain the operation of SCRs and TRIACs
- Identify how single-phase and polyphase rectifiers operate
- Compare rectifier outputs with and without filter components

Basic Test Equipment

Objectives:

- Identify the schematic symbols used to represent various reactive devices
- 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
- 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
- Discuss some of the important safety precautions you must take when using a multimeter

Troubleshooting with Volt-Ohm-Milliamp Meters

Objectives:

- List the safe practices you should use when troubleshooting with a VOM
- Describe the purpose of a continuity test
- Perform tests for short circuits
- Perform resistance tests on resistors, fuses, solenoids, relays, switches, transformers, motors, and semiconductors
- Measure current by using a direct series connection or by using a clamp-type ammeter
- 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

Using Basic Oscilloscopes

Objectives:

- Explain how an oscilloscope operates and describe its component parts
- Describe how to perform low-voltage measurements on circuit boards
- Explain how to measure the voltage output of a power supply and measure AC ripple
- Describe how to perform measurements in SCR and TRIAC circuits
- Test both DC and AC servo motor controller circuits, as well as heater controller circuits
- Perform basic scope measurements on digital circuits

Conductors and Insulators in Industry

Objectives:

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

Working with Conduit

Objectives:

- 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

Electrical Boxes

Objectives:

- Describe the role of electrical boxes in an installation
- Explain why circuits are interrupted
- Explain when and where boxes are used in wiring systems
- 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 boxes

Industrial Enclosures and Raceways

Objectives:

- 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

Connecting Industrial Equipment, Part 1

Objectives:

- Describe the use of flexible conduit, strain relief fittings, plug connections, and terminal blocks in industrial electrical systems
- Discuss why there are often two raceways wired 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

Connecting Industrial Equipment, Part 2

Objectives:

- 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

Industrial Fuses

Objectives:

- 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

Industrial Circuit Breakers

Objectives:

- Explain the thermal and magnetic operation of a circuit breaker
- Explain how a combination circuit breaker operates
- Identify an electronic circuit breaker and describe its operating principles
- List the various types of industrial circuit breakers
- Describe the various types of circuit that single- 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

Plugs, Receptacles, and Lampholders

Objectives:

- 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 select 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 lampholders

Industrial Switches

Objectives:

- 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

Industrial Relay Ladder Logic

Objectives:

- 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 you've learned

Industrial Relays, Contactors, and Solenoids

Objectives:

- Distinguish between types of control relays, contactors, magnetic starters, and solenoids
- Describe how control relays, contactors, magnetic starters, and solenoids operate
- Identify the component parts of control relays, contactors, magnetic starters, and solenoids
- Identify specific applications for each type of device

Reading Electrical Schematic Diagrams

Objectives:

- Identify standard electrical symbols and describe their meaning
- Describe the parts of a schematic diagram
- Explain the flow of electrical current through circuit devices
- Describe and identify electrical drawings, block diagrams, wiring diagrams, and electrical schematic diagrams
- Interpret switch status and describe a switching circuit's operating behavior
- Trace wiring diagrams for motor controls
- Identify a ladder diagram and describe its function

Electrical Blueprint Reading

Objectives:

- Explain how blueprints are prepared
- 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 on blueprints
- Interpret the common symbols used on electrical blueprints
- List the common abbreviations used on electrical blueprints
- Trace a wiring diagram and understand it

Electrical Lamps Part 1

Objectives:

- 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

Electrical Lamps Part 2

Objectives:

- List the advantages and disadvantages of each lamp type
- Recognize the different characteristics of each lamp
- Identify the proper application for common types of discharge lamps
- Interpret discharge lamp specifications
- Understand the basic manufacturer's ordering codes
- Recognize faults that lead to discharge lamp failure
- Realize complications that may occur when working with discharge lamps

Lighting Control

Objectives:

- Combine natural light and dimming devices efficiently
- Use multilevel 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

Introduction to the NEC, Electrical Installation, and Branch Circuits

Objectives:

- Describe the purpose of the National Electrical Code
- Use the NEC to locate and understand definitions essential to the application of the code
- Understand the NEC's basic structure and layout
- Determine which receptacles require Ground Fault Circuit Interrupter (GFCI) Protection
- Lay out general-purpose receptacles and lighting in a single-family dwelling
- Identify a grounded conductor
- Define the four major types of branch circuits
- Define key pieces in the creation of color wheels and other color systems

Loads, Service, and Overcurrent Protection

Objectives:

- Calculate load requirements for one-family and multifamily dwellings
- Apply demand factors to general lighting loads
- Understand the requirements for installing service conductors and equipment in various occupancies
- Understand the importance of the construction and installation of conductors to the integrity of an electrical system
- Define ampacity and apply the concept to the safe installation of equipment and outlets
- Understand the importance of overcurrent protection and list the common overcurrent protection devices employed to address overcurrent conditions

Grounding, Wiring, and Raceway Systems

Objectives:

- Differentiate between grounding and bonding and understand the importance of each to the application of the NEC
- Correctly use the NEC to determine sizing for grounding electrodes and equipment grounding conductors for raceways and equipment
- Use the NEC to determine minimum cover requirements for underground conductors, cables and raceways
- Understand the requirements for securing and supporting raceways and cables in ceiling and roof assemblies
- Use the NEC to select and apply the proper wiring method and wiring materials based on specific applications
- Use appropriate tables in the NEC to determine that a specific junction box can safely handle a given number of conductors before installation

Switching, Cords and Cables, Motors, and Related Systems

Objectives:

- Identify and properly apply the different types of switches defined in the NEC
- Understand the grounding requirements for switches, switchboards, and panelboards
- Use Table 4004 to determine correct applications of flexible cords and cables
- Define luminaire as it pertains to the NEC
- Use the NEC to determine proper locations, fixtures, lampholders, and grounding of luminaires
- Identify standard and special-use receptacles, and understand the applicable rules for new and replacement installations
- Understand the NEC requirements for the installation, control, protection, and disconnection of appliances identified in Article 422
- Understand the basic NEC installation requirements for motors, motor circuits, and motor controls

Transformers and Special Locations

Objectives:

- Use the NEC to determine guarding, ventilation, grounding, and location requirements for various types of transformers
- Define transformer vault and identify the NEC sections that apply to their construction
- Use the NEC to calculate OCPD sizes for transformers
- Define hazardous locations and the class, divisions, and groups used to classify hazardous locations by the NEC
- Understand the application of various devices required for hazardous location installations
- Briefly describe the specialized requirements of the NEC that apply to other special locations, such as health care facilities and places of assembly

