

Learning Objectives for NCIST Integrated Systems Technology Program

MECHANICAL TECHNOLOGY

HYDRAULICS CLASS 1

LAP 1 Hydraulic Power Systems

Objectives

- 1 Define hydraulics and give an application
- 2 Describe the functions of five basic components of a hydraulic system
- 3 Define hydraulic pressure and give its units of measurement
- 4 Describe the operation of a hydraulic power unit
- 5 Describe the function of a hydraulic schematic
- 6 Describe the function of a hydraulic quick disconnect fitting and give its schematic symbol
- 7 Describe the function of a tee and give its schematic symbol
- 8 Describe the operation of a pressure gage and give its schematic symbol
- 9 Describe the function of a hydraulic cylinder and give an application
- 10 Describe the operation of a double-acting hydraulic cylinder and give its schematic symbol
- 11 Describe the operation of a 3-position, 4-way DCV and give an application
- 12 Describe the operation of a 3-position, 4-way DCV and give its schematic symbol

Skills

- 1 Read a hydraulic pressure gage
- 2 Read the liquid level and temperature in the reservoir
- 3 Operate a hydraulic power unit
- 4 Connect and disconnect a hydraulic hose that uses quick-connect fittings
- 5 Use a tee to connect two circuit branches together
- 6 Connect and operate a double-acting hydraulic cylinder using a 3-position, manually-operated DCV
- 7 Design a dual cylinder hydraulic circuit

LAP 2 Basic Hydraulic Circuits

Objectives

- 1 Define flow rate and explain how it can be measured
- 2 Describe the operation of two types of flowmeters and give their schematic symbol
- 3 Describe the operation of a fixed-displacement pump and give its schematic symbol
- 4 Describe the operation of three types of fixed displacement pumps and give an application of each
- 5 Describe the main function of a needle valve
- 6 Describe the operation of a needle valve and give its schematic symbol
- 7 Describe the function of a hydraulic motor and give an application
- 8 Describe the operation of a hydraulic motor and give its schematic symbol

- 9 List three types of hydraulic motors and give an application of each
- 10 Describe eight basic rules for drawing hydraulic schematics

Skills

- 1 Connect and read a flow meter
- 2 Connect and operate a needle valve to control the speed of an actuator
- 3 Control the speed of an actuator using a manually-operated DCV
- 4 Connect and operate a bi-directional hydraulic motor using a 3-position, manually-operated DCV
- 5 Draw a hydraulic schematic from the actual circuit connections on a pictorial
- 6 Connect a hydraulic circuit given a schematic
- 7 Design a multiple actuator hydraulic circuit

LAP 3 Principles of Hydraulic Pressure and Flow

Objectives

- 1 Describe how to calculate the actual force output of an extending cylinder
- 2 Describe how to calculate the force output of a hydraulic cylinder in retraction (pull)
- 3 State Pascal's Law and explain its significance in hydraulics
- 4 Explain how force is multiplied using Pascal's Law
- 5 Describe two types of resistance in a hydraulic system
- 6 Explain how Delta P describes hydraulic resistance
- 7 Explain how pressure is distributed in a hydraulic system
- 8 Describe two methods of representing hydraulic pressure
- 9 Describe how oil flows on the suction side of the pump

Skills

- 1 Calculate the extension force of a cylinder given its size and pressure
- 2 Measure the force output of an extending cylinder
- 3 Calculate the retraction force of a cylinder given its size and pressure
- 4 Measure the force output of a retracting cylinder
- 5 Measure Delta P across a hydraulic component
- 6 Convert between absolute pressure and gage hydraulic pressure

LAP 4 Hydraulic Speed Control

Objectives

- 1 Describe the function of a relief valve and give an application
- 2 Describe the operation of a direct-acting relief valve and give its schematic symbol
- 3 Describe how a relief valve is used for system protection
- 4 Describe how a relief valve is used for speed control assistance
- 5 Describe the function of a check valve and give an application
- 6 Describe the operation of three types of check valves and give their schematic symbol
- 7 Describe the function of the flow control valve and give an application
- 8 Describe the operation of a flow control valve and give its schematic symbol

- 9 Describe the effect of actuator load changes on flow control valve operation
- 10 Describe the operation of a meter-in flow control circuit and give an application
- 11 Describe the operation of a meter-out flow control circuit and give an application
- 12 Define independent speed control and give an application
- 13 Explain how speed control valves can be used to provide multiple speeds
- 14 Describe how to calculate the extend speed of a hydraulic cylinder
- 15 Describe how to calculate the retract speed of a cylinder
- 16 Describe how to calculate the stroke time of a cylinder

Skills

- 1 Connect a relief valve in a circuit to limit pressure in the system
- 2 Design a circuit to provide bypass flow
- 3 Connect and adjust a flow control valve to control speed of an actuator
- 4 Connect and operate a meter-in flow control circuit
- 5 Connect and operate a meter-out flow control circuit
- 6 Design an independent speed control circuit
- 7 Design a two-speed actuator circuit
- 8 Calculate the extend speed of a hydraulic cylinder given its size and a flow rate
- 9 Calculate the retract speed of a cylinder given its size and a flow rate
- 10 Calculate the cylinder stroke time given its size and a flow rate

LAP 5 Pressure Control Circuits

Objectives

- 1 Describe the function of a pressure sequence valve and give an application
- 2 Describe the operation of a direct-acting sequence valve and give its schematic symbol
- 3 Describe the function of a by-pass check valve in a sequence valve circuit
- 4 Describe the operation of an integral check valve and give its schematic symbol
- 5 Describe the function of a two-sequence valve control circuit
- 6 Explain why a sequence valve is externally drained
- 7 Describe the function of a pressure reducing valve and give an application
- 8 Describe the operation of a direct-acting PRV and give its schematic symbol
- 9 Describe the function of a PRV's bypass check valve
- 10 Explain why a PRV is externally drained

Skills

- 1 Connect and adjust the pressure setting of a sequence valve
- 2 Connect and operate a pressure sequence circuit
- 3 Design a pressure sequence circuit
- 4 Design a two-sequence valve control circuit
- 5 Connect and adjust the pressure setting of a PRV
- 6 Connect and operate a reduced pressure circuit
- 7 Design a hydraulic circuit that uses a pressure reducing valve

HYDRAULICS CLASS 2 (Replaced by Pneumatics Class 2 in Pneumatics Option)

LAP 1 Hydraulic DCV Applications

Objectives

- 1 Describe and explain the terms used to specify DCVs
- 2 Describe the function of a hydraulic 4/2 DCV and name one application
- 3 Describe the operation of a hydraulic 4/2 DCV and give its schematic symbol
- 4 Describe the function of a hydraulic 3/2 DCV and name one application
- 5 Describe the operation of a hydraulic 3/2 DCV and give its schematic symbol
- 6 Describe the function of a hydraulic pilot-operated DCV and name one application
- 7 Describe the operation of a hydraulic pilot-operated DCV and give a schematic symbol
- 8 Describe the function of a hydraulic cam-operated valve and name one application
- 9 List and describe the applications of two types of hydraulic cam-operated valves
- 10 Describe the operation of a hydraulic 4/2 cam-operated valve and give its schematic symbol

