Mechanical and Electrical Maintenance

Trades Safety: Getting Started

Objectives:

- List the physical hazards associated with chemicals and describe how to avoid them
- Name several electrical shock hazards and the techniques used to prevent shocks
- List the steps in a lockout/tagout procedure
- Explain the importance of machine guarding, and name several types of machine guards
- Name the five classes of fire and how to extinguish each of them
- Describe the proper technique used to manually lift a heavy load
- Explain how to avoid hand injuries when using hand and power tools
- List some of the hazards involved in welding and hot cutting operations and how to prevent them
- Explain how job analysis and ergonomics are used to improve the workplace
- Explain the importance of using personal protective equipment (PPE)
- Name the agencies and organizations that make and enforce safety

Working Safely with Chemicals

Objectives:

- Recognize the different ways in which a chemical can cause you physical injury
- Name the paths of entry along which chemicals enter your body
- Describe the basic types of injuries caused by chemicals
- Identify potential chemical hazards in the 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 when handling chemicals
- Explain the role of government 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 five 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 evacuate a burning building in a safe manner

Safe Handling of Pressurized Gases and Welding

Objectives:

- Identify common welding gases and the hazards associated with each of them
- Safely handle and store different types of gas cylinders
- Recognize the safety considerations involved in the setup and operation of electric arc-welding equipment
- Explain how to safely set up and operate a basic gas welding rig
- 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
- Understand the importance of proper ventilation when welding
- Describe how to effectively deal with confined spaces when performing welding operations

Advanced Electrical Safety

Objectives:

- Explain how electricity can harm you and property
- Discuss the importance of using quality electrical components
- Describe why it's important to properly ground electrical installations
- Understand the type of equipment used in hazardous locations
- List the safety practices required when performing electrical work
- Discuss the importance of workspace clearance around electrical enclosures

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
- Identify the parts of a powered lift truck and similar mechanized material-handling equipment
- Explain how to operate various types of mechanized material-handling equipment safely
- 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 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 operating industrial equipment

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 n
- 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

Bench Work Part 1

Objectives:

- Familiarize yourself with the nature of bench work
- Familiarize yourself with wrenches, hammers, pliers, and screwdrivers
- Familiarize yourself with punches, twist drills, reamers, and broaches
- Familiarize yourself with saws, chisels, and snips
- Familiarize yourself with finishing and grinding tools

Bench Work Part 2

Objectives:

- Identify threaded fasteners
- Describe thread systems
- Describe hole preparation for threaded fasteners
- Identify mechanical fasteners
- Describe rivets
- Describe keys
- Describe pins
- Familiarize yourself with threading with hand tools

Bench Work Part 3

Objectives:

- Describe tolerance, allowance, clearance, and fit
- Describe installation of machine components
- Describe babbitting
- Familiarize yourself with cutoff saws
- Familiarize yourself with soldering
- Familiarize yourself with brazing

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

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 Distribution

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 devices
- Define the terms voltage, current, and resistance, and explain their relationship in a circuit
- Discuss how voltage, current, and resistance are measured with a multimeter
- 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
- Identify insulation and continuity problems by using a megger
- 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 electrical components
- 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

Component Testers

Objectives:

- Identify the type of component tester used in connection with such “piece parts” as resistors, capacitors, and inductors
- Calculate turns ratio
- Demonstrate the correct connection scheme for testing diodes, SCRs, and transistors,

Digital Test Equipment

Objectives:

- Convert back and forth between the decimal numbering system and the binary, octal, and hexadecimal numbering systems
- Identify a logic gate, and explain how it’s used to make logical decisions
- Explain how a flip-flop stores information
- Describe how a logic probe and an IC logic clip are used
- Explain the important uses of the oscilloscope and the logic analyzer in checking, testing, and troubleshooting digital systems

Preventive 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

Preventive 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

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

Fuses

Objectives:

- Evaluate basic ratings and specifications for fuses
- Select the correct fuse size and type for a particular current range
- Convert a standard plug fuse holder to one that will accept a specific type S fuse
- Specify the proper fuse for a circuit, based on both temporary overloads and high short-circuit currents
- Replace the fuse link in a renewable fuse
- Identify by sight miniature (or instrument) fuses
- Tell where and why fuse cutouts and lightning arresters are used
- Replace a fuse with the proper substitute fuse for a particular application
- Explain how fuses are rated, using correct fuse terminology

Lubrication, Part 1

Objectives:

- Describe the various types of friction
- Discuss how materials wear
- List the various functions lubricants perform in industry
- Explain how lubricants reduce friction
- Classify lubricants depending upon their composition, properties, and additives
- Understand why certain lubricants are chosen for certain tasks
- Explain how to safely handle and store lubricants

Lubrication, Part 2

Objectives:

- Explain how to manually apply various types of lubricants in an industrial environment
- Describe total-loss lubrication
- Identify a nonloss lubrication system's components and describe their operation
- Explain how to maintain a nonloss lubrication system
- Identify the proper lubrication procedures to use for special industrial applications including sealed bearings, oil-impregnated bearings, and food-processing plants
- Explain how lubricant-conditioning systems work and how to maintain them
- Describe how automatic lubrication systems work and how to maintain them
- List the tasks involved in preventive and predictive lubrication maintenance

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 dimensions and with their abbreviations
- Convert between millimeters and inches

Precision Measuring Instruments, Part 2

Objectives:

- Properly read standard and metric micrometers
- Read a vernier micrometer
- Choose special micrometers appropriately for various measuring tasks
- Recognize five kinds of depth and height gages and demonstrate the ability to read a depth gage
- Read the scale on a vernier bevel protractor
- Explain the uses of many kinds of indicators and gages in shopwork
- Describe how to minimize cosine error when using dial test indicators

Precision Measuring Instruments, Part 3

Objectives:

- Explain the use of optical comparators and toolmaker's microscopes
- Recognize the setup and operation of an optical alignment system—including laser and alignment telescopes
- Understand the use of digital readout gauges, and the use of both absolute and incremental measuring
- Recognize the uses for in-process and post-process gauging, including video inspection and CNC tool presetters
- Understand the use of hardness testers and video material testing
- Recognize the uses for modern nondestructive material testing, including magnetic particle inspection and ultrasonic testing

Bearings and Seals, Part 1

Objectives:

- Understand what friction is and how bearings help reduce it
- Explain the difference between plain and antifriction bearings
- List the different types of plain bearings
- Understand the characteristics of plain bearings
- Recognize the importance of proper handling, installation, and lubrication of plain bearings
- List different materials used to make plain bearings and how material type affects their use
- Explain how to prevent premature failure of plain bearings

Bearings and Seals Part 2

Objectives:

- Identify the various parts of an antifriction bearing
- Identify the various parts of a seal
- Choose the proper seal for a given application
- Explain the importance of providing bearings with a sufficient supply of the proper lubricant and the result of failing to do so
- Differentiate between the features and capabilities of the different types of antifriction bearings
- Identify common problems that occur in antifriction bearings and suggest potential solutions

Pumps, Part 1

Objectives:

- Describe the main parts of a centrifugal pump
- Explain how a centrifugal pump operates
- Identify different types of centrifugal pumps
- Calculate the capacity or head of a centrifugal pump
- Explain and use head and capacity curves
- Explain the affinity laws and how they affect centrifugal pumps

Pumps, Part 2

Objectives:

- Discuss the main parts of a centrifugal pump
- Discuss applications for different pumps
- Install and maintain centrifugal pumps
- List the steps needed to troubleshoot problems associated with centrifugal pump operation

Pumps, Part 3

Objectives:

- List the main parts of rotary and reciprocating pumps
- Identify applications specific to rotary and reciprocating pumps
- List the procedures for the installation and maintenance of rotary and reciprocating pumps
- Identify troubleshooting procedures associated with the operation of rotary and reciprocating pumps

Mechanical Power Transmission, Part 1

Objectives:

- Explain the physical principles that govern mechanical power transmissions
- Identify and name the type of shaft misalignment present in a given application, and select the type of coupling that compensates for it
- Name the major components of any coupling and state their functions
- Describe the major difference between a resilient coupling and an all-metal coupling
- Identify the major components in a belt-drive system
- Explain the operating principles of flat-belt, V-belt, and positive-belt type drives
- Name the major operating advantages of each type of belt drive, and show how to compute the speed ratio of a belt drive
- State the main steps in installing various types of belt drives
- Select the proper solution for a problem with an operating belt drive

Mechanical Power Transmission, Part 2

Objectives:

- Identify different gear types and explain their unique operating characteristics
- Describe how to mount and remove a gear from its shaft
- Explain the main gear dimensions
- Interpret gear and gearbox ratings
- List the general types of gearboxes and explain the kind of applications for which each is best suited
- Describe how gearboxes are lubricate

Mechanical Power Transmission, Part 3

Objectives:

- Identify different chain drive configurations and explain their unique operating characteristics
- Describe the general procedure for installing coupling links and maintaining and checking chain tension
- Interpret chain drive system ratings
- Describe the different ways in which chain drive systems are lubricated
- Understand the rating system for brakes and clutches
- Identify the different types of brake and clutch systems, and the applications each type is suited for
- Explain the considerations in selecting a specific multimedia drive
- Describe the predictive-maintenance techniques used on mechanical power transmission systems, and the analysis of power transmission problems

Hydraulic Power Basics

Objectives:

- Define hydraulic power
- Describe the advantages of hydraulic power
- Describe and apply the basic laws of fluids
- Recognize the relationships among force, pressure, and fluid flow
- Describe the basic properties of fluid and fluid handling procedures
- Identify important safety precautions for hydraulic systems

Hydraulic Components: Actuators, Pumps, and Motors

Objectives:

- Explain how linear actuators work
- Identify the features of various types of linear actuators
- Describe the operation of several types of rotary actuators
- Describe how a pump works
- Explain the effects of cavitation and aeration

Hydraulic Components: Conductors, Conditioners, and Fluids

Objectives:

- Identify the parts most reservoirs have in common and explain the function of each part
- List the various types of reservoirs, heat exchangers, and accumulators and explain the applications for each type
- Explain how heat exchangers work
- Identify the parts that most heat exchangers have in common and explain the function of each part
- Understand the operating principles of accumulators and identify the parts that most types of accumulators have in common
- Differentiate between different types of conductors and select the right conductor for the proper application
- Outline the proper procedure for maintaining fittings and seals

Hydraulic Power System Control

Objectives:

- Explain the need for control components in a typical hydraulic system
- Identify each of the three families of control devices: pressure, flow and directional control valves
- Understand each of the three control families' methods of control and practical applications
- Explain the operating principles and identify the features of various types of pressure control valves
- Explain the operating principles and identify the features of various types of flow control valves
- Explain the operating principles and identify the features of various types of directional control valves • Interpret simple schematic symbols representing valve configurations

Hydraulic System Schematics

Objectives:

- Name the important parts of a hydraulic circuit
- Describe the different types of symbols that are used in fluid power diagrams
- Identify various graphical symbols that are used on schematic diagrams
- Explain the operation of valves and switches in a hydraulic system
- Explain how Boolean algebra is used to diagram fluid power control systems

Hydraulic Power System Troubleshooting

Objectives:

- Understand and explain the function of the hydraulic components that make up a complete system
- Calculate the required size of components such as cylinders and motors
- List the procedures needed to maintain hydraulic systems
- Recognize the electrical devices that interface with hydraulic components
- Analyze and troubleshoot hydraulic-system failures

Predictive Maintenance

Objectives:

- Define what PDM is and how it can be used in industry
- Identify the various types of technologies used in PDM
- Explain what goals should be considered for a new and a maturing PDM program
- Discuss the scope of basic mechanical PDM
- Explain how a time waveform and a frequency spectrum can be used to identify machine faults

Predictive Maintenance: Vibration Analysis

Objectives:

- Explain how vibration measurements are taken and the systems used to identify measurement points
- Identify balance, looseness, and misalignment problems
- Discuss the techniques used to diagnose rolling-element bearing faults
- Explain how journal bearing condition monitoring and fault analysis is performed
- Identify speed reducer faults that occur in the gear sets or the internal bearings
- Describe how resonance can affect the operation of equipment

Predictive Maintenance— Advanced Topics

Objectives:

- Explain the steps involved in performing balance and alignment on industrial machines
- Discuss the use and operation of ultrasonic equipment to find problems such as electrical arcing, bearing faults, and internal and external air leaks in pneumatic systems
- Describe the procedures used in electrical signature analysis (ESA) and how this inspection system can find motor problems
- Explain how oil analysis can detect lubricant problems and contamination
- Describe how thermography is used in a PDM program

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

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-Optic 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

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

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

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
- Identify automatic and manual signaling devices
- Explain the operation of capacitive and inductive switches
- Determine the type of enclosure appropriate for a given environment

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
- Explain how a PLC can be used with a D/A module to provide infinite motor speed control and how to troubleshoot these systems
- Describe PLC system troubleshooting and how to use a PLC to find intermittent system problems

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

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 t:o 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

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 Karnaug h 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 Circuits

Objectives:

- Identify expected logic levels by measuring d-e (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 011 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 m 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 11 Explain the kinds of buses used for industrial digital systems
- List uses logic gates in systems that perform industrial tasks 11 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

Introduction to Computers

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 O 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

Microprocessor 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, How it Does What it Does

Objectives:

- Power up your XK-300 Microprocessor Training Laboratory
- 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 Vee and Vss connections, and check out other chip connections
- Send instructions 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 JCS XK-300 Microprocessor Trainer
- List the nine varieties of instructions for the MC6802
- Run a program that 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, How to Make it Do the Work You Want Done

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, Concepts for Writing Your Own Programs

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 given MPU undertaking
- Streamline a program, both to save memory space and to make it run more efficiently
- Utilize mnemonics (say nee-MON-iks) 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 magnetic tape, using a cassette interface
- Discuss the basics of a disk controller
- Manage the protocol between MPU and line printer
- Tel l 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, 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 placed in the software
- Eliminate software bugs that cause unwanted loops or break up proper loops
- Describe what assemblers, compilers, 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