Preventative Maintenance

Objectives:

- Describe the function of inspection and scheduled maintenance as the basis of preventive maintenance
- Explain why preventive maintenance is performed and how it's scheduled
- Identify those within industry who should be part of preventive maintenance planning and execution
- Discuss the causes, effects, and goals of a successful preventive maintenance program
- Explain how a computerized preventive maintenance program can be developed and implemented

Preventative Maintenance Techniques

Objectives:

- Explain how to inspect and properly maintain a belt, chain, and gearbox power transmission system
- Discuss why proper alignment is necessary when operating a power transmission system
- List the steps needed to properly maintain an AC or DC motor
- Explain how to perform a start-up or bump test of a motor
- Describe how to perform PM tasks on pneumatic systems
- Describe how to maintain both floor and elevated conveyor systems
- Identify the types of elevators and vertical lifts in your plant and the proper PM procedures for this equipment
- Explain how to maintain liquid and vacuum pump systems
- Describe how to perform a basic alignment of in-line shafts
- List the proper PM procedures for electronic controllers and robot systems

Wiring Electrical Circuits

Objectives:

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

Storage Batteries

Objectives:

- Identify the characteristics of lead-acid batteries, including their voltage, capacity, and efficiency
- Explain the effects of such factors as temperature and operating conditions on battery action
- Install, maintain, test, and charge storage batteries
- Seek employment wherever a knowledge of storage batteries is required

Transformers

Objectives:

- Explain the main parts of a transformer and how it can change an a-c voltage or current from one value to another
- Describe the differences between step-up, stepdown, and isolation transformers
- State the relationships between the turns ratio, voltage, current, and power in transformers
- Select a replacement transformer that will physically and electrically meet the characteristics of the original faulty transformer
- Describe transformer power losses and how to reduce them
- Explain the operation of tapped transformers, transformers with two or more secondaries, autotransformers, and high-frequency transformers
- State the main causes of transformer problems
- Connect three single-phase transformers for three-phase operation
- Calculate line current (if phase current is known) in A-Δ connected transformers
- Explain the characteristics and operation of distribution transformers

Local Distribution of Electrical Power

Objectives:

- 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

Underground Power Systems

Objectives:

- 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

Industrial Direct Current Motors

Objectives:

- Discuss the principles of magnetism and electromagnetism and the primary rule of like and unlike magnetic poles
- Explain how magnetic forces can produce work in a linear (straight line) or in a rotational manner
- Describe how like and unlike magnetic poles can be used to rotate a magnet
- Explain how a single-coil armature motor operates
- Identify the typical component of a DC motor and describe its purpose
- List the steps used to troubleshoot a DC motor
- Describe how various types of DC motor speed controls operate and how they control the motor's output speed
- Identify various types of DC motors such as universal, stepper, PM, servo, and brushless

Industrial Alternating Current Motors

Objectives:

- Explain how AC electricity creates a changing magnetic field in and around a coil
- Discuss the principles of electromagnetic induction
- Explain why a motor needs a system for starting the rotor and how this is performed with a shaded-pole, split-phase capacitor, and repulsion-induction motor
- List the possible problems with single-phase motors and the steps taken to troubleshoot these problems
- Identify the components of a polyphase motor and describe its operation
- Explain how to troubleshoot polyphase motor systems
- Identify the basic motor starter systems used in single-phase and three-phase AC motors

Controlling Industrial Motors

Objectives:

- Explain how stepper motors operate and how they're electronically controlled
- List the steps used to troubleshoot stepper motors and controllers
- Define how an AC motor rotates in synchronous speed to the AC line frequency
- Explain how a frequency inverter can alter the three-phase output frequency and thereby control motor speed
- Identify proper troubleshooting procedures to use when working on AC inverter systems
- Describe how pulse width modulation is used to control a servo motor and how to find the causes of servo system problems such as inaccuracy and oscillation
- Explain how a brushless motor operates and how the controller commutates the motor to provide a precise positioning of the motor's shaft
- List the steps to use when troubleshooting brushless motor and controller systems

Fractional-Horsepower Motors

Objectives:

- Name the types of fractional-horsepower induction motors
- Identify the types of direct-current motors
- Explain the operating characteristics of universal motors and identify concentrated-pole and distributed-field compensated motors
- Identify the different types of repulsion motors

Industrial Motor Applications

Objectives:

- Understand the relation between horsepower, speed, and torque
- Calculate the required torque and power for a specific inertial load
- Understand the operating characteristics of various motor types and know which applications are best suited by each type
- Understand the various types of motor couplings and choose the right coupler for a specific application
- Select motor drives for various types of industrial applications

Motor Control Fundamentals

Objectives:

- Explain the operation of a motor starter
- Differentiate between NEMA and IEC starters
- Interpret control circuits using control diagrams
- Determine the proper size of a starter for a given motor
- Describe the operations of reversing and multi-speed starters

Industrial Motor Controls Part 1

Objectives:

- Define the function of the central processing unit (CPU)
- Describe the CPU scan
- Identify analog and discrete signals
- Describe different types of PLC memory
- Explain the function of input and output systems
- Identify the elements of a relay ladder logic program
- Describe the operation of timers and counters

Industrial Motor Controls Part 2

Objectives:

- Describe typical PLC elements such as contacts and coils
- Explain how PLCs scan or solve ladder logic programs
- Explain typical ladder logic terminology and symbology
- Describe the operation of a PLC-controlled pick-and-place robot and how to troubleshoot the robot using the PLC system
- Explain how the programming console for a PLC will highlight power flow as a troubleshooting aid
- List the steps to the development of ladder logic for a mixing vat and describe how to troubleshoot the vat
- Explain how the use of internal coils makes ladder logic development easier for a multidirection motor system as used in a roll stand machine

Repairing D-C Motors

Objectives:

- Armature Construction and Windings
- Characteristics of Coil Insulation
- How to Find Armature Defects
- Repair of Mechanical Defects
- Commutator Problems
- Rebuilding of Armature
- Rebuilding of Commutator
- Rewinding for Change in Voltage
- Winding of Armature Coils

Repairing D-C Motors and Generators

Objectives:

- Field-Coil Construction
- Finding and Repairing Field-Coil Faults
- Repairs Requiring Rewinding of Coils
- Brush Construction
- Position of Brushes
- Brush Faults and Their Repair

A-C Motor Repair Part 1

Objectives:

- Determine motor condition
- Preparation for stator rewinding
- Stators with partly closed slots
- Stators with open slots

A-C Motor Repair Part 2

Objectives:

- Rotors
- Characteristics of Wave Windings
- Winding of wave-wound rotors
- Synchronous motors

Repairing Fractional-Horsepower Motors

Objectives:

- Troubleshooting Defective Motors
- Mechanical Faults and Their Repair
- Testing for Electrical Faults

Reconnecting Induction Motors

Objectives:

- Operation and connection of induction motors
- Motor reconnection for voltage changes only
- Motor reconnection for change in number of phases, number of poles, frequency, and output
- How to check density of magnetic flux

Electric Heating

Objectives:

- 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 factors 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

Controls for Air Conditioning

Objectives:

- 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 an HVAC system based on ladder logic and schematic diagrams

Basic Semiconductor Components: Diodes

Objectives:

- Describe how diodes work and how to determine if they're working properly
- Explain how different types of diodes function
- List a variety of diode uses in electronic systems
- List the characteristics that make a particular diode useful in a given situation
- Know how a diode works with other components in an electronic circuit
- Select a proper diode for replacement in a circuit

Basic Semiconductor Components: Transistors

Objectives:

- Describe the construction of bipolar transistors, and explain how their operation resembles that of the diode
- Explain how bipolar transistors can control and amplify current in a circuit
- Describe the construction and operation of JFETs and MOSFETs
- Use an ohmmeter to perform basic tests on bipolar transistors
- Perform some basic troubleshooting measurements and calculations on circuits that contain amplifying devices

Switching Devices

Objectives:

- List the advantages and disadvantages of various switch types
- Analyze basic relay ladder diagrams
- Explain how a diode can be used as a switch
- List some of the problems of diode switching
- Describe how very rapid electronic switching is accomplished
- Explain the circumstances in which a mechanical switch may be preferable to a rapid electronic switch

Electronic Sensors

Objectives:

- Describe some important thermoelectric effects
- Explain the importance of a bridge circuit in certain types of electronic instrumentation
- Describe how certain nonlinear resistors are used in circuits
- Explain how certain components can be used as protection devices for circuits
- Define the scientific terms stress and strain

Special Rectifiers: Electron Tubes

Objectives:

- List four different methods of obtaining electron emission
- Explain how vacuum tubes and gas-filled tubes operate
- Describe how a triode uses a control grid to control electron flow
- Explain why a screen grid is used in a tetrode
- Describe the function of a suppressor grid in a pentode
- Describe how electron beams are controlled in a cathode ray tube (CRT)
- Troubleshoot a half-wave rectifier power supply

Optoelectronic and Fiber-Topic Components

Objectives:

- Explain why electronics and optics are natural partners in the field of optoelectronics
- Identify the modern theories of light and how they help you to understand optoelectronic applications
- Describe the basic theory of light communications
- Explain the basic theory and applications of bar codes
- Identify the advantage of using infrared light instead of visual light with intrusion alarms and television remote controls
- Describe the basic operation of electron microscopes and their advantages over optical microscopes
- Explain how fluorescent light and other light sources operate

Electronics Hardware

Objectives:

- Identify various connector and terminal types and their specific applications
- Identify many types of wire and cables and specify the applications for each type
- Determine the expected resistance of a wire
- Estimate the change in wire resistance with changing wire characteristics
- Select the proper soldering equipment and material for electronic component soldering jobs
- Outline the proper procedures for soldering components in both PC board and SMT applications
- Explain the special handling procedures required when working with SMT components

Industrial Electronic Troubleshooting

Objectives:

- Explain why a safety inspection is the first inspection that should be made on a failed piece of equipment
- Discuss how to make safety a part of all troubleshooting and repair procedures
- Understand how to collect accurate data on trouble clues
- Describe how to use system indicators to help you troubleshoot an electronic system problem
- List the steps for proper basic troubleshooting, such as identifying failure trends, seeking obvious causes, and circuit board swapping
- Describe how to perform advanced troubleshooting, such as using binary divide techniques and focusing on one of many failure possibilities
- List the aptitude and attitude qualities needed to be a good industrial troubleshooter

Electronic Troubleshooting of Industrial Motor Controllers

Objectives:

- Describe various methods of controlling the speed and direction of a DC motor
- Explain the proper steps for troubleshooting a DC motor controller
- List the various types of stepper motor drives and explain how to troubleshoot these systems
- Define how DC servo systems operate and explain the normal test points for locating faults in these systems
- List the types of adjustable frequency drives and explain how to troubleshoot their circuits
- Describe how brushless servo systems operate and how to troubleshoot various problems with these systems

Troubleshooting Sensing Devices and Systems

Objectives:

- Identify the components of a typical limit switch and describe how to test these devices
- Describe the operation of pressure switches
- Identify the components of and troubleshooting procedures for temperature-sensing devices and level detectors
- Describe the operation of and troubleshooting methods for proximity, ultrasonic, photoelectric, fiber optic, and laser sensors
- Define the proper troubleshooting methods for sensors that are connected to input modules

Troubleshooting Industrial Control Systems and Output Devices

Objectives:

- Describe the operation of relays and solenoids and procedures for troubleshooting them
- Explain how to troubleshoot across-the-line starters and contactors, including solid-state controlled contactors
- Explain the importance of arc-suppression diodes and resistor/capacitor networks in output-device circuits
- Define the operation of and repair methods for simple numeric readouts
- Explain how DC and AC output modules operate and how to troubleshoot them
- Identify different types of closed-loop control systems and methods to troubleshoot and repair them
- Explain how to troubleshoot and repair human/machine interface systems

Troubleshooting Industrial Computer Systems and Software

Objectives:

- Discuss the principal parts and types of memory found on a computer motherboard
- Identify power supply components and ratings
- Locate the main power supply fuse and identify the type of power supply by its connectors
- Identify the various types of computer drive systems and their cables
- List the repair and troubleshooting procedures for computer hardware and software problems
- Describe the operation of and troubleshooting procedures for optical and RF identification systems
- Explain the purpose of vision system hardware and software and the troubleshooting procedures for them

Industrial Computer Networks

Objectives:

- Describe the methods of communication within networks
- Explain the configurations of various types of industrial network systems
- Identify and describe different types of network cables
- Discuss various network protocols
- Describe troubleshooting methods for networks

Audio and RF Circuits

Objectives:

- Describe how sound intensity is measured
- Compare the advantages of AM and FM transmission
- Describe how narrow-band FM is used in industrial communications
- Explain the advantages of coaxial cable over copper wire as a transmission medium
- Discuss the tone frequencies that are used in control systems, including subaudible and ultrasonic tones
- Describe how pushbutton dialing can be used in industrial systems
- Explain the different methods used to assemble common emitter amplifiers
- Identify different common-emitter amplifiers on a schematic drawing

Oscillators, Feedback, and Waveforms

Objectives:

- Explain how an oscillator works
- Identify several basic oscillator circuits
- Discuss how feedback is obtained in an oscillator
- Recognize several different waveforms, and explain how they're created
- Understand how a phase-locked loop works as a frequency synthesizer
- Explain how a 555 integrated circuit timer/oscillator produces a square wave

Electronic Power Supply Systems

Objectives:

- Explain the basic function of rectifiers
- Describe how half-wave and full-wave rectifier circuits operate
- Determine the output voltage from various rectifier circuits
- Calculate the percent of voltage regulation in a power supply
- Explain the operation of filters and bleeder resistors in power supplies
- Describe the purpose of a voltage-divider network in a power supply
- Explain the operation of electronic voltage regulators
- Describe the operation of several commonly used industrial power supplies

Industrial Amplification Systems

Objectives:

- Explain how a power amplifier is different from a voltage amplifier
- Calculate dB gain by using input and output resistances, impedances, and phase angles
- Describe the advantages and disadvantages of VMOS, BiFET, Darlington, push-pull, and complementary amplifiers
- Explain how to use amplifiers to obtain the proper phase angles needed to operate a twophase induction motor
- Analyze an operational amplifier on the basis of the virtual ground or the summing point
- Describe how an amplifier introduces distortion and noise in an amplified signal

Servo and Control Systems

Objectives:

- Explain the functions of the various components of a servo system
- Discuss the overall operation of servo systems
- Describe the common applications of servo systems
- Discuss the use of various electronic circuits in servo applications
- Calculate the gain of servo systems

Pulse and Logic Circuits

Objectives:

- Explain the differences between digital and analog circuits
- Define how slow-speed circuits compare to fastspeed digital circuits
- Tell how logic zeroes and ones-also called lows and highs-are used
- Compare the different kinds of logic gates
- Identify latch or flip-flop circuits
- Explain the difference between serial and parallel inputs and outputs

Programmable Controllers and Microprocessors

Objectives:

- Identify the inputs and outputs used in a PC, and describe their functions
- State the functions of the various blocks of a microprocessor system
- Cite the advantages and disadvantages of different kinds of memory devices
- Indicate the different ways that PCs may be programmed
- Identify the language, jargon, and mnemonics associated with microprocessors and programmable controllers

Introduction to Troubleshooting

Objectives:

- Locate the causes of trouble in basic electronic circuits by the logical process of eliminating various alternatives
- Read electronics schematics and recognize component symbols
- Recognize actual components and circuits by comparison with a schematic
- Discuss safety measures and first-aid care

Basic Troubleshooting Methods

Objectives:

- Recognize symptoms; know what they are, how to use them, and how to refine them
- List the methods of quickly isolating trouble areas by separating what's right from what "ain't"
- Describe the various troubleshooting techniques
- Explain where and how to use different troubleshooting methods, either separately or in tandem, to speed up the resolution of your troubleshooting assignments

Selecting Instruments for Troubleshooting

Objectives:

- Discuss the different kinds of basic meters and oscilloscopes
- Select the right instrument for a given job
- Explain instrument response, circuit loading, accuracy, and other data
- Demonstrate how to use a meter to make both out-of-circuit and in-circuit tests on several basic components
- Read and explain both analog and digital readouts
- Describe instrument specifications, and explain how to interpret them
- Define common oscilloscope and meter controls and their uses

Measuring Techniques in Troubleshooting

Objectives:

- Measure test voltages and currents
- Understand how loading can affect tests, and how to minimize loading effects
- Make high-voltage measurements safely
- Measure alternating current without opening the circuit
- Set up and make a-c (alternating-current), d-c (direct current), frequency, and time measurements with an oscilloscope
- Use wattmeters, frequency counters; capacitor meters, insulation testers, and other special instruments found in industry
- Test digital circuits using digital probes and pulse injectors

Support Services for Troubleshooting

Objectives:

- Demonstrate good soldering techniques
- Select and maintain solder tips
- Describe the various desoldering methods
- Care for desoldering irons and systems
- Discuss troubleshooting aids
- Explain troubleshooting strategies

Practical Troubleshooting Problems

Objectives:

- Recognize the various kinds of power supplies, and the troubles to be expected from each
- Explain how ohmmeters, voltmeters, and oscilloscopes are used to locate power-supply troubles
- Describe how regulators work, including what symptoms they develop and how to read them
- Define how to test electrolytics, transistors, diodes, and other parts, within as well as outside the circuit
- Explain the testing of digital circuits, including how it differs from and compares with other kinds of troubleshooting
- Recognize microprocessors, and be able to find troubles in them and in digital systems

Approach to Troubleshooting

Objectives:

- Lay out a schedule for preventive maintenance of digital and microprocessor equipment
- Name the “levels” of advanced digital/MPU troubleshooting
- Explain the significance of system block diagrams to speedy troubleshooting
- Select appropriate test nodes for various kinds of industrial electronic systems
- Describe advanced concepts of symptom analysis in digital and microprocessor systems

Analysis of Systems

Objectives:

- Explain system thinking
- Utilize diagnostic thinking
- Isolate faults in digital, analog, and microprocessor subsystems
- Analyze activity on bus systems that are common to industrial electronic systems
- Describe several popular bus, standards

Test Equipment Applications

Objectives:

- List testing equipment you’re likely to need to troubleshoot systems in your company
- Describe functions of various modern test instruments
- Utilize delayed sweep in modern oscilloscopes
- Set up operating controls of advanced instruments for industrial troubleshooting
- Choose the instrument most appropriate to a given set of symptoms displayed in a particular type of system

Safe Troubleshooting Practices

Objectives:

- List the factors involved in troubleshooting industrial electronic systems safely
- Describe or demonstrate the correct use of hand tools most frequently used for servicing
- Practice safe techniques while working around heavy electric power
- Recognize the need for cardiopulmonary resuscitation (CPR), and administer CPR effectively

Troubleshooting Industrial Systems Part 1

Objectives:

- Make and use troubleshooting flowcharts
- Use symptom clue tables to speed troubleshooting
- Approach heavy-duty a-c control as readily as you tackle servicing in any other subsystem
- Analyze failure rates and apply your analysis to regular maintenance and troubleshooting
- Test and evaluate individual linear and digital devices

Troubleshooting Industrial Systems Part 2

Objectives:

- Apply a digital oscilloscope where and when it seems indicated
- Attach a logic analyzer to multiple nodes as well as to buses
- Capture signatures in equipment that has been prepared for this technique, and analyze what you find
- Establish useful signatures in systems not so prepared by the manufacturer

Reactance and Impedance

Objectives:

- Explain how resistors, capacitors, and inductors work in DC (direct current) circuits
- Calculate time relationships in circuits
- Determine the reactance of a capacitor or inductor in an AC (alternating current) circuit
- Calculate the impedance of series RLC (resistive-inductive-capacitive) circuits
- Find the phase angle between the voltage and current in parallel RC (resistive-capacitive), RL (resistive-inductive), and series RLC circuits
- Work with j operators

Resonant Circuits

Objectives:

- Understand the difference between time domain and frequency domain displays
- List all the conditions necessary for series and parallel resonance
- Calculate the resonant frequency of an LC (inductive-capacitive) circuit
- Calculate the value of the quality factor Q
- Describe the relationship between Q and bandwidth
- Describe some of the uses of tuned circuits in a radio
- Understand the results of distributed components

Applications and Troubleshooting of Resonant Circuits

Objectives:

- Estimate voltages for troubleshooting both DC and AC circuits
- Explain the importance of impedance matching
- Identify the circuits for low-pass, high-pass, band-pass, and band-reject filters
- Identify two important power-supply filter designs
- Describe the relation between the band-pass and the 3 dB (decibel) points on a filter's characteristic curve
- Explain how transmission lines are related to resonant circuits and waveguides
- Explain how transmission lines can be used as components or tuned circuits

Rectifiers and Power Supplies

Objectives:

- Identify the basic types of electronic rectifiers
- List the advantages of different rectifier connections
- Determine the current through and the voltage across nonlinear components, such as diodes
- Discuss the operation of power supply filters
- Explain how voltage dividers are used in power supplies
- Calculate the values of voltage divider components
- Describe how voltage-regulating devices and circuits operate
- Explain how current and voltage are regulated in power supplies

Amplifiers

Objectives:

- Indicate the advantages of the various classes of transistor amplifier operations
- Calculate the dB gain of an amplifier
- Identify several types of transistor amplifier circuits
- Explain the methods that are used for biasing amplifiers
- Explain how to perform simple troubleshooting operations on amplifiers
- Understand the various types of distortion that are introduced by amplifiers

Oscillators

Objectives:

- Explain the principal differences between several types of oscillator circuits
- Describe the flywheel effect and how it's produced
- Calculate the resonant frequency of a basic oscillator circuit
- Explain the operation of complex RLC tuned circuits
- Explain the operation of oscillators that have LC feedback circuits
- Explain the operation of oscillators that have RC feedback circuits
- Discuss the basic applications of oscillator circuits
- Describe how a frequency synthesizer works

Modulation and Detection Circuits

Objectives:

- Explain the various forms of modulation
- Determine the degree of amplitude and frequency modulation
- Describe the frequencies that result from combining or mixing two signals
- Calculate the bandwidth of AM and FM signals
- Describe the advantages and disadvantages of pulse-code modulation
- Explain the theory and applications of phase-locked loops
- Describe the various types of demodulation circuits, and the functions of the various circuit components
- Discuss the advantages and disadvantages of different types of pulse modulation, such as PAM, PWM, and PPM

Switching Circuits

Objectives:

- Identify the output conditions for various gate circuits
- Show how transistors are used as logic gates
- Discuss the operation of multivibrators and flip-flops
- Discuss the advantages and disadvantages of various logic families
- Show the application of Boolean algebra to logic circuitry

Logic Circuits

Objectives:

- Convert binary numbers to other number systems, and vice versa
- Develop and use truth tables
- Describe and explain the use of some of the more common encoders, decoders, and converter circuits
- Explain how adders, subtracters, and comparators are used

Gating and Counting Circuits

Objectives:

- Describe the working of arithmetic-logic gates
- Work with half-adder and full-adder circuits
- Discuss the use of subtracter circuits
- Identify applications for both decade and binary counters
- Determine the modulus of a counter

Pulse and Digital Circuits

Objectives:

- Sketch several types of pulses, and point out those dimensions or characteristics of pulses that are of particular interest in electronic circuits and systems
- Explain the relationship of time constants to pulse-forming circuits
- Identify the different types of output waveforms obtained from integrating circuits and differentiating circuits when pulses are applied to their inputs
- Draw schematics for basic integrating and differentiating circuits
- Identify basic limiter and clamper circuits, and describe how they improve the operation of pulse circuits and digital systems
- Discuss the use of pulses to trigger other circuits
- Explain how pulses can represent binary numbers

Pulse Techniques

Objectives:

- Calculate the rise time of a pulse or square wave from an oscilloscope display
- Identify a glitch, and understand its effect on digital circuits
- Measure pulse width and settling time
- Determine pulse repetition rate from the period of a pulse waveform
- Explain the difference between frequency and time domains
- Understand how Fourier analysis is used to explain the makeup of various waveforms

Pulse Generators

Objectives:

- Determine the voltage across a charging or discharging capacitor at any instant of time
- Calculate the current through an RL circuit for any instant of time
- Explain the importance of five time constants
- Explain the relationship between time-constant and integrating or differentiating circuits
- Explain the operation of multivibrators
- Tell why a Schmitt trigger is important in the study of pulse circuits

Wave-Shaping Circuits

Objectives:

- Distinguish between a clipper and a limiter
- Recognize a baseline stabilizer capable of stabilizing to zero volts
- Limit a waveform to some value other than zero volts
- Explain how a waveform can be clamped to a positive or negative voltage
- Discuss why a d-c (direct-current) restorer circuit is sometimes needed
- Compare an ideal clamping circuit with those that exist in the real world
- Identify a sawmaker circuit
- Explain how amplifiers change the characteristics of a pulse

Timing

Objectives:

- Describe how timers are used in spot welders and list other applications of timers
- Explain the purpose of each internal part of the 555 IC (integrated-circuit) timer
- Tell how counters are used for timing
- Explain how a one-shot multivibrator can be used to obtain a fixed time interval and how a 555 IC timer can be used as a monostable multivibrator
- Compare the 555 and 3905 IC timers