Skills

- 1 Connect and operate a hydraulic DCV with a tandem-center spool
- 2 Select a spool option for a hydraulic DCV based on application information
- 3 Connect and operate a hydraulic 4/2 DCV
- 4 Connect and operate a 4/2 DCV to function as a 3/2 DCV
- 5 Design a hydraulic circuit using a 2-position DCV
- 6 Connect and operate a hydraulic pilot-operated DCV
- 7 Connect, adjust and operate a hydraulic cam-operated valve
- 8 Design a hydraulic sequence circuit that uses a cam-operated hydraulic valve
- 9 Design a hydraulic rapid traverse - slow feed circuit that uses a cam-operated valve

LAP 2 Hydraulic Cylinder Applications

Objectives

- 1 Describe the operation of four types of cylinders and give an application of each
- 2 Describe the construction of two types of cylinders and give an application
- 3 Describe three common cylinder mounting styles and give an application
- 4 Describe three common cylinder feature options
- 5 Describe the principle of cylinder regeneration and name an application
- 6 Describe the operation of a basic regeneration circuit
- 7 Describe how to calculate the extend speed of a cylinder in regeneration
- 8 Describe how to calculate the extend force of a cylinder in regeneration
- 9 Describe the function of a pressure-compensated flow control valve and name one application
- 10 Describe the operation of a pressure-compensated flow control valve and give its schematic symbol
- 11 Describe the function of a double-rod cylinder and name one application
- 12 Describe the operation of a double-rod cylinder and give its symbol
- 13 Define cylinder synchronization and name three application
- 14 Explain why cylinders do not operate in synchronization

- 15 List and describe the operation of five methods used to synchronization circuit using flow control valves

Skills

- 1 Select a cylinder mounting style for a given application
- 2 Connect and operate a basic regenerative circuit
- 3 Calculate the extend speed of a cylinder in regeneration
- 4 Calculate the extend force of a cylinder in regeneration
- 5 Connect and operate a pressure compensated flow-control valve
- 6 Set up, adjust, and operate a cylinder synchronization circuit using flow control valves
- 7 Set up and operate a synchronization circuit using series actuators

LAP 3 Hydraulic Relief Valve Operation

Objectives

- 1 Explain the advantage of a pilot-operated relief valve
- 2 Describe the operation of a pilot-operated relief valve and give its complete schematic symbol
- 3 Describe the function of the vent port of a pilot-operated relief valve
- 4 Describe two methods of pump unloading and give an application of each
- 5 Describe the operation of a remote-controlled relief valve circuit
- 6 Describe multiple pressure relief valve operation and give one application

Skills

- 1 Connect a pilot-operated relief valve to unload a pump by venting
- 2 Connect and operate a remotely controlled p.o. relief valve circuit
- 3 Design a circuit to provide a two-pressure control with unloading

LAP 4 Hydraulic Check Valve Applications

Objectives

- 1 Explain how actuator relaxation occurs in a multi-actuator circuit
- 2 Describe the operation of a P-port check valve circuit
- 3 Design the construction of an integral P-port check valve
- 4 Describe the function of a pilot-operated check valve and give its schematic symbol
- 5 Describe the operation of a pilot-operated check valve and give an application
- 6 Describe the operation of load-lock circuits using one POC valve
- 7 Describe the operation of load-lock circuit that use two POC valves
- 8 Describe the operation of a double-POC check valve
- 9 Describe the function of a prefill valve and give an application
- 10 Define POC valve pilot ratio and explain its importance
- 11 Describe how to calculate the pressure required to open a POC valve
- 12 Define pressure intensification and explain its importance
- 13 Describe how to calculate the maximum pressure in a POC valve circuit
- 14 Describe the function and operation of a POC valve with decompression poppet

15 List five application guidelines for POC valves

Skills

- 1 Connect and operate a P-port check valve circuit
- 2 Connect and operate a hydraulic pilot-operated check valve
- 3 Connect and operate a load-lock circuit using a pilot-operated valve
- 4 Measure pilot-operated check valve pilot pressure
- 5 Calculate the pilot pressure required to open a POC valve
- 6 Calculate the maximum pressure in a POC valve circuit
- 7 Design a POC valve circuit

Pneumatics Class 2 (Replaced by Hydraulics Class 2 in Hydraulics Option)

LAP 1 PNEUMATIC DCV APPLICATIONS

Objectives

- 1 Describe the function of a pneumatic cam-operated valve and give an application
- 2 Describe the operation of a pneumatic cam-operated DCV and give its schematic symbol
- 3 Describe the operation of a 2-speed pneumatic circuit using a cam valve
- 4 Describe three methods of decelerating a pneumatic cylinder
- 5 Describe the function of two-way valves
- 6 Describe the construction and operation of five types of two-way valves

Skills

- 1 Connect and operate a pneumatic cam-operated 4/2 DCV
- 2 Connect and operate a pneumatic cam-operated 3/2 DCV
- 3 Design a rapid traverse-slow feed pneumatic circuit
- 4 Design a pneumatic circuit to sequence two cylinders
- 5 Connect and operate a cylinder deceleration circuit using power braking
- 6 Connect and operate a two-way valve

LAP 2 AIR LOGIC

Objectives

- 1 Describe the function of an externally air-piloted DCV and give an application
- 2 Describe the function of a detent and give its schematic symbol
- 3 Describe four types of pneumatic DCV construction
- 4 Describe the operation of an externally air-piloted DCV and give its schematic symbol
- 5 Define air logic and give two applications
- 6 List four advantages and four disadvantages of air logic
- 7 Describe the operation of an air logic cylinder sequence circuit
- 8 Describe the function of a shuttle valve and give an application
- 9 Describe the operation of a shuttle valve and give its schematic symbol
- 10 Describe the operation of a pneumatic seal-in circuit

Skills

- 1 Connect and operate an externally air-piloted DCV using the manual override
- 2 Design a pneumatic circuit that uses an externally air-piloted DCV
- 3 Connect and operate a cam-operated sequence circuit
- 4 Connect and operate an air logic circuit to control a reciprocating cylinder

LAP 1 MOVING LOADS PNEUMATICALLY

Objectives

- 1 Describe the two types of pneumatic cylinder loads
- 2 Describe four forces that act against cylinder movement
- 3 Describe three load factors that affect a pneumatic cylinder circuit operation
- 4 Describe how cylinder sizes are specified
- 5 Describe five common tie rod cylinder mounting styles and give an application of each
- 6 Describe the function of a quick exhaust valve and give an application
- OBJECTIVE 7 Describe the operation of a quick exhaust valve and give its schematic symbol
- 8 Describe the operation of a pressure regulator under flow conditions
- 9 Explain how a regulator and a 3-way valve can be used in a double-acting cylinder application
- 10 Describe how to size a pneumatic cylinder
- 11 Describe the function of an oversized cylinder rod
- 12 Describe the function of a stop tube and give an application
- 13 Explain how to determine pneumatic cylinder air flow rate for a given speed
- 14 Describe the operation of two types of hand-held tachometers used to measure motor speed
- 15 Define pneumatic motor torque and give its units of measurement
- 16 Define three types of torque specifications: starting, breakaway, and running
- 17 Describe how to use a torque-speed curve to determine pneumatic motor speed
- 18 Describe how to size a pneumatic motor
- 19 Explain how to calculate the flow rate needed for a pneumatic motor
- 20 Describe the function of an air bearing and give an application
- 21 Describe how to size an air bearing

