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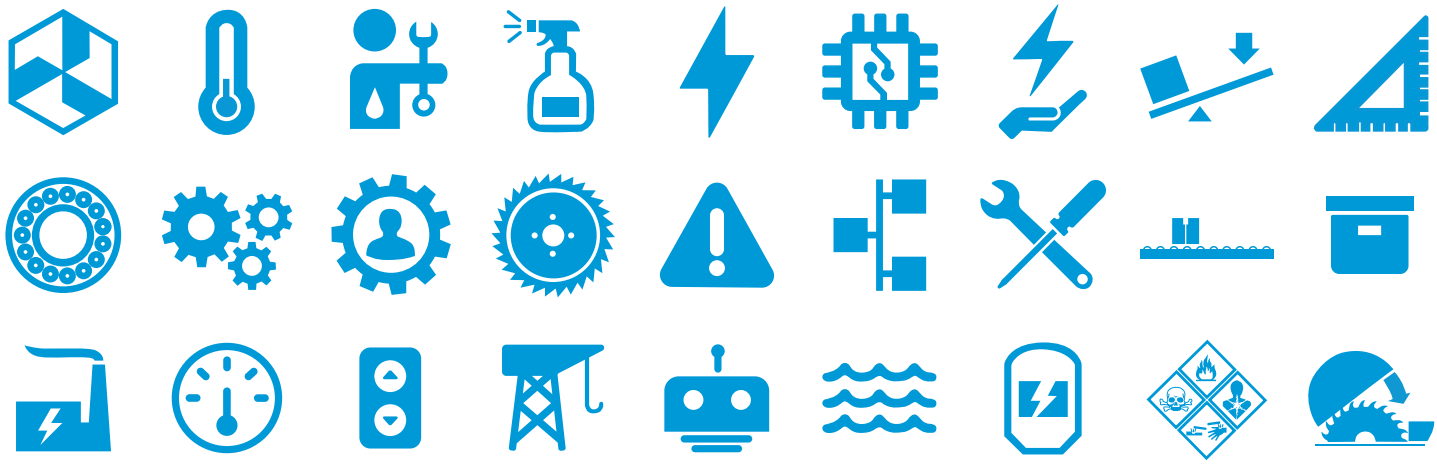
Mechatronics Custom Books

SCP 207	Electromechanics and Pneumatics
SCP 226	Industrial Maintenance
SCP 237	Fundamentals of Industrial Machinery
SCP 245	Tools and Instruments for Technicians
SCP 250	Introduction to Power Technology
SCP 254	Mechanical and Electrical Readings
SCP 275	Electromechanical Devices
SCP 478	Introduction to Automation
SCP 490	Introduction to Mechatronics
SCP 498	Automated Production Concepts I
SCP 499	Automated Production Concepts II



Electromechanics and Pneumatics

Course #SCP 207

Chapter 1: DC Motors

Topics

Principles of DC Motors; Counter-Electromotive Force (CEMF); Armature Reaction; Self-Induction and Commutation; Interpoles; Torque in DC Motors; Factors Determining Torque; Work and Power; Speed Regulation; Kinds of DC Motors; Shunt Motors; Torque Variation in a Shunt Motor; Effects of an Open-Shunt Field; Series Motor; Compound Motors; Cumulative Compound Motors; Differential Compound Motors

Objectives

- Explain what happens during self-induction and commutation.
- Define CEMF.
- State the difference between speed regulation and speed control.
- Name the kinds of dc motors.
- Explain the different operating characteristics of series, shunt, and compound motors.

Chapter 2: DC Electromagnets

Topics

Magnets and Magnetic Materials; Magnetic Forces; Magnetic Fields; Effect of Distance on Magnetic Field Strength; Magnetic Shielding; Solenoids; U-Shaped Magnets; Reducing the Effects of Residual Magnetism; Uses for Solenoids; Choosing the Right Solenoid; Causes of Solenoid Problems; Relays; Polarized Relays; Protecting Relay Contacts

Objectives

- State the definition of residual magnetism.
- Explain the effects of distance on magnetic field strength.
- Discuss the characteristics and uses of solenoids.
- Discuss the characteristics of relays.

Chapter 3: DC Relays

Topics

Relay Operating Characteristics; Overload Relays; DC Motor Acceleration; Shunt Relays; Series Lockout Relays; Double-Coil Series Lockout Relays; Two-Coil Lockout Relays; Inductive Time-Delay Relays; Magnetic Blowout Coils; Dynamic Braking; Electrically Operated Brakes

Objectives

- Name three factors that determine the performance and reliability of a relay.
- Name the six types of commonly used relays.
- Explain the operation of each type of relay.
- Explain dynamic braking.
- Describe how a disc brake is attached to a motor.

Chapter 4: DC Controllers

Topics

Factors Affecting Motor Speed; Classification by Performance; Low-Voltage Protection; Overvoltage Protection; Low-Voltage Release; Overload Protection; Temperature Compensation; Controller Overload Reset; Manual Starters; Magnetic Controllers; Drum Controller

Objectives

- List the kinds of functions performed by motor-control devices.
- Name the types of motor controllers and discuss their operating characteristics.
- Explain how each of the three kinds of thermal overload relays works.
- Name the kinds of resets for overload relays.

Chapter 5: DC Power Supplies

Topics

Electron Emission; Electron Tubes; Vacuum-Tube Diode; Vacuum-Tube Diode Rectifiers; Semiconductors; Why Semiconductors Fail; Comparing Generators to Rectifiers; Automotive AC-DC Power Supply; Checking Diodes; Identifying Replacement Semiconductors

Objectives

- Discuss the operating principles of vacuum tubes and rectifiers
- Name the four types of filters commonly used in rectifier circuits.
- Identify a mercury-vapor diode.
- List common causes of semiconductor failure.
- State the criteria for selecting replacement semiconductors.

Chapter 6: Silicon Controlled Rectifiers

Topics

Principles of SCRs; Pulse Timing in DC Circuits; Trigger Pulses; SCR Control of Motors; DC Applications of SCRs; AC-DC Conversion; AC Applications of SCRs

Objectives

- State the definition of a silicon controlled rectifier.
- Explain how an SCR works.
- Explain how to increase the effective current and the power delivered to a motor by an SCR motor control.
- List four dc applications of SCRs.

Chapter 7: Motor Starters

Topics

Selecting Motor Controls; Motor Controllers; Controller Enclosures; Starters; Manual Motor-Starting Switches; Magnetic Controls; Armature Assemblies; Magnetic Circuits; Shading Coil; Magnet Coils; Effects of Voltage Variation; NEMA Sizes for Magnetic Starters; AC Hum; Magnetic Starter Control Circuits; Auxiliary Contacts; Reversing Starters; Combination Starters

Objectives

- Describe the difference between a manual starter and a magnetic starter.
- Explain the function of a shading coil in a magnetic starter.
- Explain the effects of low voltage on a controller.
- State the reason why holding-circuit interlocks are required on magnetic starters and contactors.
- Demonstrate how to reverse the shaft rotation of a three-phase motor.

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Chapter 8: Switches and Controls
Topics

Industrial Pushbuttons; Standard-Duty Pushbuttons; Selector Switches; Wall Boxes; Single-Contact Ratings; Heavy-Duty Pushbuttons; Contact Ratings; Pushbutton-Station Descriptions; Oiltight Pushbuttons; Pushbutton Operators; Selector-Switch Operators; Key-Operated Selector Switches; Illuminated Pushbuttons; Contact Blocks; Indicating Lights; Circuit Diagrams; Joy-Stick Operators; Assembled Pushbutton Stations; Legend Plates

Objectives

- Discuss the characteristics of industrial switches and controls.
- Identify the five most commonly used NEMA pushbutton stations.
- Demonstrate how to mount an oil-tight control station both vertically and horizontally.
- Explain the difference between standard and press-to-test indicating lights.
- Explain how a three-wire control circuit works.

Chapter 9: Limit Switches
Topics

Precision Snapswitches; Precision-Snapswitch Elements; Precision-Snapswitch Applications; Precision-Snapswitch Selection; Snapswitch Contact Arrangements; Snapswitch Operating Characteristics; Limit-Switch Contact Arrangement; Actuators for Limit Switches; Limit-Switch Enclosures; Mounting Limit Switches; Cam Design; Mercury Tilt Switches; Replacement of Mercury Switches; Failure of Mercury Switches

Objectives

- List the main parts of a precision snap-action limit switch.
- Describe the contact arrangement of a snapswitch.
- Describe the kinds of actuators used in limit switches.
- List the rules for the proper design and application of limit switch cams.
- Explain how a mercury switch works.

Chapter 10: Special Control Switches
Topics

Reversing Drum Switches; Foot Switches; Transfer Switches; Plugging Switches; Mechanical and Magnetic Plugging Switches; Selecting a Plugging Switch; Mechanical Pressure Switches; Bellows Pressure Switches; Diaphragm Pressure Switches; Piston Pressure Switches; Characteristics of Pressure Switches; Mechanical Temperature Switches; Float Switches

Objectives

- Explain how a drum switch works.
- Select the best switch for stopping a motor quickly.
- List the criteria for selecting a plugging switch.
- Identify different types of pressure switches.
- State the definition of pressure differential.

Chapter 11: Control Relays
Topics

Types of Relays; Operation of Relay Contacts; Relay Mountings and Enclosures; Relay Terminals; Relay Definitions; Time-Delay Relays; Voltage-Sensing Relays; Frequency-Sensing Relays; Phase-Sequence-Sensing Relays; Reed Relays; Kinds of Reed Relays; Operation of Reed Relays; NEMA Classes for Industrial Relays; Industrial Relay Construction; Causes of Relay Failures

Objectives

- State the definition of a relay.
- Explain the function of relay contacts.
- Select the best relay for use where large movement of the contacts or high contact force is required.
- List the advantages of a reed relay.
- Tell why industrial relays usually have double-break contacts.

Chapter 12: Equipment for Hazardous Locations
Topics

Enclosures for Hazardous Locations; Sources of Ignition; Combustion Principles; Evaluation of Hazardous Areas; Enclosures for Class I, Divisions 1 and 2; Switchgear and Industrial Controls; Lighting Fixtures; Motors and Generators; Plugs and Receptacles; Portable Equipment; Conduit for Class I Locations; Seals for Conduit Systems; Mineral-Insulated Cable; Armored Cable

Objectives

- List the requirements an enclosure must meet in order to be called explosion proof.
- List the characteristics of switchgear and industrial controls in hazardous conditions.
- List three situations in hazardous locations that require the use of seals.
- List the three basic conditions that can cause fire or explosion.
- Demonstrate how to terminate armored cable that enters an explosion proof housing.

Chapter 13: Principles of Pneumatics
Topics

Fluid Power Systems; Pneumatic Systems; Force, Weight, and Mass; Pressure; Work and Energy; Diffusion and Dispersion; Separation of Gases and Liquids; Compressibility; Laws of Pneumatics; Transmission of Pneumatic Fluid Power; Pneumatic Leverage; Air Properties; Air Flow in Pipes; Viscosity of Air; Bernoulli's Law; Components of Pneumatic Power Systems

Objectives

- Explain how force is transmitted in a pneumatic system.
- Calculate force and work.
- List two factors that affect the results of pressure calculations.
- Explain pneumatic leverage.
- Briefly explain the physical laws affecting the behavior of a confined gas.

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Chapter 14: Primary Air Treatment
Topics

Air Treatment; Preliminary Filtering; Relative Humidity; Effects of Moisture; Water Removal; Dew Point; Moisture Separators; Oil Scrubbers; Air Dryers; Air Receivers

Objectives

- Describe techniques for cleaning compressor filters.
- Define relative humidity and dew point.
- Explain the effects of temperature and pressure on the air's ability to hold moisture.
- Describe aftercooler operation.
- Explain the functions of separators, oil scrubbers, and air dryers.

Chapter 15: Secondary Air Treatment
Topics

Methods of Treatment; Contaminant Separation; Contaminant Filtration; Filter Classification and Rating; Types of Media; Surface Filters; Depth Filters; Adsorption Filters; Absorption Filters; Lubricating the Air

Objectives

- Describe the two main methods of contaminant separation.
- Explain how filters are classified.
- List contaminant particle sizes and particle contamination categories as they occur in filters.
- List applications for the most common types of filter media.
- Identify system location for lubrication equipment installation.

Chapter 16: Piping, Hoses, and Tubing
Topics

Piping Requirements; Airflow; Piping; Pipe Applications; Metallic Tubing; Tube Bending; Tube Fittings; Tubing Installation; Nonmetallic Tubing; Hoses; Hose Fittings; Quick-Disconnect Couplings; Hose Installation

Objectives

- State the importance of laminar flow.
- List the factors that affect pressure loss in a pipe.
- State direction and amount of slope for compressor discharge pipes.
- Discuss procedures for pipe, tube, and hose installation.
- Describe safe working procedures for disconnecting air hoses.

Chapter 17: Directional Control Valves
Topics

Control Valves; Manually Operated Valves; Automatically Operated Valves; Control Valve Elements; Two-Way Valves; Three-Way Valves; Four-Way Valves; Five-Way Valves; Valve Accessories

Objectives

- Describe the four methods of identifying control valves.
- List four basic types of manually operated, two-way valves.
- Describe the operation of a two-position, direct acting, normally closed solenoid valve.
- Explain one major advantage of using a four-way valve.
- Describe the construction of a three-way valve.

Chapter 18: Pressure-Control Valves
Topics

Controlling Pressure; Venting Excess Pressure; Relief Valve Construction; Pressure Regulators; Regulator Modifications; Logic Functions

Objectives

- List two ways a valve can control compressor pressure output.
- Describe construction of two basic types of pressure-relief valves.
- Contrast a pressure regulator with a pressure-relief valve.
- State the limit imposed by Federal Law on the pressure allowed when an air hose is used to blow off chips.

Chapter 19: Pneumatic Cylinders
Topics

Pneumatic Cylinders; Double-Acting Cylinders; Single-Acting Cylinders; Two-Piston Cylinders; Cylinder Construction; Rod Packings; Cylinder Mounting; Selecting a Cylinder; Cushioning

Objectives

- Tell the difference between pneumatic and hydraulic cylinders.
- Describe the construction and operation of a single-acting cylinder.
- State the purpose of an exhaust flow control metering valve.
- Describe the action of a pivoted cylinder.
- Explain the size relationship between a cylinder port and a valve port.

Chapter 20: Pneumatic Motors
Topics

Pneumatic Motors; Motor Classification; Rating and Selection Factors; Pneumatic Motor Construction; Rotary Vane Motors; Piston Motors; Rotary Actuators; Portable Air Tools; Air Boosters

Objectives

- Explain pneumatic motor classification.
- Define torque.
- Describe pneumatic motor construction.
- Calculate a motor's horsepower, given its torque and speed.
- Differentiate between a pneumatic motor and a rotary actuator.