Pulse Circuit Applications

Objectives:

- Determine the on period for a 555 monostable multivibrator circuit
- • Describe how a 555 timer can be used in an astable multivibrator circuit
- • Determine the free-running frequency of a 555 astable multivibrator
- • Discuss the use of synchronization for astable multivibrators, and for astable 555 timer freerunning circuits
- • Describe how pulses are used for measuring both voltage and capacity, and how switching regulators work in power-supply systems

Troubleshooting Pulse Circuits

Objectives:

- List the characteristics of pulses to be tested
- Compare the troubleshooting of pulse circuits with that of other systems
- Determine which part of digital and pulse circuits to test first in quick troubleshooting procedures
- Explain the use of logic analyzers and the purpose of single-step testing
- Understand the troubleshooting techniques for a microprocessor system

Logic Circuit Fundamentals

Objectives:

- Define terms commonly used in electronic logic
- Identify the symbols of electronic logic in system diagrams
- Explain those simple logic circuits used in industrial machinery
- Draw simple logic diagrams, and interpret those that others have drafted
- Name and recognize the logic circuits that use discrete components
- Discuss basic integrated-circuit logic devices
- List the symbols and notation conventions of Boolean logic
- Write simple Boolean algebra equations

Introduction to Number Systems

Objectives:

- Explain the binary numbering used by computers and digital electronics equipment
- Understand hexadecimal notation as is used in machine-language programs
- Recognize octal numbers, and know how they’re used
- Count in binary, octal, and hexadecimal numbers
- Convert values from one number system to another
- Perform simple calculations in all four number systems
- Explain the main advantage of the binary-coded decimal (BCD) system as compared with the ordinary binary number system

Logic Devices and Diagrams

Objectives:

- Draw logic diagrams that conform to a desired logic function
- Define Boolean variables, terms, and expressions
- Trace logic circuitry through gates, whether they’re discrete or parts of ICs
- Figure out the logic equivalents for complex logic circuits
- Simplify logic circuitry through Karnaugh mapping
- Recognize those binary patterns that produce a particular result in logic circuitry
- Compile truth tables for complex logic functions

Logic Families

Objectives:

- Define the major families of digital logic ICs (integrated circuits)
- Identify a logic family from its operating parameters
- Define such terms as SSI, MSI, LSI, and VLSI
- Describe IC packaging for logic components
- Understand such logic-device qualities as noise immunity and noise margin
- Explain the meaning of fan-in and fan-out
- Interpret specification sheets for logic ICs

Applications of Logic Circuits

Objectives:

- Explain the functions of digital circuits composed of simple logic gates
- Design a simple binary ladder for digital-to-analog conversion
- Compile truth tables for sequential logic devices
- Recognize the diagram symbols for various types of flip-flops
- Read timing diagrams for flip-flops and counters
- Explain registers, counters, decoders, and multiplexers
- Understand just how logic registers perform arithmetic operations

Troubleshooting Logic Controllers

Objectives:

- Identify expected logic levels by measuring d-c (direct-current) supply voltages
- List key specifications for logic circuit test equipment
- Trace logic functions with a logic probe, and identify errors
- Use an oscilloscope as a logic tracer
- Describe the fundamental operations of a logic analyzer
- Explain what a signature analyzer does
- Wire up a logic probe of your own
- Calculate approximate frequency of a digital signal from oscilloscope readings
- Replace MOS (metal-oxide semiconductor) devices without damage to them or to the system equipment

Linear and Digital Circuit Principles

Objectives:

- Draw transfer curves for functions of both linear and digital devices
- Explain the nature of analog operation, as compared to digital
- List the advantages of digital operation, and those of analog (linear)
- Describe the operation and uses of Hall-effect devices
- Identify circuits wired up from linear or digital ICs
- Discuss voltage and power parameters for digital and linear devices
- Draw diagrams of common linear and digital circuit hookups
- Recognize applications for the popular SSI (small-scale integration) and MSI (medium-scale integration) digital ICs

Integrated-Circuit Techniques

Objectives:

- Name the materials and processes used in IC fabrication, and list their purposes
- Locate the data you need in order to use ICs properly
- Understand and use manufacturers' numbering systems
- Explain the key parameters for most linear and digital IC devices
- Discuss typical applications for digital and linear technologies
- Describe the technologies incorporated in hybrid ICs
- Place ICs safely into industrial operating environments
- Keep IC voltages and currents within safe operating limits

Linear Integrated Circuits

Objectives:

- Diagram the concepts of sensing and process control with linear ICs
- Recognize diagrams for common linear devices and functions
- Define the words analog' and linear as they apply to industrial electronics
- List several kinds of analog IC amplifiers
- Describe the operation of a general-purpose op amp (operational amplifier)
- Explain how an active filter works
- Follow the operation of a phase-locked-loop IC

Digital Integrated Circuits

Objectives:

- Read logic diagrams for digital IC (integrated-circuit) devices and functions
- Explain the inputs and outputs of several digital ICs
- Distinguish which kinds of latches or flip-flops an advanced IC uses
- Differentiate between a shift register and a port register
- Explain the difference between asynchronous and synchronous counters
- Discuss the difference between bus drivers and display drivers

Integrated-Circuit Logic Systems

Objectives:

- Interpret full-scale schematic diagrams for industrial equipment
- Interchange digital devices in designs without destroying performance
- Explain the kinds of buses used for industrial digital systems
- List uses for logic gates in systems that perform industrial tasks
- Relate digital systems to specific operations

Troubleshooting Linear and Digital IC Systems

Objectives:

- Approach troubleshooting with a systems outlook
- Verify inputs to linear and digital sections and subsystems
- Use a digital multimeter appropriately in IC systems
- Choose a proper instrument for each troubleshooting test
- Identify IC and connector socket pins for troubleshooting
- Interpret indications from a clip-on logic tester
- Wire up test jigs that save troubleshooting time
- Analyze oscilloscope waveforms in linear IC stages

Industrial Computer Fundamentals

Objectives:

- Describe some of the limitations of early industrial computers
- Tell how analog computers evolved, and why their popularity has waned
- Explain the differences in the ways analog and digital computers are used
- Understand why digital computers have largely supplanted analog types
- Describe what goes on inside an industrial computer
- Draw block diagrams showing typical industrial computer applications
- Name the different ‘types of industrial computer displays
- List some important manufacturing tasks undertaken by modern computers
- Describe what it takes to write software programs for industrial computers

Digital and Analog Systems

Objectives:

- Explain the fundamental principles involved in analog computer systems
- Recognize commonly used analog computer diagram symbols, and explain their meanings
- Explain the fundamental principles of digital computing systems
- Describe the functioning of open and closed loops
- Explain the difference between switched and proportional-control schemes
- Name several types of proportional-control arrangements

Software and Programming

Objectives:

- Define the term software
- Describe those industrial systems that need software
- List some of the sources of industrial software
- Recognize the standard symbols used in industrial control diagrams
- Explain how to use ladder logic, machine and assembly language, and BASIC
- Lay out simple control problems in terms of Boolean algebra
- Write control algorithms in ladder logic
- Use fundamental logic simplification techniques

Computer-Aided Control Systems

Objectives:

- Draw a block diagram of a CAD/CAM system
- Describe the equipment needed for computer-aided graphics
- Recognize CAD/CAM software
- List some requirements for selecting a CAD or CAM system
- Explain the benefits of computer aid in industrial operations
- Cite applications for computer-aided design and drafting (CADD)

Interfacing Principles

Objectives:

- List the services that interface devices perform
- Describe the nature of serial and parallel data movements
- Discuss methods for converting analog data to digital data
- Explain signal conditioning
- Draw an ordinary analog/digital control loop and identify its components
- Describe the parity method of checking data transfers for errors

Introduction to Computer

Objectives:

- List the most important factors on which the selection of a computer is based
- Name some of the skilled jobs and positions related to computer work
- Describe what is meant by the term “multiplexing”
- Tell what is meant by “bugs” as the term relates to computers
- Point out the main sections of a computer
- Identify some of the peripheral items in a computer system
- Define some of the important terms used in computing work such as “ROM,” “RAM,” “subroutine,” “video monitor,” and others
- Tell how a microprocessor plays a part in a computer system

Introduction to Microprocessor Applications

Objectives:

- Explain how bytes are comprised of bits
- Describe how a microprocessor acts only on the receipt of codes from its instruction set and explain two examples
- Tell how a microprocessor uses a feedback loop to control machinery
- Compare the history of the MPU with the advancement of electronics from the vacuum tube through to very large scale integration (VLSI)
- Explain how an MPU system is used for maintenance diagnosis
- Tell what is meant by “scratchpad” memory and “handshaking”
- Translate bit patterns to binary 1 and 0 patterns
- Explain MPU firmware, including who prepare it and what they do with it

Microprocessor Basics, Part 1: Underlying Principles and Concepts

Objectives:

- Draw the logic symbols of the buffer and noninverting buffer, and the NOT, AND, OR, NAND, NOR, XOR, and XNOR logic gates; and understand their use in logic circuits
- Show how logic gates are applied in security and safety applications
- Explain how analog and digital signals differ
- Identify pulse characteristics, including pulse width, pulse repetition, rate, pulse recurrence time, duty cycle, rising edge, and falling edge
- Set up and explain truth tables for logic gates
- Draw the logic diagrams for two R-S flip-flops, the D flip-flop, and for the J-K flip-flop, and explain their operations and truth tables for all possible input and clock-pulse conditions
- Determine the equivalent binary number for a decimal number (and vice versa)
- Count in binary numbers

Microprocessors Basics, Part 2: How a Microprocessor Works

Objectives:

- List the registers and work centers in a typical microprocessor
- Tell how a microprocessor brings data into its registers
- Describe how data enters and leaves a microprocessor
- Explain how a microprocessor sends data into memory, and later finds it
- Explain the purpose of the instruction register and decoder
- Point out the position of an ALU (arithmetic-logic unit) in a microprocessor
- Describe the function of accumulators
- Detail how condition codes or status flags keep track of ALU activities
- Follow a program counter as it steps through program execution
- Define a stack, and name the duties of the stack pointer
- Tell why the MPU has an index register, and how it can be used
- Name the control inputs and outputs of an MPU, and tell what each one does

Working with an Uncomplicated Microprocessor, MC6802 Part 1

Objectives:

- Explain the effect of a d-c voltage regulator, and apply it to the proper MPU pins
- Measure a-c (alternating current), and ripple voltages in an MPU power supply
- Trace and test VCC and VSS connections, and check out other chip connections
- Send instruction into a microprocessor
- Explain which MPU logic will cause read and write operations
- Bring data into a microprocessor from direct or extended addresses in memory
- Name the main addressing modes of the MC6802 microprocessor instruction set
- Set a flag in the CCR (condition codes register) to force a program branch
- Decode an address and use the memory-mapping concept of in/out control
- Direct data to a particular register inside an MPU
- Address either on-chip or external RAM (random-access memory)

Software-Microprocessor Programming Principles

Objectives:

- Quickly convert among the decimal, hexadecimal, and octal number systems
- Follow and develop simple programs written in hexadecimal notation
- Store a program in the read-write memory of your ICS XK-300 Microprocessor Trainer
- List the nine varieties of instructions for the MC6802
- Run a program the you have written which subtracts hexadecimal numbers
- Use two's-complement math to find the decimal value of a negative-signed binary number

Working with an Uncomplicated Microprocessor, MC6802 Part 2

Objectives:

- Find the entry vectors for the four major types of interrupt, including Reset
- Arrange either a 1-bit or a whole-byte prompt
- Locate display or other output addresses in a memory-mapped MPU system
- Display contents of memory chips in RAM and ROM, and map the memory
- Examine registers of the MC6802 microprocessor
- Use single-step execution as a software-debugging tool

Software-Microprocessor Programming Principles Part 2

Objectives:

- Think through a programming task, and break it into component parts
- List the procedures necessary for an MPU to perform each part of the job
- Draw a flowchart that illustrates the most efficient sequence for a give MPU undertaking
- Streamline a program, both to save memory space and to make it run more efficiently
- Utilize mnemonics in writing source code for a program
- Document your program plan with appropriate comments on a Programming Sheet
- Differentiate between an effective address and the object code for that address
- Demonstrate that you can choose wisely from among the several op codes available for some MPU commands
- Assemble object code for a program you've written
- Manipulate data inside and outside the MPU by the use of software
- Program the MPU to do advanced arithmetic
- Build your own reference book of useful routines and subroutines that you've devised
- Use conditional branches for decision-making
- Control program execution by careful use of jumps and branches

Interfacing through Serial and Parallel Ports

Objectives:

- Explain the difference between serial- and parallel-data transfer
- Address output ports without the use of peripheral adapters
- Memory-map a peripheral interface adapter (PIA)
- Use interrupts to bring an outside task to the attention of the MPU
- Discuss the concept of parity and how it keeps data transfer accurate
- Direct the MPU to input or output data in the pulse and handshake modes
- Save data on magnetics tape, using a cassette interface
- Discuss the basics of a disk controller
- Manage the protocol between MPU and line printer
- Tell how an MPU makes characters on a video terminal

Troubleshooting Microprocessor Equipment Part 1

Objectives:

- Diagram the main modules of a microprocessor system from its operation
- Arrange trial runs of the equipment so that you can judge its performance
- Analyze equipment operation (or nonoperation) and decide where a fault may lie
- List the four main steps in tracing down the breakdown of a specific part
- Go directly to key test points that will tell you most about system operation
- Check out software associated with a system, and eliminate bugs that develop
- Design diagnostic routines that exercise various portions of a system
- Read monitor listings and identify any built-in diagnostic possibilities
- Assess system operation by use of breakpoints place in the software
- Eliminate software bugs that cause unwanted loops or break up proper loops
- Describe what assemblers, compliers, and interpreters do

Troubleshooting Microprocessor Equipment Part 2

Objectives:

- Use a digital multimeter to trace VCC problems
- Trace logic through gates and decoders with a logic probe
- Build your own logic tracer and assess its readings
- Apply a logic pulser properly, and evaluate its circuit effects
- Interpret what a triggered oscilloscope tells you about digital operations
- Understand the application of a logic analyzer
- Explain the concepts behind signature analysis used as a troubleshooting tool
- Verify the grounding integrity of a microprocessor system installation
- Hunt down cable and connector problems that disable a system
- Check out all the sections of a computer or MPU-controller mainframe
- “Ring” three-state buses for shorts and opens
- Maintain peripheral equipment, including keyboards, video monitors, line printers, and disk drives

Other families of Microprocessors

Objectives:

- Find and use specification sheets on microprocessors and support chips
- Recognize the architecture of several popular microprocessors
- Employ many different addressing modes in software
- Recognize the meaning and use of the those instructions peculiar to advanced MPUs
- Define the characteristics and applications of microprocessors with 16-bit data buses
- Explain the 24-bit addressing system used in at least one modern microprocessor
- Understand the directions being taken in current microprocessor development

Physical Properties and Their Measurement Part 1

Objectives:

- Determine the slope of a line and the direction of acceleration vectors
- Calculate centripetal force and angular acceleration
- Solve problems involving power, work, efficiency, and mechanical advantage

Physical Properties and Their Measurement Part 2

Objectives:

- Describe how the properties of a liquid determine the liquid's viscosity
- Convert temperature readings from the English system of measure to the SI system
- Solve problems involving heat, light, and sound

Measuring Instruments and Signal Processing

Objectives:

- Given a particular schematic, identify the correct circuit function
- Identify the principle upon which a permanent-magnet meter movement works
- Distinguish between indicating, recording, and integrating instruments
- Correlate the proper logic gate with a typical logic statement
- Select certain working parts, given a particular meter movement construction

Transducers

Objectives:

- Identify basic types of transducers and similar sensing devices
- Explain the operating principles of transducers
- Discuss the characteristics and applications of various types of transducers
- Select the proper transducer for any particular industrial application

Introduction to Control Systems

Objectives:

- Discuss the types of components in a closed-loop system, and their functions
- Recognize the effect of deviation and duration on control response
- Explain the functions of the various types of synchro systems
- Calculate signal responses from scaling transducers
- Cite the function of the various microprocessor parts

Controllers

Objectives:

- Relate the role of the controller in a process-control system
- Identify the various terms and response characteristics of controller systems
- Recognize the symbols and nomenclature used to describe controller circuits
- Select the correct module symbol for a desired controller action

Control System Methods

Objectives:

- Select the proper logic gate to obtain the desired output for any given input
- Write the logic statement for a logic circuit
- Determine the binary word output of a memory unit
- Describe the functions of registers in a microprocessor unit

Data Logging, Transmission, and Display

Objectives:

- Discuss various data-input methods, codes, and devices
- Feel at home with the various special terms used in the computer field
- Understand the different methods of communication between computers and related equipment
- Write a simple computer program

Control System Applications, Maintenance, and Troubleshooting

Objectives:

- Explain the meaning of reliability and performance as they relate to control systems
- Calculate simple probabilities
- Discuss the methods of increasing system reliability
- Explain how people fit into control system operation and management
- Outline how to troubleshoot a controller
- Discuss how digital computers impact controller reliability

Voltage and Frequency Controllers

Objectives:

- Identify the four methods of converting power from one form to another
- Understand a plant distribution system for power
- Point out the effects of fluorescent lamps, heating equipment, and electronic equipment on the line voltage
- Understand the methods of preventing voltage fluctuations in the power system
- Describe how power factor affects the operation of the plant power system
- Describe a crowbar circuit
- Know how a ferroresonant transformer works
- Understand how the output of an inverter can be adjusted to have any desired frequency

Nondestructive Test Equipment

Objectives:

- Describe the advantages and disadvantages of each major NDT method
- Describe the equipment and procedures for each widely used NDT method
- Relate the basic concepts behind each NDT method
- Describe the use of electronics in NDT methods
- Draw a simple diagram of an X-ray machine
- Cite the equipment components used for ultrasonic testing

Resistance Welding Equipment

Objectives:

- Describe two types of electric welding
- Identify the steps in making a resistance weld
- Explain how capacitor discharge welders operate
- Discuss the use of ignitrons in resistance welders
- Calculate the form factor of a waveform
- Calculate the percent duty cycle of an electronic device

Induction and Dielectric Heating

Objectives:

- Explain the spin theory of magnetism
- Discuss how induction heating works
- Define the three ways of transferring heat
- Describe source applications of induction heating
- Explain how dielectric heating works
- Describe some applications of dielectric heating
- Discuss the advantages of induction and dielectric heating
- List the disadvantages of induction and dielectric heating

Cranes, Scales, and Materials Handling

Objectives:

- Describe the types of cranes and where they're used in industry
- Tell about important factors concerned with wiring cranes, and controlling, braking, and stopping crane motors
- List four kinds of crane controls and describe their special features
- Identify the types of remote radio-control systems and be familiar with the special rules concerning them
- Describe the kinds of instruments designed for crane work
- Describe how strain gages are used in load cells as a part of electronic weighing systems
- List the methods of calibrating heavy-duty weighing systems and the main features of each type