Skills

- 1 Select a cylinder mounting style for a given application
- 2 Connect and operate a quick exhaust valve
- 3 Connect and operate a 3-way valve and regulator in a double-acting cylinder application
- 4 Size a pneumatic cylinder given a load
- 5 Calculate the air flow rate needed to cycle pneumatic cylinders
- 6 Measure pneumatic motor speed using a strobe-light tachometer
- 7 Select a pneumatic motor
- 8 Calculate the air flow needed for a pneumatic motor
- 9 Size an air bearing given a load
- 10 Connect and operate an air bearing

LAP 2 VACUUM SYSTEMS

Objectives

- 1 Define a vacuum and give three industrial applications
- 2 List and describe three methods of representing vacuum pressure

- 3 List and give an advantage of each of three devices used to measure vacuum levels
- 4 Describe the operation of two types of manometers
- 5 List two methods used to produce vacuums and give an advantage of each
- 6 Describe the operation of a Venturi (Bernoulli's Law) and give an application
- 7 Describe the operation of a vacuum cup
- 8 Describe the operation of a vacuum lifter and give an application

Skills

- 1 Convert between units of mercury and units of air pressure
- 2 Connect and read a vacuum gage
- 3 Convert between units of water column and units of water pressure
- 4 Connect and read a manometer
- 5 Connect and operate a vacuum generator
- 6 Calculate vacuum cup lift force
- 7 Connect and operate a vacuum cup
- 8 Design the vacuum cup portion of a handling rack

Electro-Fluid Power Class 1

LAP 3 Power Devices

Objectives

- 1 Describe the function of a power diagram
- 2 Describe the function of electro-hydraulic controls and give an application
- 3 Describe the operation of two types of hydraulic solenoids and explain the application of each
- 4 Describe the operation of a solenoid-operated hydraulic DCV and give its schematic symbol
- 5 Describe the function and operation of a hydraulic DCV manual override
- 6 Describe the function of electro-pneumatic controls and give an application
- 7 Describe the operation of two types of solenoid-operated pneumatic DCVs
- 8 Describe the operation of a pneumatic DCV
- 9 Describe the function and operation of a pneumatic DCV manual override
- 10 Describe the function of a control transformer
- 11 Describe the operation of a control transformer and give its schematic symbol
- 12 Describe the function of circuit protection and list two types
- 13 Describe the operation of a fuse and give its schematic symbol
- 14 Describe the operation of a circuit breaker and give its schematic symbol

Skills

- 1 Use the manual override of a solenoid-operated hydraulic DCV to jog a cylinder
- 2 Connect and operate a double-acting cylinder using a 4/3 solenoid-operated hydraulic DCV
- 3 Connect and operate a double-acting cylinder using a 4/2 solenoid-operated DCV
- 4 Connect and operate a hydraulic motor using a 4/2 solenoid-operated DCV
- 5 Use the manual override of a solenoid-operated pneumatic DCV to jog a cylinder
- 6 Connect and operate a double-acting cylinder using a 5/3 solenoid-operated pneumatic DCV
- 7 Connect and operate a single-acting cylinder using a 5/2 solenoid-operated pneumatic DCV
- 8 Connect and operate a unidirectional pneumatic motor using a 5/2 solenoid-operated DCV
- 9 Replace a fuse

LAP 4 Control Relays

Objectives

- 1 Describe the function of a control relay and give an application
- 2 Describe the operation of an electromechanical relay and give its ladder diagram symbol
- 3 Describe the construction of a general purpose relay and give an application
- 4 Describe how relay contacts are specified
- 5 Describe the construction of a machine control relay
- 6 Describe the operation of a relay used to energize a fluid power valve solenoid
- 7 Describe the operation of a relay to perform control logic
- 8 Describe the function of a seal-in circuit
- 9 Describe the operation of a seal-in circuit
- 10 Describe the operation of a uni-directional motor control start/stop circuit
- 11 Describe the operation of a bi-directional motor control start/stop circuit

Skills

- 1 Connect and operate a relay given a ladder diagram
- 2 Connect and operate a relay to energize a fluid power solenoid
- 3 Connect and operate a relay to perform a seal-in relay function
- 4 Design a logic circuit that uses a relay
- 5 Connect and operate a uni-directional motor control start/stop circuit
- 6 Connect and operate a bi-functional motor control start/stop circuit
- 7 Design a motor control circuit with multiple start/stop pushbuttons
- 8 Design a bi-directional motor control circuit that uses a single pushbutton

LAP 5 Sequencing Control

Objectives

- 1 Describe the function of a limit switch and give an application
- 2 Describe the operation of a limit switch and give its schematic symbol
- 3 Describe how to interpret limit switch symbols
- 4 Describe the construction of a heavy duty limit switch and give an application
- 5 Describe the construction of a light duty limit switch and give an application
- 6 Describe the operation of limit switch in an event sequencing circuit
- 7 Describe the operation of a single-cycle cylinder reciprocation circuit
- 8 Describe the operation of a continuous-cycle reciprocation circuit
- 9 Describe the operation of a single-cycle reciprocation circuit with a 2-solenoid DCV
- 10 Describe the function of multiple cylinders in a machine
- 11 Describe how multiple cylinders are controlled using one limit switch and give an application
- 12 Describe how multiple cylinders are controlled with multiple limit switches and give an application

Pneumatics 1 Class

LAP 1 Pneumatic Power Systems

Objectives

- 1 Define pneumatics and give an application
- 2 Describe the functions of basic components of a pneumatic system
- 3 Define pneumatic pressure and give its units of measurement
- 4 Describe the function of a pneumatic schematic
- 5 Explain six pneumatic safety rules
- 6 Describe the function of a pressure regulator valve and give an application
- 7 Describe the operation of a pressure regulator and give its schematic symbol
- 8 Describe the function of an air filter
- 9 Describe the operation of an air filter and give its schematic symbol
- 10 Describe the function of a pneumatic quick connect fitting and give its schematic symbol
- 11 Describe the function of a tee and a cross and give their schematic symbols
- 12 Describe the function of a pneumatic cylinder and give an application
- 13 Describe the operation of a double-acting pneumatic cylinder and give its schematic symbol
- 14 Describe the function of a 5-way, 3-position pneumatic DCV and give an application
- 15 Describe the operation of a 5-way, 3-position pneumatic DCV and give its schematic symbol