Chapter 21: Pneumatic Diagrams
Topics

Types of Symbols; How Schematic Symbols are Constructed; Diagraming an Air-Supply System; A Simple System; Timing Circuits; Safety Circuits; Symbols for Special Devices; System Schematics

Objectives

- Explain the different types of symbols used in pneumatic schematic diagrams—how they are constructed and what they show.
- Describe the operation of timing and safety circuits.
- Analyze the schematic diagram of a fluid-power system.

Chapter 22: Installing Pneumatic Components
Topics

The Compressor and Auxiliaries; Compressor Intakes; Compressor Foundations; Aftercoolers; Receivers; Dryers; Pipe Installation; Pipe Support; Pipe Threads; Tubing; Tubing Fittings; Hose Installation; Control Systems; Control-Valve Installation; Solenoid Coils; Cylinder Installation

Objectives

- Describe the proper installation of the compressor and its auxiliaries.
- Describe the installation of aftercoolers, receivers, and dryers.
- Explain the correct procedures for installing pipes, tubes, and hoses in pneumatic systems.
- Describe the installation of control valves, solenoid coils, and cylinders.

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Chapter 23: System Troubleshooting
Topics

Understanding the System; Troubleshooting Procedures; Locating Troubles; The Operations Manual; Checking the Air Supply; Troubleshooting the Actuator; Checking the Control Valve; Checking a Control-Valve Actuator; Checking Sequence Valves; Checking Master Control Valves; Checking Interlocks; Making Final Adjustments; System Operation

Objectives

- List, in proper sequence, the steps to be taken in troubleshooting a pneumatic system.
- Name and describe the five important parts of every pneumatic system's operations manual.
- Describe procedures for troubleshooting the actuator.
- Explain how to check control valves, sequence valves, and interlocks.

Chapter 24: Valve Troubleshooting
Topics

Troubleshooting Controls; Troubleshooting a Circuit That Will Not Start; Checking Manual Overrides; Checking the Circuit Sequence; Checking for Locked Controls; Checking for Mechanical Interference; Electrical Solenoids; Checking an AC Solenoid; Checking a DC Solenoid; Troubleshooting Improper Sequence Operation; Improper Valve Shifting; Valves Shifting Without a Shift Signal; Changes in Control Timing; Miscellaneous Control-Element Problems; Lubrication Problems

Objectives

- Outline how to isolate a control malfunction in a pneumatic circuit.
- Explain how to troubleshoot a nonstarting or nonoperating circuit, improper sequencing of the circuit, and miscellaneous problems related to the equipment.
- Describe the proper procedures for checking electric solenoids.
- Explain how to check for problems related to valve shifting, control timing, and lubrication.

Chapter 25: Cylinder Troubleshooting
Topics

Cylinder Definitions; Cylinder Construction; Troubleshooting and Repair; Correct Cylinder Size; Adequate Air Pressure; Checking for Misalignment; Worn Packings; General Installation Techniques; Speed Controls

Objectives

- Define the different types of pneumatic cylinders.
- Describe the construction of a typical cylinder.
- Describe the proper procedures for troubleshooting cylinders, including checking for misalignment, worn packings, and adequate air pressure.
- Explain general installation techniques for cylinders and accessories.

Industrial Maintenance

Course #SCP 226

Chapter 1: Basic Blueprint Reading

Topics

Importance of Blueprints; Purpose of Blueprints; Types of Information on Blueprints; Supplementary Spaces; Detail Drawings; Interpreting a Detail Drawing; Assembly Drawings; Orthographic Projections; Auxiliary Views; Sections; Pictorial Drawings

Objectives

- Identify details, markings, and machine parts from an assembly drawing.
- Identify an object from an orthographic drawing.
- Identify elements located within the title block of a detail drawing.
- Explain why more than one orthographic projection is needed to show an object on a blueprint.

Chapter 2: Measurements and Tools

Topics

Definition of Measurement; Measurement Terminology; Function of Measurement Tools and Instruments; Classification of Measurement Instruments; Typical Portable Instrument Design; Measurements in Maintenance; Routine Maintenance and Repair; Process Monitoring and Quality Assurance; Predictive Maintenance; Screwdrivers; Wrenches; Hammers and Mallets; Chisels and Punches; Saws; Files and Rasps; Snips, Nippers, and Cutters; Pliers; Organizing Your Tools; Hazards of Power Tool Use; Rules to Observe Before Using Power Tools; Protection Against Electric Shock; Electric Drills; Electric Sanders; Portable Grinders; Portable Circular Saws; Saber Saws; Metal Shears; Electric Impact Wrenches; Rotary Hammers; Pneumatic Power Tool Safety; Pneumatic Impact Wrenches; Pneumatic Hammers; General Guidelines for Power Tools

Objectives

- Define measurement, parameter, accuracy, precision, sensitivity, and range.
- Explain why measurements are important to maintenance operations.
- Describe the general features of a portable measurement instrument.
- List the basic measurement instruments most often used in mechanical maintenance, and describe the operating principles of each.
- Name the major hand tools used in maintenance.
- State criteria for selecting the proper tools for specific jobs.
- Identify safe/unsafe practices in the use of hand tools and explain why they are safe/unsafe.
- Explain how to prolong the useful life of selected hand tools.
- Explain the advantages of having a well-organized tool box.
- State three precautions to take before using any power tool.
- Describe the safe use of each of the following power tools: electric drills, sanders, grinders, and saws; electric impact tools; pneumatic impact wrenches and hammers.
- State three general guidelines for the safe operation of any portable power tool.
- Describe the potential electrical hazards associated with electric power tools.

Chapter 3: Carpentry Products

Topics

Hardwood vs. Softwood; Lumber Sizes; Lumber Grading; Lumber Defects; Moisture Content; Milling Methods; Millwork; Plywood; Plywood Grading; Working with Plywood; Hardboard; Particleboard; Proper Storage of Lumber; Standard Nails; Special Nails; Wood Screws

Objectives

- Describe the difference between the actual and nominal dimensions of lumber.
- Tell how defects such as checks, knots, and warping limit the value and use of lumber.
- Explain how kiln drying of lumber produces different results from air drying.
- Point out the differences between solid core and veneer core plywood.
- Describe the construction and uses of particleboard.
- Compare common nails, casing nails, and finishing nails.
- List the information you must give your supplier when ordering wood screws.

Chapter 4: Power Transmission Efficiency

Topics

Belt Drives; Chain Drives; Gear Drives; Bearings; Clutches and Brakes; Drive Couplings; Vibration; Balancing Machinery; Vibration Isolation; Vibration Switches

Objectives

- Explain why proper bearing lubrication is important.
- Name the drive component responsible for the most power loss.
- List three functions of couplings.
- Show how to check coupling alignment.
- Define vibration and explain why vibration control is important.
- Compare and contrast static unbalance and dynamic unbalance.

Chapter 5: Plumbing Maintenance

Topics

Care of Hand Tools; Maintaining Plumbing Fixtures; Maintaining Water Heaters; Maintaining Waste Systems; Opening Clogs; Other Types of Clogs; Maintaining Valves; Preventive Maintenance of Valves; Maintaining Plumbing Insulation; Maintaining Pumps; Repairing Leaks

Objectives

- Name the chief points involved in the care and correct use of hand tools.
- Describe how to open the clogs and repair leaks in plumbing fixtures.
- Compare maintenance procedures for different types of valves.
- Tell how to clear stoppages and repair leaks in the drainage system.
- Explain the maintenance of water heaters, pumps, and pipe installation.

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Chapter 6: Electrical Troubleshooting
Topics

Power Generation and Distribution; Feeders, Subfeeders, and Branch Circuits; Fuses and Circuit Breakers; Current Capacity of a Wire; Understanding Basic Principles; Diagnosing Trouble; Testing for Continuity; Electrical Safety; Communication and Diagrams; Using Building Lighting Diagrams; Troubleshooting with Electrical Diagrams; Electrical Instruments

Objectives

- State the definition of switchgear.
- Identify current voltage characteristics of wire.
- List the safety rules to follow when working with electrical equipment.
- Identify a pictorial diagram, a block diagram, and a schematic diagram.
- Explain how to troubleshoot an electric problem.

Chapter 7: Standard Steels
Topics

Carbon in Steels; Steel Rolling; Steel Classification; Spark Testing; Forms of Steel Stock; Hot-Rolled Plate and Sheet; Cold-Rolled Sheet; Steel Strip; Steel Plate; Steel Bars; Structural Steel; Alloy Steels; Stainless Steels

Objectives

- State the definition of steel.
- Name the method by which a steel was made, based on its AISI code.
- Demonstrate how to conduct a spark test.
- Identify steel sheets having as-rolled edges and cut edges.
- Describe two differences between alloy steels and steels containing only iron and carbon.

Chapter 8: Fasteners
Topics

Kinds of Threaded Fasteners; Screw Threads; Screw Thread Specifications; Threaded Fastener Specifications; Types of Nuts; Washers; Safety Wiring; Keys and Pins; Rivets

Objectives

- Identify seven major types of threaded fasteners.
- Read and interpret common screw thread and threaded fastener specifications.
- Describe the three actions in a manual riveting operation, and explain why each action must be done properly.
- Demonstrate the proper technique for safety wiring a group of threaded fasteners.
- Identify three kinds of washers.

Chapter 9: Bearing Maintenance
Topics

Bearing Maintenance; Installing Plain Journal Bearings; Installing Antifriction Bearings; Mounting a Bearing; Bearing Removal; Bearing Loading Patterns; Bearing Failure Terminology; Bearing Cleaning

Objectives

- Identify a principal cause of early bearing failure.
- Describe installation procedures for antifriction and plain journal bearings.
- Name the different types of bearing failure and their causes.
- Tell how bearings should be cleaned and lubricated after inspection

Chapter 10: Bearings, Shaft Seals, Packing and Seals
Topics

Linear Motion Bearings; Ball Bearing Screw Operation; Ball Bearing Screw Design and Performance; Ball Bearing Screw Support; Preparing for installation; Installing the Ball Bearing Screw; Ball Bearing Screw Lubrication; Shaft Seals; Shaft Seal Operation; Shaft Seal Selection; Effects of Temperature; Effects of Speed; Shaft and Housing Design; Shaft Seal Installation; Shaft Seal Removal; Troubleshooting Shaft Seals; Uses of Packing and Seals; Two Types of Seals; Packing; Selecting Packing Material; Removing Old Packing; Installing New Packing; Packing Precautions; Mechanical Seals; Mechanical Seals Versus Packing; Types of Mechanical Seals; Installing Mechanical Seals; Maintaining Packing and Seals; Troubleshooting Packing and Seals

Objectives

- Name the major components of a ball bearing screw.
- Describe the major differences between a ball bearing screw and an acme screw.
- Describe the main purpose of a ball bearing screw and give an example of a typical application.
- Describe the installation procedures for a ball bearing screw.
- Name the differences between contact and labyrinth seals and explain what creates the sealing action in each.
- List the factors that determine the choice of shaft seal.
- Describe how to install a lip seal on a shaft, including shaft preparation.
- Name the major problem that arises with lip seals and list at least four conditions that can cause it..
- Identify the two major functions of packing and seals.
- Explain selection and installation of packing rings on a pump shaft.
- Identify the components of typical mechanical seals.
- Name at least three advantages of mechanical seals over packing.
- Describe how to install a mechanical seal on a pump shaft.
- Discuss the care and maintenance of packing and seals.

Chapter 11: Rigging Techniques
Topics

Tools of Industrial Rigging; the Rigging System; Determining the Weight of a Load; Calculating an Allowable Load; Determining Center of Gravity; Vertical and Horizontal Force; Types of Slings; Hooks; Hoist Hooks; Special-Purpose Rigging Hooks; Hook Operating Practices

Objectives

- Identify the tools used in rigging and explain the purpose of each.
- Give examples of three methods of calculating the weight of a load.
- Explain center of gravity and its importance in rigging a load.
- Describe four common sling arrangements and the relation between sling angle and horizontal force.
- Name five types of hooks frequently used in rigging and explain the purpose of each.
- Discuss proper hook use and cite four reasons for removing a hook from service.

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Chapter 12: Pump and Motor Troubleshooting
Topics

Pumps and Motors; Troubleshooting; Gear Pump Problems; Vane Pump Problems; Vane Motors; Axial-Piston Pump Problems; Radial-Piston Pump Problems; Pump and Motor Repair; Pump Maintenance Checks; Troubleshooting Chart (Pumps); Troubleshooting Chart (Motors)

Objectives

- List the proper procedures for troubleshooting pumps and motors.
- Name some common causes of pump failure.
- Describe typical causes of cavitation.
- Discuss the major sources of problems in gear pumps and vane pumps.
- Describe the effects of contaminants in axial-piston and radial-piston pumps.
- Explain the differences between a vane motor and a vane pump.

Chapter 13: Air Compressor Troubleshooting
Topics

Cooling Reciprocating Compressors; Compressor Lubrication; Compressor Valves; Crankcase Ventilation; Piston Rings and Bearings; Control Systems; Rotary Compressors; Vane Compressors; Rotary-Screw Compressors; Centrifugal Compressors

Objectives

- Describe methods of cooling and lubricating reciprocating compressors.
- Explain the proper maintenance of compressor valves.
- Identify problems associated with the control system of a compressor.
- Describe the basic maintenance requirements of rotary, vane, rotary-screw, and centrifugal compressors.

Chapter 14: Hydraulic/Pneumatic Troubleshooting
Topics

Air-Oil Tanks; Air-Hydraulic Boosters; Pressure Boosters; Single-Pressure Booster Systems; Dual-Pressure Booster Systems; Hydraulic-Control Cylinders; Fast-Advance Cylinders; Combined Air-Oil cylinders; Pneumatic Cushioning; Air-Hydraulic System Interlock; Pneumatic Servos; Troubleshooting Air-Oil Systems

Objectives

- Explain why and how compressed air and hydraulic pressure are combined.
- Describe the role of boosters in pneumatic/hydraulic systems.
- Explain how single-pressure and dual-pressure booster systems work.
- Describe the advantages and disadvantages of combined air-oil cylinders.
- Explain how pneumatic and hydraulic actions can be interlocked.
- Discuss the proper troubleshooting procedures for air-oil systems.