Skills

- 1 Read a pneumatic pressure gage
- 2 Connect and adjust a pressure regulator
- 3 Drain a pneumatic filter
- 4 Connect a pneumatic hose that uses quick-connect fittings
- 5 Use a tee to connect two circuit branches together
- 6 Use a cross to connect three circuit branches together
- 7 Connect and operate a double-acting pneumatic cylinder using a 3-position, manually-operated DCV
- 8 Design a multiple cylinder pneumatic circuit

LAP 2 Basic Pneumatic Circuits

Objectives

- 1 Describe the function of a single-acting pneumatic cylinder and give an application
- 2 Describe the operation of a single-acting, spring-return cylinder and give its schematic symbol
- 3 Describe the function of a 3/2 pneumatic DCV and give an application
- 4 Describe the operation of a 3/2 pneumatic DCV and give its schematic symbol
- 5 Describe the function of a pneumatic motor and give an application
- 6 Describe the operation of a pneumatic motor and give its schematic symbol
- 7 Describe the function of a muffler and give its schematic symbol
- 8 List three common pneumatic motor designs and explain where they are used
- 9 Describe the line symbols used with fluid power circuits
- 10 Describe seven basic rules for drawing pneumatic schematics

Skills

- 1 Connect and operate a single-acting pneumatic cylinder using a 3/2 manually-operated DCV
- 2 Connect and operate a unidirectional pneumatic motor using a 3-way, manually-operated DCV
- 3 Identify pneumatic symbols
- 4 Draw a pneumatic schematic from the actual circuit connections on the machine
- 5 Connect a pneumatic circuit given a schematic
- 6 Design a multiple actuator pneumatic circuit

LAP 3 Principles of Pneumatic Pressure and Flow

Objectives

- 1 Describe how to calculate the force output of an extending cylinder
- 2 Describe how to calculate the force output of a cylinder in retraction (pull)
- 3 State Pascal's Law and explain its significance in pneumatics
- 4 Explain how force is multiplied using Pascal's Law
- 5 Describe two methods of representing pressure
- 6 Explain how air pressure is created in a pneumatic system
- 7 State Boyle's Law and explain its significance
- 8 Explain how a pneumatic system creates air flow
- 9 Describe two types of resistance in a pneumatic system
- 10 Explain how Delta P describes pneumatic resistance and explain its importance
- 11 Describe what determines the speed of a pneumatic actuator

Skills

- 1 Calculate the extension force of a cylinder given its size and pressure
- 2 Measure the force output of an extending cylinder
- 3 Calculate the retraction force of a cylinder given its size and pressure
- 4 Convert between gage and absolute pressures
- 5 Use Boyle's Law to calculate changes in pressure and volume
- 6 Measure Delta P across pneumatic components

LAP 4 Pneumatic Speed Control Circuits

Objectives

- 1 Describe the main function of a pneumatic needle valve and give an application
- 2 Describe the operation of a needle valve and give its schematic symbol
- 3 Define air flow rate and give its units of measurement
- 4 Describe the function of a flowmeter and give an application
- 5 Describe the operation of a rotameter and give its schematic symbol
- 6 Describe the function of a pneumatic check valve and give an application
- 7 Describe the operation of two types of pneumatic check valves and give their schematic symbols
- 8 Describe the function of the flow control valve and give an application
- 9 Describe the operation of a flow control valve and give its schematic symbol
- 10 Describe the effect of actuator load changes on flow control operation

- 11 Describe the operation of a meter-in flow control circuit and give an application
- 12 Describe the operation of a meter-out flow control circuit and give an application
- 13 Describe the operation of an exhaust port speed control and give an application
- 14 Describe the operation of a pressure port speed control and give an application
- 15 Define independent speed control and give an application

Skills

- 1 Connect and operate a needle valve to control actuator speed
- 2 Convert air volumes at pressures to free air volumes
- 3 Connect and read a flowmeter
- 4 Connect and operate a check valve
- 5 Connect and adjust a flow control valve to control speed of an actuator
- 6 Connect and operate a meter-in flow control circuit
- 7 Connect and operate a meter-out flow control circuit
- 8 Connect and operate an exhaust port speed control circuit
- 9 Connect and operate a pressure port speed control circuit
- 10 Design speed control circuits
- 11 Design a independent speed control circuit

PNEUMATICS MAINTENANCE CLASS

LAP 3 Pneumatic Maintenance

Objectives

- 1 List four sources of compressed air contamination and explain their effect
- 2 Describe the operation of three common filter elements
- 3 Describe the function of a coalescing filter and give an application
- 4 Describe the operation of a coalescing filter and give its schematic symbol
- 5 Explain how air filter elements are rated
- 6 Describe how to select a filter for an application
- 7 Define dew point and relative humidity and explain their importance
- 8 Explain how water condenses in a pneumatic systems and its effect
- 9 Describe two methods of removing water vapor from a pneumatic system
- 10 Describe the function of an aftercooler and give an application
- 11 Describe the function of a dryer and give an application
- 12 Describe the principle of operation of three types of dryers and give an application of each
- 13 Describe the operation of a refrigeration type air dryer
- 14 Describe the function of pneumatic system trap
- 15 Describe the operation of two types of pneumatic traps and give the schematic symbol of each
- 16 Describe the function of air lubrication and list three lubrication methods
- 17 Describe the function of a lubricator and give its schematic symbol
- 18 Describe the operation of three types of pneumatic lubricators and give an application of each
- 19 Describe the types of oils in lubricators
- 20 Describe how pressure gages are calibrated
- 21 Describe how acrylic flowmeters are cleaned
- 22 Describe the importance of eliminating air leaks
- 23 Describe how to locate air leaks
- 24 Describe four common pneumatic component failures and their probable causes

Skills

- 1 Change an air filter element
- 2 Select an air filter for an application
- 3 Connect, fill and adjust a lubricator
- 4 Disassemble, inspect and service a pneumatic cylinder

LAP 1 PNEUMATIC SYSTEM CONSTRUCTION

Objectives

- 1 Describe the three functions of an air line
- 2 Describe the construction of pneumatic rubber hose and give an application
- 3 Describe three methods of connecting rubber hose to a fitting
- 4 Describe the construction and give an application of three types of pneumatic fitting threads
- 5 Describe the operation of dryseal tapered pipe threads (NPTF)

- 6 Describe how to identify and specify pipe size
- 7 Describe the function of a reducing bushing and give an application
- 8 Describe how to specify the size of a reducing bushing
- 9 Describe the operation of straight threaded fittings
- 10 Describe the UNF thread size used for pneumatic fittings
- 11 Describe the function of an adapter and give an application
- 12 Describe the functions of four types of flexible plastic conductors and give an application of each
- 13 Describe how to specify flexible tubing
- 14 Describe the function of three pneumatic tubing fittings and give an application of each
- 15 Describe the function of a bulkhead fitting and give an application
- 16 Describe the function of six fitting shapes
- 17 Describe the function of a subplate and give an application
- 18 Give five guidelines used in the construction of pneumatic circuits

Skills

- 1 Install a rubber hose onto a push-on type fitting
- 2 Install and seal tapered pipe fittings using teflon sealing tape
- 3 Identify the nominal pipe size of a fitting given an example
- 4 Install a reducing bushing to connect an oversized port
- 5 Install and seal a straight thread fitting
- 6 Connect polyurethane ether tubing to a barbed fitting
- 7 Connect tubing using a ferrule type fitting
- 8 Connect tubing using a push-on type fitting
- 9 Install a bulkhead fitting
- 10 Identify the shape, type and size of tubing connectors
- 11 Install and replace a DCV on its subplate
- 12 Size, select, and install the fittings and tubing for an application

PIPING SYSTEMS CLASS

LAP 1 METAL PIPING SYSTEMS

Objectives

- 1 Describe the function of a piping system and give an application
- 2 Describe the color code system to identify pipe function
- 3 Describe the functions of the basic components of a piping system
- 4 Describe three types of piping and give an application of each
- 5 Describe seven rules of safe dress for working with piping
- 6 Describe nine piping rules
- 7 List four types of metal pipe materials and give an application of each
- 8 Describe how metal pipe is specified
- 9 Describe how to calculate the head loss given pipe size and flow rate

Skills

- 1 Identify pipe function by color code
- 2 Identify pipe size and type by measurement
- 3 Identify pipe size given a specification
- 4 Write a pipe specification given its dimensions
- 5 Calculate head loss for a given pipe size and flow rate

LAP 2 METAL PIPING INSTALLATION

- 1 Describe two methods of attaching metal pipe
- 2 Describe the function of four categories of fittings
- 3 Describe the functions of thirteen types of fittings
- 4 Describe the construction of four types of pipe threads and give an application of each
- 5 Describe four categories used to specify fittings
- 6 Describe the construction of seven types of pipe hangers and give an application of each
- 7 Describe how to install a pipe hanger
- 8 Describe the function of a piping schematic drawing
- 9 Identify the pipe fitting schematic symbols
- 10 Describe four methods of measuring a section of piping
- 11 Describe how to calculate pipe length given a piping schematic drawing
- 12 Describe how to design a piping system
- 13 Describe how to cut metal pipe
- 14 Describe the operation of a pipe threading machine
- 15 Describe how to prepare pipe for assembly
- 16 Describe how to assemble threaded pipe
- 17 Describe the function of an expansion joint and give an application
- 18 Describe the operation of an expansion joint
- 19 Describe the function of three types of pipe insulation and give an application of each
- 20 Describe how to maintain a metal piping system

Skills

- 1 Identify fitting type and size given a sample
- 2 Read and interpret a piping schematic drawing
- 3 Calculate pipe length given a piping schematic drawing
- 4 Design and draw a piping schematic for a given application
- 5 Use a saw to cut metal pipe
- 6 Use a pipe threading machine to create threads on a pipe
- 7 Prepare a pipe for assembly
- 8 Assemble threaded pipe and fittings
- 9 Install a pipe hanger
- 10 Pressurize a piping system to check for leaks
- 11 Install an expansion joint
- 12 Install pipe insulation

LAP 4 METAL TUBING SYSTEMS

Objectives

- 1 Describe the characteristics of two categories of tubing and give an application
- 2 Describe four types of metal tubing and give an application of each
- 3 Describe how metal tubing is specified
- 4 Describe how to cut metal tubing
- 5 Describe how to use a tube cutter to cut metal tubing
- 6 Describe the operation of a tube bender
- 7 Describe how to determine bend locations and angles
- 8 Describe three methods of assembling metal tubing
- 9 Describe how to assemble tubing using flared and flareless fittings
- 10 Describe how to solder metal tubing
- 11 Describe how to calculate the head loss given metal tubing size and flow rate
- 12 Describe how to select and size metal tubing for a given application
- 13 Describe how to maintain a metal tubing system

Skills

- 1 Identify metal tubing specification by measurement
- 2 Identify metal tubing given a specification
- 3 Write a tubing specification given its dimensions
- 4 Cut off tubing using a tube cutter
- 5 Determine bend locations and angles given a tubing layout drawing
- 6 Use a tube bender to bend tubing to a certain angle
- 7 Assemble copper tubing using flared and flareless fittings
- 8 Cut, bend and assemble steel tubing using flared and flareless fittings
- 9 Calculate the head loss given metal tubing size and flow rate
- 10 Select and size metal tubing for an application

LAP 5 HOSES

Objectives

- 1 Describe the function of the three basic components of hose
- 2 Describe the characteristics of two categories of hose and give an application of each
- 3 Describe the construction of five types of rubber hose and give an application of each
- 4 Describe the construction of two types of metal hose and give an application of each
- 5 Describe three types of hose fittings
- 6 Describe how hose is specified
- 7 Describe how to determine the length of a hose for an application
- 8 Describe how to cut hose
- 9 Describe three methods of attaching a fitting to a hose
- 10 Describe the operation of a hose crimping machine
- 11 Describe how to calculate the pressure drop given hose size and flow rate
- 12 Describe how to select and size hose for an application
- 13 Describe how to maintain a hose system

Skills

- 1 Identify hose size by measurement
- 2 Identify hose size given a specification
- 3 Write a hose specification given its dimensions
- 4 Determine hose length given a layout drawing
- 5 Cut off hose using a cut-off saw
- 6 Attach push-lock fittings to hose
- 7 Crimp fittings on to a hose
- 8 Attach a hose
- 9 Calculate the pressure drop given hose size and flow rate
- 10 Select and size hose for an application

Hydraulic Troubleshooting Class 1 (Replaced by Pneumatic Troubleshooting Class 1 in Pneumatic Option)

LAP 1 Hydraulic Component Troubleshooting

Objectives

- 1 Define hydraulic troubleshooting and explain its importance
- 2 Describe two levels of hydraulic troubleshooting and give an application of each
- 3 Describe two methods of testing a hydraulic component and give an application of each
- 4 Describe six hydraulic safe dress rules
- 5 Describe eight hydraulic troubleshooting safety rules
- 6 Describe the function of a pressure-compensated pump and give an application
- 7 List two types of pressure-compensated pumps and give an application of each

- 8 Describe the operation of a pressure-compensated vane pump and give its schematic symbol
- 9 Describe the operation of a pressure-compensated piston pump
- 10 Identify the schematic symbol of a hydraulic pressure-compensated pump
- 11 Describe how to start up a pressure-compensated vane pump
- 12 Describe how to adjust the pressure setting of a pressure-compensated vane pump
- 13 Describe how to set a pressure-compensated pump and relief valve combination
- 14 Describe the procedure to shut down a hydraulic system
- 15 Describe the function of automatic and manual modes and give an application of each
- 16 Describe the procedure to shut down a hydraulic system for maintenance
- 17 Describe the function of a maximum volume stop
- 18 Describe how to adjust the setting of a maximum volume stop