Chapter 15: Installing Machinery and Equipment
Topics

The Engineer Plans the Installation; The Maintenance Supervisor's Responsibilities; Relocating Underground Piping; Relocating Underground Wiring and Cables; Protecting Nearby Buildings and Equipment; Barricading the Work Area; Removing Excavated Material; Foundation and Footings; Reinforced Concrete; Materials for Reinforcing Concrete; Using Wooden Forms; The Right Concrete Mixture; Materials for Fill around Foundation; Positioning Anchor Bolts with a Template; Installing Alignment Plates; Surface Finish of Concrete; Setting or Curing Time for Concrete; Finishing Flooring around Foundation; Outdoor Foundations; Safety Precautions for Excavation Work; Uncrating New Equipment; Relocating Existing Equipment; Know the Weight of the Load; Machinery for Lifting Equipment; Raising Equipment with Jacks; Lifting Plant Equipment with Slings; Hand Tools for Moving Equipment; Crowbars; Preparing to Move the Equipment; Making the Move; Setting the Equipment in Position; Personal Safety during Installation; Electric Power Connections; Hydraulic and Pneumatic Power Connections; Coolant Systems for Equipment; Equipment Safety Devices; Settings and Adjustments; Equipment Operating Pressure; Limit Switches and Stops; Checking the Equipment Setup; Initial Running under Power; Test Run Guidelines; Making the Test Run; Safety Precautions for Installing Equipment

Objectives

- Tell who plans the installation of new equipment and list the steps involved.
- Define the terms foundation and footing.
- Tell which type of ground will support the most weight.
- Explain how steel rods are held in position when pouring a concrete footing.
- Name the best materials for filling around a foundation.
- Explain how to protect concrete that might come into contact with oil or chemicals.
- Tell how long new concrete must sit before equipment is installed on it.
- Explain the procedures involved in relocating existing equipment.
- Tell two things you must know before lifting equipment with a hoist.
- List three things to consider when selecting a jack.
- Explain the operation and uses of a roller skid.
- Tell where to find a floor's allowable load.
- Explain how to test for the presence of moisture in electrical equipment.
- Tell what device is commonly used to prevent excessive pressure in a hot water heater.
- Explain the function of a pressure regulating valve.
- List the steps to take before initial equipment startup.
- Tell the usual cause of excessive temperature during equipment startup.

Fundamentals of Industrial Machinery

Course #SCP 237

Chapter 1: Electrical Safety

Topics

The Electric Circuit; Injuries from Electricity; First Aid for Shock Victims; National Electrical Code; Static Electricity

Objectives

- Define the following terms: electric current, circuit, potential difference, ampere, watt, ohm, and volt.
- State Ohm's Law.
- Explain the function of each wire in a simple electric circuit and tell the color(s) used to identify each.
- List the three factors that affect the severity of an electric shock.
- Describe the effects of electric current on the human body.
- Tell the three most important points about first aid for shock victims.
- Explain how static electricity is generated, why its accumulation can be dangerous, and how it can be avoided.

Chapter 2: Multimeters

Topics

The Multimeter; Guidelines for Using a Multimeter; An All-Purpose Graphical DMM; More Advanced Meter Functions; Multimeter Accessories; Multimeter Safety

Objectives

- Demonstrate how to measure ac and dc current and voltage with a multimeter.
- Describe the function of a current probe.
- Explain how to isolate the source of a glitch with a graphical multimeter.
- Demonstrate how to read the screen display of a graphical multimeter in the Trend mode.
- Explain why you set a meter to its highest range before taking your first measurement.
- Define autoranging and auto-polarity.
- List three safety precautions to take when using multimeters.

Chapter 3: Electrician's Tools

Topics

The Electrician; EMT Bender; Correcting Knocked Over Stubs; Bending Rigid Conduit; Assembling Rigid Conduit; Knockout Punches; Fish Tapes; Pliers; Wire and Cable Strippers; Electrician's Screwdrivers; Test and Safety Equipment

Objectives

- Explain how to use an EMT bender and a neon circuit tester.
- List the parts of a knockout punch.
- Name the uses of the all-purpose tool.

Chapter 4: Introduction to Process Control

Topics

Process Variables; On-Off Process Control; Functions of Automatic Process Control; Typical Process Control Applications; Measuring Data in Control Systems; Controlling Variables Automatically; Error, Signal Evaluation, and Feedback; Open- and Closed-Loop Control Systems

Objectives

- Define setpoint, control point, and error.
- Explain how measurement and control are related in industrial processes.
- Describe the four essential functions of an automatic control system.
- Discuss the functions of PLCs and industrial computers in control systems.
- Identify variables in industrial processes.
- Explain the importance of feedback in a closed-loop control system.

Chapter 5: Control Loops

Topics

Control Loops; Control Loop Definitions; Process Sensors; Sensor Characteristics; Controllers; Recorders; Signal Conditioners; Final Control Elements; Control Loop Applications

Objectives

- Explain the difference between an open loop and a closed loop.
- Define error, feedback, disturbance, and feedforward control.
- List several kinds of process sensors and describe the operation of each.
- Explain how accuracy, resolution, sensitivity, linearity, and step response affect sensor operation.
- Describe the functions of process controllers, recorders, signal conditioners, and final control elements.
- Explain the basic operation of a typical control loop.

Chapter 6: Introduction to Programmable Logic Controllers

Topics

The Electromagnetic Relay; Characteristics of Programmable Controllers; Applications of Programmable Controllers; Limitations of Programmable Controllers; Parts of a Programmable Logic Controller System; The Input Side; The Processor; The Output Side; Programming Devices; Power Supplies

Objectives

- Describe an electromagnetic relay and define the terms control circuit, power circuit, NO and NC.
- Define programmable logic controller.
- Describe the general type of application in which a programmable logic controller would best be used, and give examples.
- Define scan time.
- Name each of the blocks in a block diagram of a programmable logic controller system and explain how each functions within the system as a whole.
- Define memory and explain the different type.

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Chapter 7: Machine Elements
Topics

The Machine; Machine Motions; Mechanisms; Lever Linkages; Four-Bar Linkages; Cam-and-Follower Mechanisms; Devices For Producing Linear Motion; Ratchet-and-Pawl Mechanisms; Fluid-Powered Mechanisms; Applying Your Knowledge of Mechanisms

Objectives

- List the four classifications of mechanisms.
- Name the six basic motion conversions, and give an example of each.
- Explain the functions of bell cranks, Pitman arms, and toggle bars.
- Name three types of four-bar linkages, and explain how they function.
- Describe the ratchet-and-pawl mechanism.

Chapter 8: Pneumatic Diagrams
Topics

Types of Symbols; How Schematic Symbols are Constructed; Diagraming an Air-Supply System; A Simple System; Timing Circuits; Safety Circuits; Symbols for Special Devices; System Schematics

Objectives

- Explain the different types of symbols used in pneumatic schematic diagrams—how they are constructed and what they show.
- Describe the operation of timing and safety circuits.
- Analyze the schematic diagram of a fluid-power system.

Chapter 9: Hydraulic Diagrams
Topics

Types of Hydraulic Diagrams; What is a Schematic?; Characteristics of Schematics; Lines; Symbols; What Kind of Schematic?; Guidelines for Reading Schematics; Look for Flow Patterns; Look for Guides; Read Diagrams Carefully; Read Symbols Carefully; Use the Step-by-Step Approach; Basic Elements of a Hydraulic System; Pumps; Actuators; Control Valves; Conductors and Connectors; Fluid Storage and Conditioning Equipment; A Hydraulic Circuit; Sequence-Valve Circuit

Objectives

- Name three basic types of hydraulic diagrams, and explain the purposes of each.
- Describe how a valve symbol is constructed.
- List the steps to follow when reading a schematic diagram.
- Identify common hydraulic symbols.

Chapter 10: Bearings and Shafts
Topics

Bearing Classification; Bearing Selection; Principles of Bearing Operation; Shafts and Shafting; Shaft Materials; Shaft Stresses; Vibration and Critical Speed; Fits and Clearances

Objectives

- Name the two main categories of bearings and cite their advantages.
- Identify bearings by the kind of support they provide.
- Describe the three kinds of stresses acting on shafts.
- Explain natural frequency of vibration and critical speed.
- Name and describe three classes of fits.

Chapter 11: Chain Drives
Topics

Types of Chain Drive; Installing and Aligning Shafts; Mounting the Drive Sprockets; Mounting the Drive Chain; Test Running with No Load; Lubrication Recommendations; Lubrication Methods or Types; Test Running with Full Load; Preventive Maintenance of Chain; Care of Stored Chain; Troubleshooting Chain Drives; Chain Drives and Safety

Objectives

- List four types of chain drives.
- Describe the procedure for aligning the driving and driven shafts.
- Distinguish between bored sprockets and bushed sprockets and tell how each is mounted.
- Tell how a drive chain is mounted on the sprockets.
- List four methods of lubrication for chain drives.
- Explain both no-load and full-load test running procedures.
- Describe the causes of fatigue breaks, tensile breaks, rapid chain wear, roller wear, and side plate spreading.

Chapter 12: Belt Drives
Topics

Types of Belt Drive; Installing and Aligning Drives; Mounting Sheaves and Pulleys; Installation of V-belts; Adjusting the Sheave Centers; Use of Idler Sheaves; Adjusting V-belt Tension; Test-Running and Initial Run-in; Flat Belt Drives; Positive Belt Drives; Preventive Maintenance of Belts; Operating Environment for Belts; Troubleshooting Belt Drives; Belt Drives and Safety

Objectives

- List the three general types of belt drive and explain how they work.
- Tell how sheaves and pulleys are mounted and aligned on their shafts.
- Explain why all the belts in a multi-belt drive must be replaced at the same time.
- Describe two ways of taking up slack in a stretched V-belt.
- List three ways of splicing the ends of a flat belt together.
- Differentiate between the way positive-drive belts and other types of belt transmit power.

Tools and Instruments for Technicians

Course #SCP 245

Chapter 1: Measuring Tools

Topics

Linear and Angular Measurement; Units of Linear Measurement; Rules and Measuring Tapes; Using Rules and Tapes; Calipers; Slide Calipers; Vernier Calipers; Micrometer Caliper; Using the Micrometer; Squares

Objectives

- Explain how to hold a rigid rule correctly when measuring an object and show from which point the measurement begins.
- Describe how to set lock joint transfer-type calipers.
- Identify vernier calipers.
- Explain how to take a measurement with a micrometer caliper.
- Name the parts of a combination square.

Chapter 2: Wrenches and Screwdrivers

Topics

Using Wrenches; Open-End Wrenches; Box-End Wrenches; Combination Wrenches; Socket Wrenches; Socket Handles; Socket-Screw Wrenches; Adjustable Wrenches; Torque Wrenches; Using Wrenches Safely; Using Screwdrivers; Standard Screwdrivers; Cross-Slot Screwdrivers; Spiral Ratchet Screwdrivers; Offset Screwdrivers; Driving a Screw; Removing a Screw; Restoring a Screwdriver Blade; Using Screwdrivers Safely

Objectives

- Identify types of materials used for making wrenches.
- Identify open-end, box-end, socket, socket-head, adjustable, torque, and striking-face wrenches.
- Describe two sizes that are important in identifying a socket wrench.
- Identify standard, Phillips, offset, and spiral-ratchet screwdrivers.
- List the steps to follow when driving a screw.

Chapter 3: Electrician's Tools

Topics

The Electrician; EMT Bender; Correcting Knocked Over Stubs; Bending Rigid Conduit; Assembling Rigid Conduit; Knockout Punches; Fish Tapes; Pliers; Wire and Cable Strippers; Electrician's Screwdrivers; Test and Safety Equipment

Objectives

- Explain how to use an EMT bender and a neon circuit tester.
- List the parts of a knockout punch.
- Name the uses of the all-purpose tool.

Chapter 4: Metalworking Tools

Topics

Vises; Hacksaws; Using Hacksaws; Files; File Cuts; File Specifications; Selecting a File; Using Files; Taps; Tap Sizes; Using Taps; Dies; Thread Classes; Using Dies; Reamers; Using Reamers

Objectives

- Select the proper hacksaw blades for cutting various materials.
- Explain the difference between single-cut and double-cut files.
- List the types of taps usually found in a tap set.
- Explain how to cut an external thread on a bolt, screw, or stud.
- Explain how to remove a reamer from a hole.

Chapter 5 Hoisting and Pulling Tools

Topics

Hoisting with Rope; Knots; Wire Rope; Slings; Sling Angles; Sling Hitches; Center of Gravity; Sling Spreader Beams; Block and Tackle; Chain Fall; Chain Load Pullers; Machine Part Pullers; Jaw Pullers; Slide-Hammer Pullers; Choosing the Proper Puller

Objectives

- Explain how to prevent synthetic and fiber rope from unraveling.
- Explain how individual wires and strands of wire are formed into wire rope.
- Identify the most appropriate sling for use near corrosive chemicals.
- Identify a slide-hammer puller.
- Describe different kinds of slings and loads.

Chapter 6: Electrical Hazards

Topics

The Importance of Electrical Safety; The Electric Circuit; Electric Shock; Electric Arc; Basic Rules of Electrical Safety; Hazardous Electrical Locations; Additional Hazards

Objectives

- List the three main factors that determine the effect of electric current on the human body.
- Explain what to do if a person is a victim of electric shock.
- Name four precautions you can take to guard against electric shock.
- Define the term qualified person.
- Summarize the basic rules of electrical safety.

Chapter 7: Electrical Safety Equipment

Topics

Work Clothes; Personal Protective Equipment; Special Body Protection; Foot Protection; Gloves; Head Protection; Eye Protection; Face Protection; Safety Harnesses and Lifelines; Respiratory Protection; Lockout Devices; Barricade Tape; Electrical Tools; Voltage Testers

Objectives

- Describe appropriate clothing and PPE to wear when working with electricity.
- Explain first aid procedures for eyes.
- Describe the devices used to lock out power.
- Tell how to keep plant personnel out of an area where electrical work is being performed.
- Explain the purpose of a voltage tester.

Chapter 8: Electrical Procedures

Topics

Energy Control; Electrical Safety Lockout; OSHA Lockout/Tagout Procedures; Using Power Tools Safely; Power Tool Safety Rules; Recognizing Electric Shock Victims; First Aid for Shock Victims

Objectives

- Explain the concepts of energy control and zero energy state.
- Summarize the OSHA lockout procedure.
- Explain how portable power tools are grounded.
- List some common symptoms of electric shock.
- Summarize the steps involved in administering CPR.

Tools and Instruments for Technicians, Cont.
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Chapter 9: Grounding, Ground Faults, and Short Circuits
Topics

Equipment Grounding; Circuit Grounding; Protection Against Ground Faults; Transformer Grounding; Effects of Impedance; Grounding Through Enclosures; Visual Indication of Ground for Ungrounded Circuits; Grounded Conductor Alarms; Detecting Faults Automatically; Static Electricity

Objectives

- State the reason why circuits should be grounded.
- Explain how to test a circuit for proper grounding.
- Explain how a ground-fault circuit interrupter works.
- Contrast current electricity and static electricity and explain why each can be hazardous.
- Identify the correct extinguisher to use on flammable liquid fires and on energized electrical equipment fires.