Skills

- 1 Start up a pressure-compensated hydraulic vane pump
- 2 Adjust the pressure-compensator on a pressure-compensated pump
- 3 Shut down a hydraulic system
- 4 Use manual mode to operate an actuator
- 5 Shut down a hydraulic system for a maintenance operation
- 6 Adjust the maximum volume stop on a pressure-compensated pump

LAP 2 **Pressure-Compensated Pump Performance**

Objectives

- 1 Define cavitation and explain its effect
- 2 Describe eight causes of cavitation
- 3 Define pseudo-cavitation and explain its effect
- 4 Describe four causes of pseudo-cavitation
- 5 Describe the flow vs. pressure characteristics of a pressure-compensated pump
- 6 Determine where to set the compensator setting on a hydraulic pump
- 7 Describe how volumetric pump efficiency affects flow rate
- 8 Describe the effect of wear on flow vs. pressure characteristics of a pressure-compensated pump
- 9 Describe the function of a case drain on a pressure-compensated pump
- 10 Describe the input power characteristics of a pressure-compensated pump
- 11 Describe the function of the horsepower limiting option

Skills

- 1 Recognize the sound of cavitation
- 2 Recognize the sound of pseudo-cavitation
- 3 Measure and graph flow vs. pressure for a pressure-compensated pump
- 4 Measure case drain flow
- 5 Measure and graph output power of a pressure-compensated pump

LAP 3 Troubleshooting Hydraulic Pumps

Objectives

- 1 Describe four types of in-circuit component tests and give an application of each
- 2 Describe three hydraulic troubleshooting measurements and give an application of each
- 3 Describe the construction of 3 types of pressure test points and give an application of each
- 4 Name the two typical locations of pressure test points
- 5 Describe three ways to use a flow meter to troubleshoot a hydraulic system
- 6 Describe two methods of measuring flow
- 7 Describe eleven symptoms of pressure-compensated pump failure
- 8 Describe how to interpret a troubleshooting chart
- 9 Describe how to inspect and troubleshoot a pressure-compensated pump

Skills

- 1 Use a pressure test point to troubleshoot a hydraulic system
- 2 Test a hydraulic system by measuring fluid flow
- 3 Troubleshoot a pressure-compensated vane pump using an in-circuit test

LAP 9 Troubleshooting Hydraulic Systems

Objectives

- 1 Describe three categories of hydraulic system faults and give an example of each
- 2 Describe the four methods of system level troubleshooting
- 3 Describe the function of a troubleshooting flowchart
- 4 Describe the construction of a troubleshooting flowchart
- 5 Describe how to use a flowchart to aid in troubleshooting
- 6 Describe how to use PLC I/O indicators to troubleshoot a hydraulic system process
- 7 Describe how to troubleshoot zero system pressure
- 8 Describe how to troubleshoot low system pressure
- 9 Describe how to troubleshoot high system pressure
- 10 Describe how to troubleshoot a hot hydraulic system
- 11 Describe how to troubleshoot vibration in a hydraulic system
- 12 Describe how to troubleshoot an actuator that will not move
- 13 Describe how to troubleshoot an actuator that moves out of sequence
- 14 Describe how to troubleshoot a pressure change problem in a multiple pressure circuit
- 15 Describe how to troubleshoot a speed change problem in a multiple speed circuit
- 16 Describe how to troubleshoot erratic actuator movement
- 17 Describe how to troubleshoot slow actuator speed
- 18 Describe how to troubleshoot fast actuator speed
- 19 Describe how to troubleshoot incorrect acceleration or deceleration

Skills

- 1 Troubleshoot a hydraulic system using PLC indicator lights

- 2 Troubleshoot zero system pressure
- 3 Troubleshoot low system pressure
- 4 Troubleshoot high system pressure
- 5 Troubleshoot vibration in a hydraulic system
- 6 Troubleshoot an actuator that will not move
- 7 Troubleshoot a pressure change problem in a multiple pressure circuit
- 8 Troubleshoot a speed change problem in a multiple speed circuit
- 9 Troubleshoot erratic actuator movement
- 10 Troubleshoot slow actuator speed
- 11 Troubleshoot fast actuator speed
- 12 Troubleshoot incorrect acceleration or deceleration

Pneumatic Troubleshooting Class 1 (Replaced by Hydraulic Troubleshooting Class 1 in Hydraulics Option)

LAP 3 AIR COMPRESSORS

SEGMENT 1	COMPRESSOR TYPES
OBJECTIVE 1	Describe two categories of air compressors and give an application of each
OBJECTIVE 2	List two types of positive displacement air compressors and give an application
of each	
OBJECTIVE 3	List two types of dynamic compressors and give an application of each
OBJECTIVE 4	Describe the functions of ten basic components of an air compressor system
Activity 1	Air compressor component identification
OBJECTIVE 5	Describe the eight air compressor safety rules
OBJECTIVE 6	Describe how to start and shut down a small reciprocating piston air
compressor	
SKILL 1	Start-up and shut down a small reciprocating piston air compressor
SEGMENT 2	RECIPROCATING COMPRESSOR SYSTEMS
OBJECTIVE 7	Describe the operation of a single stage reciprocating piston compressor
OBJECTIVE 8	Describe the operation of a two stage reciprocating piston air compressor
Activity 2	Hand pump operation
OBJECTIVE 9	Describe the function of start/stop control
OBJECTIVE 10	Describe the operation of an air compressor pressure switch
OBJECTIVE 11	Describe how to set air compressor cut-in and cut-out pressures
SKILL 2	Determine the cut-in and cut-out pressures on a compressor pressure switch
SKILL 3	Set air compressor cut-in and cut-out pressures
OBJECTIVE 12	Describe the operation of a pneumatic safety relief valve and explain its
importance	
SKILL 4	Test the operation of a safety relief valve
SEGMENT 3	COMPRESSOR FLOW CONCEPTS
OBJECTIVE 13	Define the ideal gas law and explain its importance
OBJECTIVE 14	Define two temperature scales, gage and absolute, and give an application of
each	
SKILL 5	Convert between gage and absolute temperatures
Activity 3	Effect of temperature change on compressed air
SKILL 6	Use the ideal gas law to calculate the effect of changes in air temperature,
pressure, and volume	
OBJECTIVE 15	Describe two methods of measuring air compressor flow rates
SKILL 7	Use a pump-up test to measure compressor flow
SKILL 8	Use an orifice plate flow meter to determine flow rate
SEGMENT 4	COMPRESSOR PERFORMANCE
OBJECTIVE 16	Describe five factors used in the selection of an air compressor
OBJECTIVE 17	Describe the types of data found on a compressor name plate
SKILL 9	Interpret an air compressor name plate
OBJECTIVE 18	Describe how to size an air compressor
SKILL 10	Size an air compressor given application data