Chapter 10: Fuses and Circuit Breakers
Topics

The Purpose of a Fuse; Lead-Wire Fuses; Cartridge Fuses; Dual-Element Cartridge Fuses; Current-Limiting Fuses; Power Fuses; Cartridge Fuse Classes, Sizes, and Ratings; Installing Cartridge Fuses; Plug Fuses; Glass-Tube Fuses; Kinds of Circuit Breakers; Magnetic Circuit Breakers; Thermal-Magnetic Circuit Breakers; Ambient-Compensated Circuit Breakers; Molded-Case Circuit Breakers; Low-Voltage Power Circuit Breakers; Circuit Breaker Tripping; Circuit Breaker Reset and Fuse Replacement

Objectives

- Explain how a dual-element cartridge fuse works.
- List the NEC rules on installing fuses.
- Explain how a circuit breaker works.
- Describe molded-case circuit breakers.
- Explain the steps involved in fuse replacement and/or circuit breaker reset.

Introduction to Power Technology

*Course #SCP 250**

Chapter 1: Steam—The Primary Force

Topics

Energy for Power Plants; Converting Energy to Electricity; The Importance of Air in Combustion; Removing Ashes and Flue Gases; Heating the Air; Boiler Design; Controlling the Water Level; Feedwater Heater; The Economizer

Objectives

- Describe the basic concepts involved in converting energy to electricity through a steam power plant.
- Explain why air is important in combustion and describe how air is heated.
- Describe the basic design of a boiler.
- List the methods commonly used to create efficiency in a boiler.

Chapter 2: How Heat is Converted to Power

Topics

The Turbine; The Generator; Using Exhausted Steam; Producing a Vacuum; Using the Condensate; Improved Coal Handling; Boiler Efficiency

Objectives

- Describe the components of an elementary turbine.
- List the uses of exhaust steam.
- Explain how a vacuum is produced in a boiler system.
- Describe how condensate is formed in a boiler system and how it can be used to create a closed cycle system.
- Explain how boiler efficiency is related to steam temperature and pressure.
- Calculate absolute temperature values using Fahrenheit and Celsius readings.

Chapter 3: Power Plant Efficiency

Topics

Thermodynamic Efficiency; Pumps; Feedwater Heating; Air Heating; The Superheater; Circulation Problems in High-Pressure Boilers; Minimum Temperatures in the System; Minor Refinements; Condenser Performance

Objectives

- List the kinds of pumps used in a boiler system and explain the function of each.
- Describe common processes by which boiler feedwater can be heated, and explain these increase boiler efficiency.
- Explain the process by which air is heated in a boiler system.
- Explain the purpose of a superheater.

Chapter 4: Handling Water, Fuel, and Wastes

Topics

Water Requirements; Physical Properties of Water; Chemical Properties of Water; Water Softening and Purification; Cooling Water; Water Disposal Problems; Air Cooling; Fossil Fuel Handling and Wastes; Flue Gases; Particle Removal; Problem Transfer; Looking to the Future

Objectives

- List the two main uses for water in a power plant.
- Describe the physical and chemical properties of water.
- Explain the past and present methods used to purify water for use in a power plant.
- Explain the common handling procedures for flue gases and solid wastes, and describe the problems involved in disposing of these wastes.
- List some of the ways in which power plant waste problems might be resolved in the future.

Chapter 5: Power Plant Operation and Control

Topics

Operating Features of a Power Plant; Power Plant Controls; Temperature Measurement; Pressure Measurement; Special Measurements; Other Power Sources; Nuclear Power

Objectives

- Give a detailed description of the arrangement of a modern steam generating plant and explain the progression of the steam cycle from one end to the other.
- Compare and contrast the common instruments for measuring temperature.
- Compare and contrast the common instruments for measuring pressure.
- List some of the special measurement devices that are important in a steam generating plant.
- List the alternate power sources described in the Chapter.
- Explain the concept of nuclear power and describe the operation of a nuclear power plant.

Chapter 6: Transforming Energy into Work

Topics

Energy and Matter; Fuels; Combustion; Temperature Measurement; Pressure Measurement; Quantity of Heat; Heat Transfer; Conduction; Radiation; Convection; Sensible and Latent Heat; Vaporization; Boiling Point; Enthalpy; Heat and Work; Basic Steam Generation

Objectives

- Define energy and describe the main forms of energy encountered in a power plant.
- Explain the process of combustion and list the three elements necessary for combustion to occur.
- Explain the principles of temperature and pressure measurement and describe the four scales on which temperature is measured.
- Describe the methods of heat transfer and the types of effects heat transfer can have on a material.
- Summarize the interrelationship of temperature, volume, and pressure in a gas.

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Chapter 7: Boiler Operation
Topics

Types of Boilers; Boiler Characteristics; Water Treatment for Boiler Use; Boiler and Cooling Tower Blowdown; Wastewater Disposal; Efficiency in the Power Plant; Thermodynamic Efficiency; Conserving Energy in the Power Plant

Objectives

- Compare the two basic types of boilers.
- Describe the characteristics by which boilers are classified.
- Explain the different processes by which water is treated for use in a boiler.
- Define blowdown and explain its importance in boiler operation.
- List the problems associated with wastewater disposal and describe how these problems are overcome.
- Describe the factors that affect boiler efficiency, as well as auxiliary equipment efficiency.
- Calculate thermodynamic efficiency.
- List practices that aid in energy conservation in all areas of the power plant.

Chapter 8: Combustion and How It Works
Topics

Coal Ranks; Coal Analyses; Coal Sizes; Coal Storage; Oil Properties; Natural Gas; Chemistry of Combustion; Oil Burners; Gas Burners; Flame Color; Flame Adjustment for Oil and Gas; Coal Firing Systems; Pulverized Coal Burners; Overfeed Stokers; Underfeed Stokers; Ash Analysis for Carbon; Combustion Efficiency; Handling Unburned Solids

Objectives

- Identify the different ranks of coal and describe how the makeup of coal affects its heating value.
- List the properties that are tested in a coal analysis.
- Summarize the properties of oil and natural gas fuels.
- Explain the combustion process in detail.
- Describe how to interpret and adjust a flame's characteristics in coal, oil, and gas burners.
- Describe the three types of coal firing systems.
- List the ways in which combustion efficiency is measured.

Chapter 9: Steam Generation
Topics

The Steam Generation Process; Temperature and Pressure Relationship; Superheating Steam and Steam Quality; Volume and Pressure Relationship; Steam Tables for Saturated Steam; How to Use Steam Tables; Circulation of Boiler Water; Steam Circulation and Tube Temperature; Steam Drum Design; Operating a High-Pressure Boiler at Low Pressure; The Complete Steam Generation System; Conserving Energy; Blowdown; Makeup Water

Objectives

- Trace the flow of water and steam through the boiler system.
- Explain the relationship between temperature and pressure and explain why superheated steam has a higher quality than saturated steam.
- Read a steam table properly and apply its information to a boiler system.
- Compare natural circulation boilers with forced circulation boilers, and explain how pressure and temperature affect the type of boiler used.
- Describe the process of operating a high-pressure boiler at low pressure.
- Describe how proper maintenance of steam traps, valves, packing, flanges, and insulation improve the energy conservation rate in a boiler system.

Chapter 10: Introduction to Safety and Health
Topics

Responsibility for Safety; Unsafe Acts and Conditions; Health Hazards; Accidents; Handling Emergencies; Safety Off the Job

Objectives

- Define the terms accident and hazard.
- Name and define the four main types of hazards.
- List and define various types of accidents.
- Compare meanings of unsafe act and unsafe condition.
- Name the three ways in which a toxic substance can enter your body.
- List ways in which a company must plan for emergencies.
- Tell the main reason for prompt accident investigation.

Chapter 11: Chemical Safety
Topics

Physical Hazards; Health Hazards; Exposure Routes; Control of Chemical Hazards; Spill Response; First Aid

Objectives

- Define chemical hazard, physical hazard, and health hazard.
- Name three kinds of physical hazards.
- Name and describe at least four kinds of health hazards.
- Identify common symptoms of chemical exposure.
- List three health hazard exposure routes.
- Name three ways of controlling chemical hazards and exposures.
- Explain first aid procedures to follow when you are exposed to a hazardous chemical.

Chapter 12: Working Safetly with Electricity
Topics

The Electric Circuit; Injuries from Electricity; First Aid for Shock Victims; National Electrical Code; Static Electricity

Objectives

- Define the following terms: electric current, circuit, potential difference, ampere, watt, ohm, and volt.
- State Ohm's Law.
- Explain the function of each wire in a simple electric circuit and tell the color(s) used to identify each.
- List the three factors that affect the severity of an electric shock.
- Describe the effects of electric current on the human body.
- Tell the three most important points about first aid for shock victims.
- Explain how static electricity is generated, why its accumulation can be dangerous, and how it can be avoided.

Chapter 13: Electrical Equipment Safety
Topics

Grounding; Ground Faults; Fuses and Circuit Breakers; Portable Power Tools; Hazardous Electrical Locations; Basic Rules of Electrical Safety

Objectives

- Explain the importance of proper grounding.
- Define the term "ground fault" and explain how ground faults occur.
- Explain the purpose and operation of the following devices: GFCI, fuse, circuit breaker.
- Identify typical hazardous electrical locations.
- Explain the purpose of explosion-proof and intrinsically safe electrical equipment.
- List at least two electrical safety rules in each of the following areas: clothing, equipment, water, lockout/tagout.

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Chapter 14: Units of Measurement
Topics

Kinds of Units; Length; Area; Volume; Angles; Time; Speed and Velocity; Mass and Weight; Force; Work and Power; Pressure; Temperature; Electricity

Objectives

- Identify various units of measurement.
- State the definition of the joule, the coulomb, and the horsepower.
- Explain how to calculate pressure.
- Explain the difference between mass and weight.
- Demonstrate how to measure the volume of an object.
- Explain the difference between the Celsius scale and the Fahrenheit scale.

Chapter 15: Metric Measurement
Topics

History; Measuring Terms; Length; Area and Volume; Mass; Time; Frequency; Speed and Velocity; Acceleration; Force and Weight; Work and Energy; Power; Temperature; Electric Current; Light; Amount of Substance; Using SI Units

Objectives

- List the seven base units in the SI (metric) system.
- Name three derived units.
- Define work and power in SI units.
- Explain what power is and how it is measured.
- Name two metric measuring instruments and their U.S. Standard equivalents.

Chapter 16: Linear Measurement
Topics

Units of Linear Measurement; Measurement Error; Tolerances; Measuring Devices; Scales and Rules; Scribers and Dividers; Bevel Gauge; Calipers; Combination Square; Reading a Vernier Scale; Using a Micrometer; Reading a Micrometer

Objectives

- List five units used for making linear measurements.
- Demonstrate how to use a micrometer.
- Explain what each head of a combination square is used for.
- State the definition of parallax error.
- Define the different types of tolerance.

Chapter 17: Measuring Temperature
Topics

Temperature and Heat; Thermometers; Temperature-Sensing Materials; Digital and Analog Thermometers; Bourdon-Tube Thermometers; Bimetallic Thermometers; Electric Thermometers; Pyrometers; Response Time and Accuracy

Objectives

- Explain the difference between heat and temperature.
- Name four different scales for measuring temperature.
- Explain the use of heat-sensitive pellets, crayons, and paints.
- Explain how Bourdon tubes work.
- Explain how a pyrometer works.

Chapter 18: Measuring Fluids
Topics

States of Matter; Measuring Liquid Level; Viscosity; Flow Rate; Measuring Volume of Flow; Humidity; Density; Measuring Specific Gravity; Pressure; Measuring Pressure; Measuring Flow Rate by Pressure

Objectives

- State the definition of a fluid.
- Describe how liquids differ from gases.
- List the instruments used to measure the level of water.
- Name two instruments that measure the flow of fluids, and explain how they work.

Chapter 19: Measuring Electricity
Topics

Structure of Matter; Electricity; Electric Circuits; Electrical Units; Measuring Current; Measuring Potential Difference; Measuring Resistance; Measuring Power; AC and DC Measurements

Objectives

- List the parts of an atom.
- Define potential difference.
- Identify a wattmeter.
- Describe the difference between alternating current and direct current.
- Describe the difference between an ohmmeter and an ammeter.

Chapter 20: Introduction to Blueprints
Topics

Importance of Blueprints; Purpose of Blueprints; Types of Information on Blueprints; Supplementary Spaces; Detail Drawings; Interpreting a Detail Drawing; Assembly Drawings; Orthographic Projections; Auxiliary Views; Sections; Pictorial Drawings

Objectives

- Identify details, markings, and machine parts from an assembly drawing.
- Identify an object from an orthographic drawing.
- Identify elements located within the title block of a detail drawing.
- Explain why more than one orthographic projection is needed to show an object on a blueprint.

Chapter 21: Machine Parts
Topics

Six Simple Machines; Screw Threads; Drawings of Screw Threads; Screw Thread Specifications; Heads; Rivets; Welds; Pins; Keys; Springs; Gears; Bearings; Belts and Pulleys

Objectives

- Describe what a machine is, and explain what it does.
- Name the two basic methods of joining machine parts.
- Name and identify from an exhibit several types of threaded fasteners.
- Name the two basic methods of permanent joining.
- Identify gears, bearings, and belt drives on drawings.
- Identify types of screw threads from a specification.

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Chapter 22: Sketching
Topics

Using Sketches; Making Sketches; Kinds of Sketches; Orthographic Sketches; Isometric Sketches; Perspective Sketches

Objectives

- Name the four kinds of sketches.
- Identify an isometric sketch.
- Describe the appearance of a perspective drawing.
- Discuss how to sketch straight lines and curved lines.
- State the definition of a vanishing point.

Chapter23: Introduction to Technical Diagrams
Topics

Symbols in Schematics; Using Schematics; Electrical Schematics; Pneumatic and Hydraulic Schematics; Piping Schematics; Value of Schematics; Looking for Flow; Electric Current; Fluid Flow

Objectives

- State the definition of a schematic.
- List some characteristics of schematics.
- Identify a schematic among other kinds of technical drawings and diagrams.
- Explain how flow is indicated on a schematic.

Chapter 24: Symbols on Schematics
Topics

Common Features of Schematics; Differences in Schematics; Using the Schematic; Understanding Symbols; Identifying Symbols; Identifying Connections; Reading Diagrams

Objectives

- Identify various types of lines on schematics
- Identify the following schematics by their symbols:
  - Electrical
  - Fluid-power
  - Piping
- Give the purpose of legends and other tables of symbols.

Chapter 25: Piping Diagrams
Topics

Piping Systems; Valves; Identifying Piping Symbols; Reading a Simple Schematic; Reading a Piping Schematic

Objectives

- Give the purpose of a valve in a piping system.
- Explain the difference between a check valve and a cock valve.
- Identify the symbols for various types of valves.
- Demonstrate the ability to determine pipe size from a diagram.

Chapter 26: Introduction to Piping Systems
Topics

Piping Systems; Fluids; Protecting Steam Lines; Keeping Fluids Clean and Moving; Piping Systems Maintenance; Valves and Fittings; Pipe Hangers and Supports; Temperature Effects; Piping Insulation; Typical Piping Systems; Maintenance Considerations

Objectives

- Describe what typical piping systems consist of, and explain their importance to plant operations.
- Identify common valves and fittings, pipe hangers and supports.
- Describe the effects of temperature on piping system components, and explain the need for insulation.
- List routine maintenance considerations for piping systems.

Chapter 27: Fittings
Topics

Functions of Fittings; Screwed Connections; Flanged Connections; Other Fittings; Welded Connections; Tube Fittings; Drawing Symbols

Objectives

- Discuss the main functions of fittings.
- Identify common pipe and tube fittings.
- Contrast screwed, flanged, and welded connections, and tell why one type of joint may be preferred for a given application.
- Explain how expansion joints and vibration dampeners work.
- Demonstrate a knowledge of the symbols used to represent joints and fittings on schematic drawings of piping systems.

Chapter 28: Common Valves
Topics

Valves; Valve Construction; Valve Sizes and Functions; Types of Industrial Valves; Gate Valves; Globe Valves; Needle Valves; Ball Valves; Butterfly Valves; Plug Valves; Check Valves; Quick-Opening Valves; Valve Maintenance; Valve Connections

Objectives

- Explain the various ways in which valves control fluid flow in piping systems.
- Identify gate, globe, needle, ball, butterfly, plug, and check valves, and tell what each is used for.
- Explain how and why quick-opening valves are used in industrial piping applications.
- Describe routine inspection, lubrication, and maintenance procedures for common valves.

Chapter 29: Principles of Hydraulics
Topics

Fluid Power and Hydraulics; Force, Weight, and Mass; Pressure; Work, Power, and Energy; Incompressibility and Nondiffusion; Hydrostatic Pressure; Pascal's Law; Transmission of Fluid Power; Fluid Flow in Pipes; Bernoulli's Principle; The Effect of Heat on Liquids; Hydraulic Power Systems

Objectives

- Explain the difference between absolute and gauge pressure.
- Demonstrate how power is calculated.
- Explain Pascal's Law.
- Describe the difference between laminar and turbulent flow.
- Name the main components of a hydraulic system.

Chapter 30: Principles of Pneumatics
Topics

Fluid Power Systems; Pneumatic Systems; Force, Weight, and Mass; Pressure; Work and Energy; Diffusion and Dispersion; Separation of Gases and Liquids; Compressibility; Laws of Pneumatics; Transmission of Pneumatic Fluid Power; Pneumatic Leverage; Air Properties; Air Flow in Pipes; Viscosity of Air; Bernoulli's Law; Components of Pneumatic Power Systems

Objectives

- Explain how force is transmitted in a pneumatic system.
- Calculate force and work.
- List two factors that affect the results of pressure calculations.
- Explain pneumatic leverage.
- Briefly explain the physical laws affecting the behavior of a confined gas.

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Chapter 31: Turbines
Topics

What is a Turbine?; Operating Principles; Turbine Classification; Gas Turbines; Condensers; Heat Rejection and Thermal Pollution; Boiler-Turbine-Generator Efficiency; Operating Data on Turbine-Generator Performance; Maintaining a Turbine-Generator System; Condenser Cooling Water Requirements; Cooling Water Systems

Objectives

- Name the five main parts of a steam turbine system and explain the function of each.
- Contrast the operating principle of an impulse turbine and a reaction turbine.
- Define the terms tandem compound and cross compound.
- Explain how a condenser improves turbine efficiency.
- Explain how an overspeed trip is activated.
- List three causes of turbine rotor vibration.
- Name the main cause of bearing failure in a turbine.

Chapter 32: Electrical Power Fundamentals
Topics

Fundamentals of Electricity; Ohm's Law for DC Circuits; Power in DC Circuits; Theories of Magnetism; Circuit Components; Circuit Types; Generators; Phase Difference; Power Factor; Three-Phase Systems; Transformers; Metering Principles; Instrument Transformers; Electric Distribution Systems and Equipment; Protective Equipment; Distribution Wiring; Substations

Objectives

- Explain the basic principles of electricity and electric power, including the significance of Ohm's Law.
- Identify the parts of an electrical circuit and describe the function of each part.
- Contrast series and parallel circuits.
- Explain the difference between the two main groups of generators and further describe each group in terms of its sources of mechanical power.
- Define phase difference and power factor, and describe a three-phase system.
- Explain the function of a transformer.
- Describe the variety of metering instruments used to measure the value of electric energy.
- Explain the purpose of an electric distribution system, and list the three main kinds.
- Name four kinds of protective equipment used in power systems.

Chapter 33: Electrical Systems Analysis
Topics

Line Diagrams; Electrical Power Billing; Electrical Demand Considerations; Determining Load Factor; Demand Analysis; Manual and Automatic Control; Demand Costs; Power Systems Analysis; Low Power Factor Costs; Causes of Low Power Factor; Power Factor Correction; Capacitors; Synchronous Motors; Transformer Losses; System Voltage Variation and Losses; Maintaining Protective Devices; Maintaining Cable Systems; Maintaining Generators and Motors; Conservation

Objectives

- Explain the purpose of a line diagram.
- List the four kinds of charges normally found on a power bill.
- Define peak demand.
- Calculate a plant's load factor.
- Describe the steps involved in performing demand analysis.
- Calculate demand cost and explain the effect of short demand peaks on billing.
- Define power factor and explain how it is calculated, what causes it to be low, and how it can be improved.
- List the types of power losses that occur in transformers and describe the cause of each.
- Explain how to maintain protective devices, cable systems, and generators and motors.
- Explain the importance of energy conservation in power plants.

Appendix A: Ratios and Proportions
Topics

Comparing Numbers; Ratios; Expressing Ratios; Writing Ratios; Units in Ratios; Proportion

Objectives

- Demonstrate how to calculate the ratio of two numbers.
- Demonstrate how to use a ratio to express a change.
- Demonstrate how to use a ratio to solve a typical plant problem.

Appendix A: Powers and Roots
Topics

Repeating Multiplication and Division; Exponential Form; Multiplying in Exponential Form; Dividing in Exponential Form; Zero Power; Fractions with Exponents; Products with Exponents; Powers of Powers; Powers of Sums and Differences; Roots; Fractional Exponents; Decimal Exponents; Negative Fractional Exponents

Objectives

- Demonstrate how to calculate the value of a number given in exponential form.
- Demonstrate how to write products and quotients of numbers given in exponential form.
- Demonstrate how to calculate the value of a number raised to a fractional power.
- Demonstrate how to calculate the value of a number raised to a negative power.

Introduction to Power Technology, Cont.
SCP 250*

Appendix A: Calculators
Topics

Using This Chapter; What a Calculator Does; Inside a Calculator; Internal Logic; Basic Functions; Special Functions; Special-Purpose Calculators

Objectives

- Explain the importance of an algorithm in a calculator.
- Describe how a calculator with arithmetic logic performs calculations.
- Describe how a calculator with algebraic logic performs calculations.
- Describe how a calculator with RPN logic differs from other calculators.

Appendix A: Geometry
Topics

Lines and Curves; Circles; Angles; Measuring Angles; Polygons; Triangles; Quadrilaterals; Constructions

Objectives

- Explain the differences among a line, a line segment, and a ray.
- Identify a radius, a chord, and a diameter of a circle.
- Demonstrate how to measure an angle with a protractor.
- Define a circle.
- Identify a right triangle, an equilateral triangle, and an isosceles triangle in a drawing.
- Demonstrate how to duplicate an angle using a straightedge and a compass.

Appendix A: Algebra
Topics

Need for Algebra; Symbols, Expressions, and Equations; Order of Operations; Parentheses; Numbers and Variables; Equations; Algebraic Laws; Writing Equations; Solving Equations

Objectives

- Demonstrate how to calculate the value of an expression by performing mixed operations in the correct order.
- Demonstrate how to write an algebraic equation, based on a relationship stated in words.
- Demonstrate how to solve an algebraic equation for a specific variable.

Appendix A: Trigonometry
Topics

Properties of Triangles; Trig Functions; Trig Tables; Inverse Trig Functions; Using Trig Functions

Objectives

- State the definition of the sine, cosine, and tangent of an angle.
- Demonstrate how to find the value of the sine, cosine, and tangent of a given angle, using either a trig table or a calculator.
- Demonstrate how to find the inverse sine, inverse cosine, and inverse tangent of a given value, using either a trig table or a calculator.
- Demonstrate how to solve a geometric problem, using trigonometry.

Mechanical and Electrical Readings

Course #SCP 254

Chapter 1: Forces and Motion

Topics

Definition of Force; Sources of Forces; Measuring Forces; Forces Applied to Stationary Objects; Normal Forces; Describing Motion; Acceleration; Types of Motion; Newton's Law of Motion

Objectives

- Name five ways forces originate.
- Explain how forces are measured.
- Define velocity, acceleration, and elastic distortion.
- Define rotary motion and reciprocating motion.
- State and explain Newton's Laws of Motion

Chapter 2: Work, Energy, and Power

Topics

Defining Work; Measuring Work; Torque; Energy; The Law of Conservation of Energy; Forms of Energy; Kinetic and Potential Energy; Power; Horsepower; Calories and Btu

Objectives

- Define work, and explain how to calculate it.
- Define the terms torque and prime mover.
- Define energy, and tell how it is measured.
- Differentiate between kinetic and potential energy, and give an example of each one.
- Define power and horsepower, and tell how each is measured.

Chapter 3: Fluid Mechanics

Topics

Definition of a Fluid; Fluids Distribute Forces; Definition of Pressure; Measuring Pressure; Sources of Fluid Pressure; Gauge Versus Absolute Pressure; Liquid Seeks Its Own Level; Velocity Head Versus Static Pressure Head; The Bernoulli Effect; Venturi Applications; Friction Head; The Siphon

Objectives

- Define a fluid.
- Define pressure, and identify common units of pressure measurement.
- State Pascal's Law, and give an example of its application.
- Explain the difference between gauge pressure and absolute pressure.
- Explain the Bernoulli Effect, and give three examples of how it is utilized in industry.
- Explain how a siphon works.

Chapter 4: Simple Machines

Topics

Simple Machines in Your Life; The Lever; Classes of Lever; The Wheel and Axle; Gear Trains; The Inclined Plane; The Wedge; Cam-and-Follower Devices; The Screw; Jackscrews; Pulleys and Pulley Systems; Mechanical Efficiency

Objectives

- Identify and name six types of simple machines.
- Calculate the ideal mechanical advantage of each of six simple machines.
- Describe the action and purpose of cam-and-follower mechanisms.
- Determine the ideal mechanical advantage of several simple gear trains.
- Explain mechanical efficiency and show how to calculate it.

Chapter 5: Machine Elements

Topics

The Machine; Machine Motions; Mechanisms; Lever Linkages; Four-Bar Linkages; Cam-and-Follower Mechanisms; Devices For Producing Linear Motion; Ratchet-and-Pawl Mechanisms; Fluid-Powered Mechanisms; Applying Your Knowledge of Mechanisms

Objectives

- List the four classifications of mechanisms.
- Name the six basic motion conversions, and give an example of each.
- Explain the functions of bell cranks, Pitman arms, and toggle bars.
- Name three types of four-bar linkages, and explain how they function.
- Describe the ratchet-and-pawl mechanism.

Chapter 6: Scalars and Vectors

Topics

Introduction to Physical Quantities; Locating Points on a Map; Vectoring a Trip on the Map; Properties of Vectors; Components of Vectors; Vector Sum; A Rule for Adding Vectors; Subtraction of Vectors; Vector Multiplication and Division

Objectives

- Explain the difference between scalars and vectors, and list examples of each.
- Draw a vector, given a verbal description.
- Describe a vector verbally, given its graphic symbol, a frame of reference, and an appropriate scale.
- Define resolution, resultant, and commutative.
- Demonstrate how to resolve a vector into its rectangular components.
- Demonstrate how to add and subtract vector quantities in one-dimensional and two-dimensional frames of reference.
- Multiply and divide a vector by a scalar.

Chapter 7: Solving Problems in DC Circuits

Topics

Sources of DC Electricity; Ohm's Law; Work; Torque; Power; Efficiency; Branch Points and Loops

Objectives

- Define Ohm's Law and use it to solve a problem.
- State the definition of a branch point.
- Solve a problem using the power formula.
- State the definition of Kirchhoff's rules.
- Define work, power, torque, and efficiency.

Mechanical and Electrical Readings, Cont.
SCP 254

Chapter 8: Multimeters
Topics

The Multimeter; Guidelines for Using a Multimeter; An All-Purpose Graphical DMM; More Advanced Meter Functions; Multimeter Accessories; Multimeter Safety

Objectives

- Demonstrate how to measure ac and dc current and voltage with a multimeter.
- Describe the function of a current probe.
- Explain how to isolate the source of a glitch with a graphical multimeter.
- Demonstrate how to read the screen display of a graphical multimeter in the Trend mode.
- Explain why you set a meter to its highest range before taking your first measurement.
- Define autoranging and auto-polarity.
- List three safety precautions to take when using multimeters.

Chapter 9: DC Series Circuits
Topics

Characteristics of a Series Circuit; Ohm's Law for Series Circuits; Current Control; Voltage Drop; Problems in Voltage Drop; Using Equations; Practice Problems; Using Kirchhoff's Rules; Power Equations

Objectives

- Describe a series circuit.
- Solve for E, I, and R in series circuits.
- State the basic rule you must follow when making changes in an equation.

Chapter 10: Parallel Circuits
Topics

Definition of a Parallel Circuit; Recognizing Parallel Circuits; Resistance in Parallel Circuits; Calculating Resistance; Voltage Drop in Parallel Circuits; Current in Parallel Circuits; Conductance; Calculating Power; Practice Problems

Objectives

- State the definition of a parallel circuit.
- Explain how to calculate the current in each branch of a parallel circuit.
- Explain how to calculate resistance in a parallel circuit.
- Calculate power in a parallel circuit.
- Find the reciprocal of any value.

Chapter 11: Series-Parallel Circuits
Topics

Complex Circuits; Examples of Series-Parallel Circuits; Kirchhoff's Rule; Series-Parallel Resistances; Two Resistors in Parallel; Redrawing Circuits; Tracing Circuits; Steps in Calculating Resistance; Calculating Circuit Values

Objectives

- State the definition of a series-parallel circuit.
- Identify series, parallel, and series-parallel circuits.
- Explain how to calculate resistances in a series-parallel circuit.
- Demonstrate how to trace and simplify a circuit.

Chapter 12: DC Circuits in Use
Topics

DC Motors and Generators; Internal Resistance of a Generator; Field Windings in DC Motors; Controlling a DC Shunt Motor; Voltage Dividers; Lighting Circuits; Three-Way Switch Circuits; Four-Way Switch Circuits

Objectives

- Explain how the three types of dc motors differ.
- Demonstrate how to increase and decrease the speed of a dc motor by adding resistors.
- Identify a three-way switch.
- Calculate current and resistance using voltage divider circuits.