LAP 1 INTRODUCTION TO PNEUMATIC TROUBLESHOOTING

SEGMENT 1	PNEUMATIC TROUBLESHOOTING CONCEPTS
OBJECTIVE 1	Define pneumatic troubleshooting and explain its importance
OBJECTIVE 2	Describe two levels of pneumatic troubleshooting and give an application of each
OBJECTIVE 3	Describe two methods of testing a pneumatic component and give an application of each
Activity 1	Pneumatic system identification
SEGMENT 2	SAFETY
OBJECTIVE 4	Describe the function of a lockout/tagout system
OBJECTIVE 5	Describe the operation of an electrical lockout/tagout system
OBJECTIVE 6	Describe the operation of a pneumatic lockout/tagout system
OBJECTIVE 7	Describe eight rules for safe dress when working with pneumatic systems
OBJECTIVE 8	Describe eight pneumatic troubleshooting safety rules
SKILL 1	Perform a lockout/tagout on a pneumatic system
Activity 2	Pneumatic system operation
SEGMENT 3	IN-CIRCUIT PNEUMATIC COMPONENT TESTING
OBJECTIVE 9	Describe four types of in-circuit component tests and give an application of each
OBJECTIVE 10	Describe three pneumatic troubleshooting measurements and give an application of each
OBJECTIVE 11	Describe the construction of a pressure test point and give an application
SKILL 2	Use a pressure test point to check system pressure

LAP 2 AIR PREPARATION TROUBLESHOOTING

SEGMENT 1	FILTER TROUBLESHOOTING
OBJECTIVE 1	Describe the construction of a pneumatic distribution system
OBJECTIVE 2	Describe four symptoms of filter failure and their causes
OBJECTIVE 3	Describe how to interpret a pneumatic troubleshooting chart
OBJECTIVE 4	Describe how to troubleshoot a filter
SKILL 1	Troubleshoot a filter using an in-circuit test
SEGMENT 2	LUBRICATOR TROUBLESHOOTING
OBJECTIVE 5	Describe four symptoms of lubricator failure and their causes
OBJECTIVE 6	Describe how to troubleshoot a lubricator
SEGMENT 3	REGULATOR TROUBLESHOOTING
OBJECTIVE 7	Describe four symptoms of regulator failure and their causes
OBJECTIVE 8	Describe how to troubleshoot a regulator
SKILL 2	Troubleshoot a regulator using an in-circuit test

LAP 3 TROUBLESHOOTING PNEUMATIC CYLINDERS

SEGMENT 1	PNEUMATIC CYLINDER TROUBLESHOOTING
OBJECTIVE 1	Describe six symptoms of pneumatic cylinder failure
OBJECTIVE 2	Describe how to troubleshoot a pneumatic cylinder
SKILL 1	Troubleshoot a cylinder using an in-circuit test
SEGMENT 2	RODLESS CYLINDER TROUBLESHOOTING
OBJECTIVE 3	Describe the function of a rodless cylinder and give an application
OBJECTIVE 4	Describe the operation of a rodless cylinder and give its schematic symbol
OBJECTIVE 5	Describe seven symptoms of rodless cylinder failure
OBJECTIVE 6	Describe how to troubleshoot a rodless cylinder
SKILL 2	Troubleshoot a rodless cylinder using an in-circuit test
SEGMENT 3	AIR-OVER-OIL SYSTEM OPERATION
OBJECTIVE 7	Describe the function of an air-over-oil system and give an application
OBJECTIVE 8	Describe the operation of an air-over-oil tank and give its schematic symbol
OBJECTIVE 9	Describe the operation of an air-over-oil system
OBJECTIVE 10	Describe how to balance the tanks in an air-over-oil system
SKILL 3	Balance the air-over-oil tanks in an air-over-oil system
SEGMENT 4	AIR-OVER-OIL SYSTEM TROUBLESHOOTING
OBJECTIVE 11	Describe five symptoms of an air-over-oil system failure
OBJECTIVE 12	Describe how to troubleshoot an air-over-oil system
SKILL 4	Troubleshoot an air-over-oil system

LAP 4 MOTOR AND ROTARY ACTUATOR TROUBLESHOOTING

SEGMENT 1	MOTOR TROUBLESHOOTING
OBJECTIVE 1	Describe five symptoms of pneumatic motor failure
OBJECTIVE 2	Describe how to troubleshoot a pneumatic motor
SKILL 1	Troubleshoot a motor using an in-circuit test
SEGMENT 2	ROTARY ACTUATOR OPERATION
OBJECTIVE 3	Describe the function of a rotary actuator and give an application
OBJECTIVE 4	Describe the operation of a vane-type rotary actuator and give its schematic symbol
OBJECTIVE 5	Describe the function of a shock absorber
OBJECTIVE 6	Describe the operation of a shock absorber
OBJECTIVE 7	Describe how to adjust a shock absorber
SKILL 2	Adjust a shock absorber
SEGMENT 3	ROTARY ACTUATOR TROUBLESHOOTING
OBJECTIVE 8	Describe five symptoms of rotary actuator failure
OBJECTIVE 9	Describe how to troubleshoot a rotary actuator
SKILL 3	Troubleshoot a rotary actuator using an in-circuit test

LAP 5 TROUBLESHOOTING DCV AND FLOW CONTROL VALVES

SEGMENT 1	DIRECTIONAL CONTROL VALVE TROUBLESHOOTING
OBJECTIVE 1	Describe the operation of an internal pilot-operated DCV and give an application
OBJECTIVE 2	Describe six symptoms of pilot-operated DCV failure and their causes
OBJECTIVE 3	Describe how to troubleshoot a pilot-operated DCV
SKILL 1	Troubleshoot a pilot-operated DCV using an in-circuit test
SEGMENT 2	FLOW CONTROL VALVE TROUBLESHOOTING
OBJECTIVE 4	Describe six symptoms of flow control valve failure and their causes
OBJECTIVE 5	Describe how to troubleshoot a flow control valve
SKILL 2	Troubleshoot a flow control valve using an in-circuit test
SEGMENT 3	QUICK EXHAUST VALVES
OBJECTIVE 6	Describe three symptoms of quick exhaust valve failure and their causes
OBJECTIVE 7	Describe how to troubleshoot a quick exhaust valve
SEGMENT 4	EXHAUST RESTRICTORS
OBJECTIVE 8	Describe the function of an exhaust restrictor and give an application
OBJECTIVE 9	Describe the operation of an exhaust restrictor
SKILL 3	Adjust an exhaust restrictor
OBJECTIVE 10	Describe five symptoms of exhaust restrictor failure
OBJECTIVE 11	Describe how to troubleshoot an exhaust restrictor