Electromechanical Devices

Course #SCP 275

Chapter 1: Forces and Motion

Topics

Definition of Force; Sources of Forces; Measuring Forces; Forces Applied to Stationary Objects; Normal Forces; Describing Motion; Acceleration; Types of Motion; Newton's Law of Motion

Objectives

- Name five ways forces originate.
- Explain how forces are measured.
- Define velocity, acceleration, and elastic distortion.
- Define rotary motion and reciprocating motion.
- State and explain Newton's Laws of Motion

Chapter 2: Work, Energy, and Power

Topics

Defining Work; Measuring Work; Torque; Energy; The Law of Conservation of Energy; Forms of Energy; Kinetic and Potential Energy; Power; Horsepower; Calories and Btu

Objectives

- Define work, and explain how to calculate it.
- Define the terms torque and prime mover.
- Define energy, and tell how it is measured.
- Differentiate between kinetic and potential energy, and give an example of each one.
- Define power and horsepower, and tell how each is measured.

Chapter 3: Simple Machines

Topics

Simple Machines in Your Life; The Lever; Classes of Lever; The Wheel and Axle; Gear Trains; The Inclined Plane; The Wedge; Cam-and-Follower Devices; The Screw; Jackscrews; Pulleys and Pulley Systems; Mechanical Efficiency

Objectives

- Identify and name six types of simple machines.
- Calculate the ideal mechanical advantage of each of six simple machines.
- Describe the action and purpose of cam-and-follower mechanisms.
- Determine the ideal mechanical advantage of several simple gear trains.
- Explain mechanical efficiency and show how to calculate it.

Chapter 4: Machine Elements

Topics

The Machine; Machine Motions; Mechanisms; Lever Linkages; Four-Bar Linkages; Cam-and-Follower Mechanisms; Devices For Producing Linear Motion; Ratchet-and-Pawl Mechanisms; Fluid-Powered Mechanisms; Applying Your Knowledge of Mechanisms

Objectives

- List the four classifications of mechanisms.
- Name the six basic motion conversions, and give an example of each.
- Explain the functions of bell cranks, Pitman arms, and toggle bars.
- Name three types of four-bar linkages, and explain how they function.
- Describe the ratchet-and-pawl mechanism.

Chapter 5: Friction and Wear

Topics

The Nature of Friction and Its Importance; Causes of Friction; Static and Kinetic Friction; Measuring Friction; Coefficients of Friction; Wear—The Major Consequence of Friction; Static Electricity

Objectives

- Define friction, identify the forces that cause it, and describe its effects.
- Differentiate between static friction and kinetic friction.
- Define coefficient of friction.
- Calculate the expected friction force between two surfaces, given the normal force and the coefficient of friction.
- Describe four types of wear.

Chapter 6: Bearings and Shafts

Topics

Bearing Classification; Bearing Selection; Principles of Bearing Operation; Shafts and Shafting; Shaft Materials; Shaft Stresses; Vibration and Critical Speed; Fits and Clearances

Objectives

- Name the two main categories of bearings and cite their advantages.
- Identify bearings by the kind of support they provide.
- Describe the three kinds of stresses acting on shafts.
- Explain natural frequency of vibration and critical speed.
- Name and describe three classes of fits.

Chapter 7: Operation of Journal Bearings

Topics

Plain Journal Bearings; Advantages of Plain Journal Bearings; Lubrication; Lubricating Grooves; Seals; Types of Plain Journal Bearings; Split Bearings; Bearing Design and Selection

Objectives

- Explain the function of lubricating grooves.
- State two reasons for using seals on plain bearings.
- Name the principal types of plain journal bearings.
- Describe the structure of two kinds of precision inserts.
- Define crush and spread.

Chapter 8: Ball and Roller Bearings

Topics

Ball and Roller Bearings; Ball Bearings; Basic Ball Bearings; Single-Row, Angular-Contact Bearings; Double-Row, Angular-Contract Bearings; Other Ball Bearings; Two-Piece, Inner-Ring Bearings; Fractured-Ring Bearings; Bearing Series; Roller Bearings; Cylindrical Roller Bearings; Spherical Roller Bearings; Tapered Roller Bearings; Needle Roller Bearings

Objectives

- Name the three basic ball bearing designs and describe their characteristics.
- Explain the purposes served by the basic roller bearing shapes and their variations in typical applications.

Electromechanical Devices, Cont.
SCP 275

Chapter 9: Bearing Seals
Topics

Why Seals Are Used; Seal Functions; Labyrinth Seals; Oil Seals; Oil Seal Terminology; Oil Seal Classification; Special Seals; Seal Selection; Other Seal Materials; Seal Applications; Other Special Seals; O-Rings and Mechanical Seals

Objectives

- Identify the functions of bearing seals.
- Describe the construction and operation of labyrinth and oil seals.
- Explain the two classification systems for oil seals.
- Name typical applications for the different kinds of seals.

Chapter 10: Belt Drives
Topics

Uses of Belt Drives; V-Belts; Special V-Belts; Timing Belts; Flat Belts; V-Belt Sheaves; Timing-Belt Pulleys; Flat-Belt Pulleys; Variable-Speed Sheaves; Manually Adjustable Sheaves; Spring-Loaded Sheaves; V-Belt Installation

Objectives

- List the factors that affect the power transmitted by a belt drive.
- Name the main components of a belt drive.
- List the standard V-belt designations.
- Explain the reason for using group belts.
- Describe installation and replacement procedures for V-belts.

Chapter 11: Gear Drives
Topics

Types of Gear Drives; Shaft-Mounted Gear Drives; Worm-Gear Drives; Miter-Gear Boxes; Gear Drive Installation; Gear Drive Maintenance; Gear Drive Definitions; Concentric-Shaft Gear Drives; Parallel-Shaft Gear Drives; Right-Angle-Shaft Gear Drives; Vertical-Shaft Gear Drives

Objectives

- Explain how additional speed reduction can be obtained with shaft-mounted gear drives.
- Describe a worm-gear drive and a miter-gear box.
- Give a general explanation of gear drive installation and maintenance.
- Define mechanical power, thermal power, and overload capacity.
- Explain what determines the service factor of a gear drive.
- Describe a concentric-shaft gear drive and a right-angle-shaft gear drive.
- Explain how parallel-shaft gear drives are lubricated.

Introduction to Automation

Course #SCP 478

Chapter 1: The Nature of Process Control

Topics

Process Variables; On-Off Process Control; Functions of Automatic Process Control; Typical Process Control Applications; Measuring Data in Control Systems; Controlling Variables Automatically; Error, Signal Evaluation, and Feedback; Open- and Closed-Loop Control Systems

Objectives

- Define setpoint, control point, and error.
- Explain how measurement and control are related in industrial processes.
- Describe the four essential functions of an automatic control system.
- Discuss the functions of PLCs and industrial computers in control systems.
- Identify variables in industrial processes.
- Explain the importance of feedback in a closed-loop control system.

Chapter 2: Elements of Process Control

Topics

Process Operation; Analog Control Signals; Digital Control Signals; ASCII; Measuring Process Variables; Measuring Pressure; Measuring Level; Measuring Flow Rate; Digital Pulse Control; Control System Terminology; Open- and Closed-Loop Control; Controller Action

Objectives

- Discuss the differences between modern automatic control systems and older ones.
- Identify the standard signals used in process control.
- Define the terms commonly used in control terminology.
- Describe on-off, proportional, integral, derivative, and PID controller action.

Chapter 3: Robotics in Automated Manufacturing

Topics

Evolution of Robotics; What is an Industrial Robot?; Essential Characteristics; Robots and Automated Manufacturing; Project Manufacturing; Job Shop; Batch Manufacturing; Repetitive (Flow) Manufacturing; Continuous Manufacturing; Robot Safety

Objectives

- Identify why robots did not appear in large numbers in manufacturing until the late 1970s.
- State the Robot Industries Association's definition of an industrial robot and explain the two key words.
- Describe how industrial robots are used in batch production systems.
- Explain how industrial robots are used in repetitive manufacturing systems that utilize transfer lines.
- List at least three factors that should be considered as part of a risk assessment when a robot system is in the development stage.
- Describe and contrast the following guarding methods: barrier, presence-sensing device, awareness device, warning system.
- Define the term zero-energy state.

Chapter 4: The Basic Robot System

Topics

Manufacturing and Robot Systems; Robot Arm; Robot Controller; Power Source; Tooling; Teaching/Programming Devices; Data Storage; Definition of Terms; Critical Specifications; Payload; Degrees of Freedom; Drive Power; Repeatability; Accuracy; Work Envelope Dimensions; Speed; Memory Capacity; Programming Support; End-of-Arm Tooling; Environmental Requirements

Objectives

- Name and describe the basic building blocks of an industrial robot.
- Name and describe the additional components that make up a robot system.
- Define the following robot terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point.
- Define and give an example of the following specifications for industrial robots: payload, repeatability, memory capacity, and environmental requirements.
- Explain the difference between accuracy and repeatability in robots.

Chapter 5: Robot Classification II

Topics

Classification by Arm Geometry; Cartesian (Rectangular) Arm Geometry; Cylindrical Arm Geometry; Spherical (Polar) Arm Geometry; Articulated Arm Geometry; Classification by Power Source; Classification by Path Control; Classification by Intelligence Level

Objectives

- Classify robots by arm geometry, power source, and path control techniques.
- Identify the basic robot work envelopes and name the arm geometries that produce them.
- Name the basic power sources used for robot motion and give an advantage and disadvantage of each.
- Identify the basic path-control techniques and describe their characteristics.

Introduction to Mechatronics

Course #SCP 490

Chapter 1: Introduction to Safety

Topics

Responsibility for Safety; Unsafe Acts and Conditions; Health Hazards; Accidents; Handling Emergencies; Safety Off the Job

Objectives

- Define the terms accident and hazard.
- Name and define the four main types of hazards.
- List and define various types of accidents.
- Compare meanings of unsafe act and unsafe condition.
- Name the three ways in which a toxic substance can enter your body.
- List ways in which a company must plan for emergencies.
- Tell the main reason for prompt accident investigation.

Chapter 2: Tool Safety

Topics

Screwdrivers; Wrenches; Pliers; Hammers and Mallets; Chisels and Punches; Knives; Electric Tools; Pneumatic Tools; Gasoline-Powered Tools

Objectives

- Name at least three causes of hand tool accidents.
- List one safety rule to follow when using each of the following: screwdriver, wrench, pliers, hammer, chisel, knife.
- Describe proper and improper dress for working with rotating power tools.
- Explain the importance of grounding electric tools.
- Name two hazards involved in pneumatic tool use and explain how to guard against them.
- Explain proper handling and storage of gasoline.

Chapter 3: Machine Safety

Topics

Point-of-Operation Guards; Fixed Guards; Special Guards; Power Transmission Guards; Other Safety Devices; OSHA Lockout/Tagout Procedures

Objectives

- Identify a machine's point of operation and other pinch points, and explain why they are dangerous.
- Identify different kinds of mechanical safeguards, and explain why they are necessary.
- Define zero energy state.
- Describe the lockout/tagout procedures established by the OSHA energy control standard.

Chapter 4: Units of Measurement

Topics

Kinds of Units; Length; Area; Volume; Angles; Time; Speed and Velocity; Mass and Weight; Force; Work and Power; Pressure; Temperature; Electricity

Objectives

- Identify various units of measurement.
- State the definition of the joule, the coulomb, and the horsepower.
- Explain how to calculate pressure.
- Explain the difference between mass and weight.
- Demonstrate how to measure the volume of an object.
- Explain the difference between the Celsius scale and the Fahrenheit scale.

Chapter 5: Metric Measurement

Topics

History; Measuring Terms; Length; Area and Volume; Mass; Time; Frequency; Speed and Velocity; Acceleration; Force and Weight; Work and Energy; Power; Temperature; Electric Current; Light; Amount of Substance; Using SI Units

Objectives

- List the seven base units in the SI (metric) system.
- Name three derived units.
- Define work and power in SI units.
- Explain what power is and how it is measured.
- Name two metric measuring instruments and their U.S. Standard equivalents.

Chapter 6: Linear Measurement

Topics

Units of Linear Measurement; Measurement Error; Tolerances; Measuring Devices; Scales and Rules; Scribers and Dividers; Bevel Gauge; Calipers; Combination Square; Reading a Vernier Scale; Using a Micrometer; Reading a Micrometer

Objectives

- List five units used for making linear measurements.
- Demonstrate how to use a micrometer.
- Explain what each head of a combination square is used for.
- State the definition of parallax error.
- Define the different types of tolerance.

Chapter 7: Surface Measurement

Topics

Comparison Measurement; Gauge Blocks; Measuring Screw Threads; Measuring Radius; Measuring Surface Texture; Hardness Testing; Testing Surface Coatings; Detecting Defects

Objectives

- Explain the difference between a continuous dial and a balanced dial on a dial indicator.
- the definition of pitch on a screw.
- Name two hardness tests.
- Explain why nondestructive testing is preferable to destructive testing on surface coatings.

Chapter 8: Bulk Measurement

Topics

Bulk Solids; Storing and Handling Bulk Solids; Conveyors; Measuring Area; Measuring Volume; Weight, Mass, and Density; Weighing Bulk Materials; Measuring Lumber

Objectives

- Explain why weight-density and the angle of repose are important to workers who handle and store loose bulk material.
- Name the two types of conveyors and list three specific examples of each type.
- Name the three basic measurements of bulk materials.
- Demonstrate how to find the radius of a circle, given its area, and how to find the area of a circle, given its circumference.
- Demonstrate how to convert a typical order of lumber into board feet.

Introduction to Mechatronics, Cont.
SCP 490

Chapter 9: Motion Measurement
Topics

Relative Motion; Displacement; Velocity; Acceleration; Average and Instantaneous Values; Motion on a Curved Path; Graphs of Motion

Objectives

- Name the three measurements of motion.
- State the definition of speed.
- Explain the difference between average and instantaneous velocity.
- Demonstrate how to interpret a graph of motion.
- Explain of the velocity of an object is shown on a graph of motion.

Chapter 10: Introduction to Blueprints
Topics

Importance of Blueprints; Purpose of Blueprints; Types of Information on Blueprints; Supplementary Spaces; Detail Drawings; Interpreting a Detail Drawing; Assembly Drawings; Orthographic Projections; Auxiliary Views; Sections; Pictorial Drawings

Objectives

- Identify details, markings, and machine parts from an assembly drawing.
- Identify an object from an orthographic drawing.
- Identify elements located within the title block of a detail drawing.
- Explain why more than one orthographic projection is needed to show an object on a blueprint.

Chapter 11: Building Drawings
Topics

Using Building Drawings; Buildings and Building Sites; Symbols and Conventions; Plat, Site Floor Plans; Working Drawings

Objectives

- Name building materials, given their standard symbols.
- Explain how to find useful information on a flow diagram.
- Explain how to find useful information on an industrial plat.
- List the contents of a set of building drawings.
- Describe the purpose of a structural drawing.

Chapter 12: Hydraulic and Pneumatic Drawings
Topics

Fluid Systems; Pascal's Law; Multiplying Forces; Pistons and Cylinders; Fluid System Components; Hydraulic and Pneumatic Symbol

Objectives

- Name the components represented by common symbols on hydraulic and pneumatic drawings.
- Name the components in a simple hydraulic power system.
- Name the components in a simple pneumatic power system.
- State Pascal's Law.
- Discuss the purposes of the components of hydraulic systems.

Chapter 13: Principles of Hydraulics
Topics

Fluid Power and Hydraulics; Force, Weight, and Mass; Pressure; Work, Power, and Energy; Incompressibility and Nondiffusion; Hydrostatic Pressure; Pascal's Law; Transmission of Fluid Power; Fluid Flow in Pipes; Bernoulli's Principle; The Effect of Heat on Liquids; Hydraulic Power Systems

Objectives

- Explain the difference between absolute and gauge pressure.
- Demonstrate how power is calculated.
- Explain Pascal's Law.
- Describe the difference between laminar and turbulent flow.
- Name the main components of a hydraulic system.

Chapter 14: Principles of Pneumatics
Topics

Fluid Power Systems; Pneumatic Systems; Force, Weight, and Mass; Pressure; Work and Energy; Diffusion and Dispersion; Separation of Gases and Liquids; Compressibility; Laws of Pneumatics; Transmission of Pneumatic Fluid Power; Pneumatic Leverage; Air Properties; Air Flow in Pipes; Viscosity of Air; Bernoulli's Law; Components of Pneumatic Power Systems

Objectives

- Explain how force is transmitted in a pneumatic system.
- Calculate force and work.
- List two factors that affect the results of pressure calculations.
- Explain pneumatic leverage.
- Briefly explain the physical laws affecting the behavior of a confined gas.

Chapter 15: Introduction to Programmable Logic Controllers
Topic

The Electromagnetic Relay; Characteristics of Programmable Controllers; Applications of Programmable Controllers; Limitations of Programmable Controllers; Parts of a Programmable Logic Controller System; The Input Side; The Processor; The Output Side; Programming Devices; Power Supplies

Objectives

- Describe an electromagnetic relay and define the terms control circuit, power circuit, NO and NC.
- Define programmable logic controller.
- Describe the general type of application in which a programmable logic controller would best be used, and give examples.
- Define scan time.
- Name each of the blocks in a block diagram of a programmable logic controller system and explain how each functions within the system as a whole.
- Define memory and explain the different types.

Introduction to Mechatronics, Cont.
SCP 490

Chapter 16: Robotics in Automated Manufacturing
Topics

Evolution of Robotics; What is an Industrial Robot?; Essential Characteristics; Robots and Automated Manufacturing; Project Manufacturing; Job Shop; Batch Manufacturing; Repetitive (Flow) Manufacturing; Continuous Manufacturing; Robot Safety

Objectives

- Identify why robots did not appear in large numbers in manufacturing until the late 1970s.
- State the Robot Industries Association's definition of an industrial robot and explain the two key words.
- Describe how industrial robots are used in batch production systems.
- Explain how industrial robots are used in repetitive manufacturing systems that utilize transfer lines.
- List at least three factors that should be considered as part of a risk assessment when a robot system is in the development stage.
- Describe and contrast the following guarding methods: barrier, presence-sensing device, awareness device, warning system.
- Define the term zero-energy state.

Chapter 17: The Basic Robot System
Topics

Manufacturing and Robot Systems; Robot Arm; Robot Controller; Power Source; Tooling; Teaching/Programming Devices; Data Storage; Definition of Terms; Critical Specifications; Payload; Degrees of Freedom; Drive Power; Repeatability; Accuracy; Work Envelope Dimensions; Speed; Memory Capacity; Programming Support; End-of-Arm Tooling; Environmental Requirements

Objectives

- Name and describe the basic building blocks of an industrial robot.
- Name and describe the additional components that make up a robot system.
- Define the following robot terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point.
- Define and give an example of the following specifications for industrial robots: payload, repeatability, memory capacity, and environmental requirements.
- Explain the difference between accuracy and repeatability in robots.

Automated Production Concepts I

Course #SCP 498

Chapter 1

Module 1: Introduction to Single-Phase Motors

Topics

Parts of a Single-Phase Motor; Definitions; NEMA Motor Standards; Motor Enclosures; Nameplate Data; Induction Motors; Single-Phase Stator Field; Single-Phase Rotor Field; Split-Phase Starting; Number of Poles; Electrical Degrees; Synchronous Speed; Starting Switches; Standard and Special Split-Phase Motors

Objectives

- List the parts of a rotor.
- List the data given on a typical motor nameplate.
- Explain how an induction motor works.
- Demonstrate how to calculate the number of electrical degrees in one complete rotation of a motor.
- Explain how a centrifugal switch works.

Module 2: Split-Phase Motors

Topics

Starting Single-Phase Motors; Stator Windings; Split-Phase Motor Connections; Identifying Motor Leads; Winding Connections; Skein Winding; Consequent-Pole Windings; Two-Speed Motors; Two-Speed, Three-Winding Motors; Four-Winding Motors; Dual-Voltage Motors; Troubleshooting Split-Phase Motors; Open Circuit in a Winding; Shorted Turns in a Winding; When a Motor Fails to Start; When a Motor Runs Slow

Objectives

- State the reason why a second stator winding is important in the single-phase induction motor.
- Explain how to identify motor leads when there are no tags or colors to identify them.
- Describe a skein winding.
- List the ways to change the speed of a motor by changing the number of poles.
- Discuss some common motor problems.

Module 3: Capacitor Motors

Topics

Kinds of Capacitor Motors; The Capacitor; Capacitor-Start Motor Operation; Rotating Magnetic Fields; Single-Voltage Reversible Motors; Single-Voltage Three-Lead Motors; Instantly Reversible Motors; Dual-Voltage Motors; Capacitor-Start Capacitor-Run Motors; Permanent-Split Motors; Reversible Capacitor-Run Motors; Two-Speed Capacitor-Run Motors; Troubleshooting Capacitor Motors; Symptoms and Causes of Motor Trouble; Replacing Capacitors

Objectives

- State the definition of a capacitor.
- Explain how to make a split-phase motor operate as a capacitor-start motor.
- Explain how the running windings are connected to make a dual-voltage motor run on either 120 or 240 volts.
- Select the best capacitor to use as a substitute for a defective capacitor when an identical unit is not available.
- List problems that cause the circuit breaker to trip when you turn on a capacitor motor.

Module 4: Repulsion Motors

Topics

Characteristics of Repulsion Motors; Repulsion-Start, Induction-Run Motors; The Repulsion Principle; Hard and Soft Neutral Planes; Purpose of the Brushes; Short-Circuiter; Commutator; Brush-Lifting Mechanism; Brush-Riding Motor; Brush Holders; Hard Neutral Setting; Brush Replacement; Repulsion Motor; Compensated Repulsion Motor; Repulsion-Induction Motor; Stator and Armature Windings; Equalizer Connections; Troubleshooting and Maintenance

Objectives

- Discuss the operating principles of a repulsion-start induction-run motor.
- Explain how to seat new brushes on the commutator.
- Discuss the functions of the major motor components.
- List the reasons a repulsion motor might fail to start.

Module 5: Synchros

Topics

A Synchro System; Rotor Construction; Stator Construction; Terminal-to-Terminal Stator Voltages; Synchro Assembly; Synchro Transmitter Operation; Receivers; A Simple Synchro System; Synchro Transmission Systems; Reversing a Receiver's Rotation; Differential Receivers and Transmitters; TX-TDX-TR Synchro Systems; Control Synchro Systems; The Control Transformer; CX-CT System

Objectives

- State the definition of the term synchro.
- Describe motor construction in a synchro.
- Demonstrate how to calculate terminal-to-terminal stator voltage.
- State the reason why the control transformer is important in a synchro control system.
- Explain how to connect a differential synchro system.

Module 6: Servos

Topics

Servomechanisms; Operation of a Basic Servomechanism; Amplidynes; Amplidyne Operation; Overtravel Control; DC Servomotors; AC Servomotors; Servocontrol Bridges; Servo Actuators

Objectives

- State the definition of a servomechanism.
- List the four characteristics needed to keep a regulated quantity matched to a reference valve in a servomechanism.
- Explain how an amplidyne control system works.
- Discuss how to control overtravel in a servomechanism.

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Chapter 2

Module 1: DC Power in Industry
Topics

Advantages of Direct Current; DC Generators; Rectifiers; DC Motors; SCR Speed Control; Storage Batteries; Charging Storage Batteries; Electroplating; Electropolishing; Electroforming; Electrolytic Refining; Electrolytic Furnaces; Arc Welding

Objectives

- List the advantages of dc over ac.
- List the brush problems caused by eddy currents.
- Name three types of batteries commonly used in the plant.
- Explain how the electroplating process works.
- Explain the difference between straight polarity and reversed polarity in arc welding.

Module 2: DC Generators
Topics

Parts of a DC Generator; Generator Action; A Simple DC Generator; Armature Reaction; Commutation; Interpoles; Separately Excited Generators; Shunt Generator; Series Generator; Compound Generators; Generator Losses; Parallel Operation of Generators

Objectives

- Explain the function of each of the main parts of the dc generator.
- Explain how to increase the number of pulses during each rotation of an armature.
- Demonstrate how to combine the shunt field and series field to produce a compound generator.
- State the reasons why electrical losses, magnetic losses, and mechanical losses occur in the dc generator.

Module 3: DC Motors
Topics

Principles of DC Motors; Counter-Electromotive Force (CEMF); Armature Reaction; Self-Induction and Commutation; Interpoles; Torque in DC Motors; Factors Determining Torque; Work and Power; Speed Regulation; Kinds of DC Motors; Shunt Motors; Torque Variation in a Shunt Motor; Effects of an Open-Shunt Field; Series Motor; Compound Motors; Cumulative Compound Motors; Differential Compound Motors

Objectives

- Explain what happens during self-induction and commutation.
- Define CEMF.
- State the difference between speed regulation and speed control.
- Name the kinds of dc motors.
- Explain the different operating characteristics of series, shunt, and compound motors.

Module 4: DC Armatures
Topics

Kinds of DC Armatures; DC Armature Windings; Simplex-Lap Windings; Simplex-Wave Windings; Armature Losses; Copper Loss; Eddy-Current Loss; Hysteresis Loss; Commutation; Armature Maintenance; Locating Armature Problems

Objectives

- Name the basic parts of an armature assembly.
- Describe the main differences between a lap winding and a wave winding.
- List the characteristics of a single-reentrant simplex-lap winding.
- State the definition of copper loss, eddy-current loss, and hysteresis loss.
- Demonstrate how to perform preventive maintenance on an armature.

Chapter 3

Module 1: Introduction to Controls
Topics

Development of Controllers; Purpose of Automatic Controllers; Kinds of Controllers; Variables; Process Dynamics; Final Control Elements; Current Proportioning; Position Proportioning; Time Proportioning; Controller Modes and Actions; Controller Terminology; Controller Alarms and Options; Advanced Controllers; Safety in Control Loops; Accuracy in Control Loops

Objectives

- Describe the kinds of controllers most often used in industrial applications.
- Discuss six important problems of process dynamics that controllers must overcome.
- Compare the actions of current proportioning, position proportioning, and time proportioning.
- Name four kinds of controller alarms.
- Discuss the importance of safety in control loops.

Module 2: Controller Operations
Topics

Kinds of Controllers; Automatic/Manual Control; Controller Range and Span; Direct- and Reverse-Acting Controllers; On/Off Controllers; Proportional Controllers; Controller Tuning; Kinds of Output; Current-Proportioning Control; Time-Proportioning Control;Position-Proportioning Control; Control Strategies

Objectives

- Explain why automatic/manual control is necessary.
- Explain how on/off controllers work and discuss the difference between on/off and proportional controllers.
- Describe a basic controller tuning process.
- Describe current-, time-, and position-proportioning controllers and name possible uses for each.
- Explain how split control works.

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Module 3: Controller Modes and Tuning
Topics

Controller Tuning; Proportional Mode; Offset; Integral Mode (Reset); Derivative Mode (Rate); Single-Mode Controller; Two-Mode Controller; Three-Mode Controller; Tuning the Control Loop; Step-Change Response Method

Objectives

- Describe the effect of the proportional, integral, and derivative modes on a controller's response to process changes.
- Discuss proper uses for the proportional, integral, and derivative modes.
- Explain how the proportional, integral, and derivative modes affect the tuning of a controller.
- Describe the procedure for tuning a controller by the step-change response method.

Module 4: Special Controller Applications and Options
Topics

Cascade Control; Feedforward Control; Ratio Control; Auctioneering Control; Hardware Options for Controllers; Auto/Manual Station; Remote Setpoint; Auxiliary Outputs; Indicators; Operational Features; Limits and Alarms

Objectives

- Compare cascade, feedforward, ratio, and auctioneering control strategies.
- Describe three optional features used with auto/manual controllers.
- Discuss the use of remote setpoint, auxiliary outputs, and several kinds of indicators as hardware options for controllers.
- Explain how input signal conditioning, anti-reset windup, adaptive gain, error-squared calculation, and setpoint/output ramp and clamp affect controller operation.
- Discuss the use of limit and alarm options available for controllers.

Module 5: Maintaining Controller Systems
Topics

Preventing Controller Problems; Electrical Noise; Electrical Noise Suppression; Regulating Primary Power; Electrical Coupling; Effects of Temperature Variations; Test Equipment; Test Connections; Maintenance and Troubleshooting

Objectives

- Describe five ways of suppressing electrical noise.
- Discuss the effects of an inadequate power supply and explain how to regulate it.
- Describe ways to avoid the harmful effects of electrical coupling.
- Explain how temperature variations affect controllers.
- Describe the kinds of equipment and proper connections needed to test controllers.
- Discuss elements of effective controller maintenance and troubleshooting.

Chapter 4

Module 1: DC Electromagnets
Topics

Magnets and Magnetic Materials; Magnetic Forces; Magnetic Fields; Effect of Distance on Magnetic Field Strength; Magnetic Shielding; Solenoids; U-Shaped Magnets; Reducing the Effects of Residual Magnetism; Uses for Solenoids; Choosing the Right Solenoid; Causes of Solenoid Problems; Relays; Polarized Relays; Protecting Relay Contacts

Objectives

- State the definition of residual magnetism.
- Explain the effects of distance on magnetic field strength.
- Discuss the characteristics and uses of solenoids.
- Discuss the characteristics of relays.

Module 2: DC Relays
Topics

Relay Operating Characteristics; Overload Relays; DC Motor Acceleration; Shunt Relays; Series Lockout Relays; Double-Coil Series Lockout Relays; Two-Coil Lockout Relays; Inductive Time-Delay Relays; Magnetic Blowout Coils; Dynamic Braking; Electrically Operated Brakes

Objectives

- Name three factors that determine the performance and reliability of a relay.
- Name the six types of commonly used relays.
- Explain the operation of each type of relay.
- Explain dynamic braking.
- Describe how a disc brake is attached to a motor.

Module 3: DC Controllers
Topics

Factors Affecting Motor Speed; Classification by Performance; Low-Voltage Protection; Overvoltage Protection; Low-Voltage Release; Overload Protection; Temperature Compensation; Controller Overload Reset; Manual Starters; Magnetic Controllers; Drum Controller

Objectives

- List the kinds of functions performed by motor-control devices.
- Name the types of motor controllers and discuss their operating characteristics.
- Explain how each of the three kinds of thermal overload relays works.
- Name the kinds of resets for overload relays.

Module 4: DC Power Supplies
Topics

Electron Emission; Electron Tubes; Vacuum-Tube Diode; Vacuum-Tube Diode Rectifiers; Semiconductors; Why Semiconductors Fail; Comparing Generators to Rectifiers; Automotive AC-DC Power Supply; Checking Diodes; Identifying Replacement Semiconductors

Objectives

- Discuss the operating principles of vacuum tubes and rectifiers
- Name the four types of filters commonly used in rectifier circuits.
- Identify a mercury-vapor diode.
- List common causes of semiconductor failure.
- State the criteria for selecting replacement semiconductors.

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Module 5: Silicon Controlled Rectifiers
Topics

Principles of SCRs; Pulse Timing in DC Circuits; Trigger Pulses; SCR Control of Motors; DC Applications of SCRs; AC-DC Conversion; AC Applications of SCRs

Objectives

- State the definition of a silicon controlled rectifier.
- Explain how an SCR works.
- Explain how to increase the effective current and the power delivered to a motor by an SCR motor control.
- List four dc applications of SCRs.

Chapter 5

Module 1: Motor Installation
Topics

Protecting Single-Phase Motors; Conductor Size; Preventing Shorts and Grounds; Single-Phase Motor Controllers; Overcurrent Protection; Disconnecting Devices; Guards and Grounding; Fuses; Selecting Fuses; Manual Single-Phase Starters; Integral-Horsepower Starters; Single-Phase Magnetic Starters; Selecting the Proper Motor; Service Factor; Classification of Insulation; Selecting Split-Phase Motors; Selecting Capacitor-Start Motors; Selecting Permanent Split-Capacitor Motors; Selecting Shaded-Pole Motors

Objectives

- Explain how to determine conductor size for motors.
- State the definition of a controller.
- List the conditions under which the frames of stationary motors must be grounded.
- Demonstrate how to determine the size of a dual-element when two or more motors are connected to one feeder.
- List the electrical and mechanical factors to consider in selecting a motor for a specific application.

Module 2: Motor Maintenance
Topics

General Maintenance Procedures; Testing Capacitors; Armature Defects; Testing Stator Windings; Locating Problems in Motors; Noisy Operation; Bearing Problems; High Temperatures; Incorrect Speed; Excessive Sparking at the Brushes; Test Equipment

Objectives

- Demonstrate how to test bearings for wear.
- Explain how to test capacitors.
- State the reason why proper belt tension in important.
- List the common causes of excessive brush sparking.

Module 3: Maintenance of DC Equipment
Topics

Inspection; Maintaining Field Coils; Locating Problems in Field Coils; Short-Circuited Field Coils; Open Field Coils; Replacing Field Coils; DC Motor Controllers; Maintaining Relays; Relay Contacts; Maintaining DC Armatures; Commutation; Maintaining the Commutator; Brush Selection and Care; Setting Brushes

Objectives

- Explain how to test field coils to determine the condition of the insulation.
- List the signs of a short-circuited field coil in a machine.
- Explain how to replace a field coil in a machine.
- Discuss how to maintain relay control.
- Name the criteria for satisfactory commutation.

Automated Production Concepts II

Course #SCP 499

Chapter 1

Module 1: History and Overview

Topics

Introduction; Development of Computers in Process Control; Business Computer Experiments; Supervisory Control and Data Acquisition (SCADA); Microprocessor-Based Instruments; Distributed Control; Personal Computers; Programmable Logic Controllers; Artificial Intelligence, Expert Systems, and Fuzzy Logic; Integrated Control Systems

Objectives

- Discuss the history of the application of computers to continuous and batch process control.
- Describe the function of an RTU in a SCADA system.
- Describe the development of distributed control systems from microprocessor-based instruments, including programmable logic controllers.
- Compare the hardware, operating systems, software, and applications of a PC with a household VCR.
- Compare the concepts of artificial intelligence, expert systems, and fuzzy and crisp logic.

Module 2: Small Computers in Process Control

Topics

Small Computers; Smart Sensors and Transmitters; Smart Signal Conditioners; Smart Final Control Elements; Special Instruments; Microprocessor-Based Panelboard Instruments; Single-Loop Controllers; Multiloop Controllers; Networks; Microprocessor-Based Indicator Circuits; Microprocessor-Based Recorders; Programmable Logic Controllers; Integrated Control Systems; Personal Computers

Objectives

- Describe the various kinds of small computers used in process control.
- Explain how a "smart" device differs from its conventional counterpart.
- Discuss the similarities between microprocessor-based instruments and conventional instruments and list several advantages of microprocessor-based instruments.
- Describe the roles of two kinds of PCs (programmable controllers and personal computers) in process control.

Module 3: DCS Architecture

Topics

Importance of Distributed Control Systems; Distributed Control System Hardware; Workstations; Remote Processing Units;Host/Guest Computers; Transmission System; Distributed Control System Software; Distributed Control System Reliability; Peripherals; What is Fieldbus?

Objectives

- Describe the elements of a typical workstation.
- Discuss the functions of remote processing units and host/guest computers in DCSs.
- Compare star, hub, and ring network topologies and token-passing, contention, and polling protocols.
- Explain why today's DCS users must be more computer literate than previously.
- Discuss ways of calculating and ensuring DCS reliability.
- Describe the functions of six typical DCS peripherals.
- List advantages and disadvantages of all-digital process control systems, such as fieldbus.

Module 4: DCS Configuration and Operation

Topics

Setting Up Distributed Control Systems; Configuration; Hierarchical Displays; DCS Model TPC-284; Preparation for Configuration; Configuring Operating Displays; Configuring Auxiliary Displays; Operation

Objectives

- Describe the basics of a simple configuration process.
- Discuss the preparatory steps required for configuration.
- Describe a typical hierarchical display arrangement and discuss the progression of the configuration process from level to level.
- Discuss the automatic configuration of auxiliary displays.
- Discuss the DCS functions for which the operator is and is not responsible.

Module 5: Systems and Application Integration

Topics

The Scope of Integration; Total Business Integration; Discrete Processes and Manufacturing Systems; Flexible Manufacturing and Materials Control; Statistical Process Control; Integration of Continuous and Batch Processes

Objectives

- Discuss the development of integration in industry.
- Describe how continuous and discrete processes fit into the concept of total business integration.
- Describe the purposes of MAP and OSI.
- Discuss the functions of CAD, CADD, CAE, CAM, and cell control in discrete processes.
- Discuss the importance of FMS, MRP, JIT, and MMS in today's integrated industrial plant.
- Explain how SPC ensures quality control in open-loop processes.
- Discuss the advantages of integrating batch, continuous, and discrete processes throughout a plant.

Chapter 2

Module 1: Digital Logic Fundamentals

Topics

Digital Logic; Boolean Algebra; Logical AND, OR, NOT Function; Positive and Negative Logic; NAND Logic; Combining Logic Circuits; TTL Logic; IC Logic Devices

Objectives

- Explain the difference between digital and analog circuits.
- Describe AND, NOT, and OR logic functions.
- Explain how solid-state switches can perform logic functions.
- Compare equivalent NAND and NOR gates using positive and negative logic.
- Discuss the importance of TTL and CMOS circuits.

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SCP 499

Module 2: Logic Building Blocks
Topics

Sequential Logic; Flip-Flops; Clocked Flip-Flops; Clock Circuits; Schmitt Triggers; Frequency Dividers; Pulse Counters; Decimal and Binary Number Systems; Other Number Systems

Objectives

- Describe the function of a logic clock.
- Explain the operation of a flip-flop.
- Discuss the differences among clocked R-S flip-flops, D-latches, and J-K master-slave flip-flops.
- Explain how to convert between the decimal and binary number systems.
- Discuss the use of BCD and the octal and hexadecimal number systems.

Module 3: Medium- and Large-Scale ICs
Topics

Integrated Circuits Defined by Size; Counters; Serial vs Parallel Data Transmission; Registers; Multiplexers; Decoders/Demultiplexers; Arithmetic Circuits; LSI Memories

Objectives

- Explain the operation of each of the following counters: ripple, BCD, synchronous, and up/down.
- Describe the operation of a shift register.
- Discuss the difference between multiplexers and decoders/demultiplexers.
- Define the terms read, write, serial access, and random access as they apply to memories.
- Discuss the purposes of RAM and ROM devices.

Module 4: Functional Logic Systems
Topics

Logic System Basics; Logic Subsystems; ROM Logic Subsystems; Microprocessors; Input/Output (I/O) Subsystems; Noncontact Switches; Multiple-Bit I/O Devices; Data Codes; Data Displays; Data Transfer

Objectives

- Describe the sections of a basic logic system.
- Compare a ROM, a PROM, and a PLA.
- Name the basic parts of a microprocessor.
- Describe common kinds of I/O interfaces and data displays.

Module 5: Troubleshooting Logic Systems
Topics

Reliability of Solid-State Components; External Faults; General Troubleshooting Practices; Gathering Information; Isolating the Problem to a Major Subsystem; Localizing the Trouble; Interpreting Logic Diagrams; Timing Waveforms; Locating Faulty Components; Test Equipment

Objectives

- Describe seven external faults that can affect solid-state circuits.
- List the major steps in efficient troubleshooting.
- Name information sources for identifying system malfunctions.
- Explain how to trace a faulty component by using a troubleshooting tree.
- Explain how to use various kinds of test equipment to pinpoint system faults.

Chapter 3

Module 1: Robotics in Automated Manufacturing
Topics

Evolution of Robotics; What is an Industrial Robot?; Essential Characteristics; Robots and Automated Manufacturing; Project Manufacturing; Job Shop; Batch Manufacturing; Repetitive (Flow) Manufacturing; Continuous Manufacturing; Robot Safety

Objectives

- Identify why robots did not appear in large numbers in manufacturing until the late 1970s.
- State the Robot Industries Association's definition of an industrial robot and explain the two key words.
- Describe how industrial robots are used in batch production systems.
- Explain how industrial robots are used in repetitive manufacturing systems that utilize transfer lines.
- List at least three factors that should be considered as part of a risk assessment when a robot system is in the development stage.
- Describe and contrast the following guarding methods: barrier, presence-sensing device, awareness device, warning system.
- Define the term zero-energy state.

Module 2: The Basic Robot System
Topics

Manufacturing and Robot Systems; Robot Arm; Robot Controller; Power Source; Tooling; Teaching/Programming Devices; Data Storage; Definition of Terms; Critical Specifications; Payload; Degrees of Freedom; Drive Power; Repeatability; Accuracy; Work Envelope Dimensions; Speed; Memory Capacity; Programming Support; End-of-Arm Tooling; Environmental Requirements

Objectives

- Name and describe the basic building blocks of an industrial robot.
- Name and describe the additional components that make up a robot system.
- Define the following robot terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point.
- Define and give an example of the following specifications for industrial robots: payload, repeatability, memory capacity, and environmental requirements.
- Explain the difference between accuracy and repeatability in robots.

Module 3: Robot Classification I
Topics

Robot Classification; Classification by Control System; Open-Loop Control; Nonservo Operation; Advantages of Open-Loop Control; Disadvantages of Open-Loop Control; Applications for Open-Loop Control; Closed-Loop Control; Advantages of Closed-Loop Control; Disadvantages of Closed-Loop Control; Applications for Closed-Loop Control; Classification by Application

Objectives

- Identify the five methods of classifying industrial robots.
- Explain the difference between robots with closed-loop control and those with open-loop control.
- Describe the techniques used in closed- and open-loop control in robot systems.
- List the advantages and disadvantages of open-and closed-loop control in robot systems.
- Distinguish between assembly and nonassembly robots according to the application for which they were designed.

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SCP 499

Module 4: Robot Classification II
Topics

Classification by Arm Geometry; Cartesian (Rectangular) Arm Geometry; Cylindrical Arm Geometry; Spherical (Polar) Arm Geometry; Articulated Arm Geometry; Classification by Power Source; Classification by Path Control; Classification by Intelligence Level

Objectives

- Classify robots by arm geometry, power source, and path control techniques.
- Identify the basic robot work envelopes and name the arm geometries that produce them.
- Name the basic power sources used for robot motion and give an advantage and disadvantage of each.
- Identify the basic path-control techniques and describe their characteristics.

Chapter 4

Module 1: Work-Cell Sensors
Topics

Sensor Overview; Simple Contact Sensors; Simple Noncontact Sensors; Simple Process Control Sensors; Complex Sensors; Complex Sensor Interface; Complex Contact Sensors; Complex Noncontact Sensors; Complex Process Control Sensors

Objectives

- List the two types of interfaces and three groups of sensors used in industrial robot systems.
- Describe the primary simple contact sensor commonly found in robot systems.
- Identify and explain the operation of the two simple noncontact sensors most often used in industrial robot installations.
- Explain the difference between the simple sensor interface and complex sensor interface.

Module 2: End-of-Arm Tooling
Topics

General Requirements; Tooling Terms; Tooling Power Sources; Tooling Overview; Standard Grippers; Servo or Nonservo Grippers; Vacuum Devices; Magnetic Devices; Flexible Pneumatic Devices; Special-Purpose Tooling; Protecting End-of-Arm Tooling; Compliance

Objectives

- Name the five general requirements all tooling must satisfy.
- Identify and describe briefly the four basic tooling power sources.
- Describe the five categories of end-of-arm tooling used in robot applications.
- Explain the function and advantages of a quick-change device.
- Define the term compliance and explain why it is important.

Module 3: Robot Teaching and Programming
Topics

Work-Cell Programming; Controller Functions; Robot Programming; On-Line Programming; On-Line Programming Example; Off-Line Programming; Defining Programmed Points; Writing Program Statements; Work Cell Control with a PLC; PLC Programming Example

Objectives

- List and describe the four basic functions of the computer(s) controlling an automated work cell.
- Name the two major types of robot programming and give advantages and disadvantages of each.
- Name and describe two basic methods of teach programming and tell when each is used.
- List three advantages of off-line programming.
- Name the two elements of a computer program for off-line robot programming.
- Explain the basics of ladder logic programming.