LAP 6 TROUBLESHOOTING VACUUM SYSTEMS

SEGMENT 1	TROUBLESHOOTING VACUUM CUPS AND GENERATORS
OBJECTIVE 1	Describe two symptoms of vacuum cup failure
OBJECTIVE 2	Describe how to inspect and troubleshoot a vacuum cup
OBJECTIVE 3	Describe three symptoms of vacuum generator failure
OBJECTIVE 4	Describe how to troubleshoot a vacuum generator
SKILL 1	Troubleshoot a vacuum generator using an in-circuit test
SEGMENT 2	VACUUM SWITCH OPERATION
OBJECTIVE 5	Describe the function of a vacuum switch and give an application
OBJECTIVE 6	Describe the operation of a vacuum switch
OBJECTIVE 7	Describe how to set the set point of a vacuum switch
SKILL 2	Adjust the set point of a pressure switch
SEGMENT 3	VACUUM SWITCH TROUBLESHOOTING
OBJECTIVE 8	Describe two symptoms of vacuum switch failure
OBJECTIVE 9	Describe how to troubleshoot a vacuum switch
SKILL 3	Troubleshoot a vacuum switch using an in-circuit test

LAP 7 TROUBLESHOOTING PNEUMATIC SYSTEMS

SEGMENT 1	TROUBLESHOOTING SYSTEMS
OBJECTIVE 1	Describe three categories of pneumatic system faults and give an example of each
OBJECTIVE 2	Describe the four methods of system level troubleshooting
OBJECTIVE 3	Describe the function of a troubleshooting flowchart
OBJECTIVE 4	Describe the construction of a troubleshooting flowchart
OBJECTIVE 5	Describe how to use a flowchart to aid in troubleshooting
OBJECTIVE 6	Describe the operation of a sequence chart
OBJECTIVE 7	Describe how to use PLC I/O indicators to troubleshoot a pneumatic system process
OBJECTIVE 8	Describe how to test an input device
SKILL 1	Troubleshoot a pneumatic system using PLC I/O indicators
SEGMENT 2	TROUBLESHOOTING SYSTEMS LEVEL FAULTS
OBJECTIVE 9	Describe how to troubleshoot zero pressure
SKILL 2	Troubleshoot zero system
OBJECTIVE 10	Describe how to troubleshoot low pressure
SKILL 3	Troubleshoot low pressure
OBJECTIVE 11	Describe how to troubleshoot high pressure
SKILL 4	Troubleshoot high pressure
SEGMENT 3	TROUBLESHOOTING MACHINE SEQUENCE FAULTS
OBJECTIVE 12	Describe how to troubleshoot an actuator that will not move
SKILL 5	Troubleshoot an actuator that will not move
OBJECTIVE 13	Describe how to troubleshoot an actuator that moves out of sequence
SKILL 6	Troubleshoot an actuator that moves out of sequence
SEGMENT 4	TROUBLESHOOTING MACHINE PERFORMANCE FAULTS
OBJECTIVE 14	Describe how to troubleshoot erratic actuator movement
OBJECTIVE 15	Describe how to troubleshoot slow actuator speed
SKILL 7	Troubleshoot slow actuator speed
OBJECTIVE 16	Describe how to troubleshoot fast actuator speed
SKILL 8	Troubleshoot fast actuator speed

Basic Mechanical Drives Class

LAP 1 Introduction To Mechanical Drive Systems

Objectives

- 1 Describe the function of a mechanical power transmission and give an advantage
- 2 Describe five methods of rotary mechanical power transmission and give an application of each
- 3 Describe 5 rules of safe dress for working with power transmission equipment
- 4 Describe 8 mechanical transmission safety rules
- 5 Describe the operation of the lockout/tagout system
- 6 Describe the function of a foundation and give three types
- 7 Describe the function and construction of a bedplate
- 8 Describe the function of a spirit level and give an application
- 9 Describe the operation of a spirit level
- 10 Describe three (3) types of motor mounts and give an application of each
- 11 Describe how fasteners are used to attach a motor mount to a bedplate
- 12 Describe how to select fastener size and type for a motor mount
- 13 Describe how to mount and level an electric motor
- 14 Describe two (2) methods of measuring motor shaft speed and give an application

Skills

- 1 Perform a lockout/tagout
- 2 Use a spirit level to determine orientation of a surface
- 3 Select a fastener size and type for a motor mount
- 4 Mount and level an electric motor
- 5 Use a digital tachometer to measure motor speed
- 6 Mount and level an electric motor to correct for a soft foot condition

LAP 2 Key Fasteners

Objectives

- 1 Describe the function and operation of a key fastener
- 2 Describe the construction of six (6) types of keys and give an application of each
- 3 Describe how keys and keyseats are specified
- 4 Describe how to measure the actual size of a key and key seat
- 5 Describe six types of set screws
- 6 Describe how to assemble a shaft to a hub using a key
- 7 Describe two (2) methods of loading a mechanical drive system
- 8 Describe how to calculate rotary mechanical power
- 9 Describe how to calculate mechanical efficiency and explain its importance
- 10 Describe two (2) methods of measuring shaft torque and give an application of each
- 11 Describe three (3) methods of measuring electric motor current

Skills

- 1 Select a key size for a given application
- 2 Measure the actual size of a key and keyseat given a sample
- 3 Cut and file key stock to fit a keyseat
- 4 Assemble a hub to a shaft using a key fastener
- 5 Use a prony brake to measure shaft torque
- 6 Calculate rotary mechanical power
- 7 Convert between English and S.I. units of motor power
- 8 Calculate mechanical efficiency
- 9 Measure electric motor current

LAP 3 Power Transmission Systems

Objectives

- 1 Describe the function of a shaft and give an application
- 2 List four (4) types of shaft materials and give an application of each
- 3 Describe how shafts are specified
- 4 Describe the function of a bearing and give an application
- 5 Define three (3) types of bearing loads and give an example of each
- 6 Describe how bearings are positioned to support a load
- 7 Describe the operation of a two (2) categories of bearings and give an application of each
- 8 Describe two (2) methods of mounting a shaft bearing and give an application of each
- 9 Describe the function of a coupling and give an application
- 10 Describe the function of a four (4) categories groups of mechanical couplings
- 11 Describe the operation of flexible jaw coupling
- 12 Describe the purpose of shaft alignment and give two (2) types of misalignment
- 13 Describe a general procedure for shaft alignment and give four (4) measurement methods
- 14 Describe the operation of the straight edge and feeler gage method

Skills

- 1 Identify shaft size given a sample
- 2 Install and adjust a pillow block antifriction bearing and shaft
- 3 Install a flexible jaw coupling
- 4 Align two (2) shafts using a straight edge and feeler gage

Light Duty V-Belt and Chain Drives Class

LAP 4 Introduction to V-Belt Drives

Objectives

- 1 Describe the function of the three (3) basic components of a belt drive
- 2 Define pitch and explain its importance
- 3 Define pitch circle, pitch diameter, and pitch length and explain their importance
- 4 Describe how to calculate the pulley ratio and explain its importance
- 5 Describe how to calculate the shaft speed and torque of a belt drive system
- 6 List five (5) types of belt drives and give an application of each
- 7 List three (3) types of V-belts and give an application of each
- 8 Describe the operation of a fractional hp v-belt drive

- 9 Describe how to install and align a V-belt drive
- 10 Describe how to determine belt tension for an application
- 11 Describe three (3) methods of adjusting belt tension
- 12 Describe three (3) methods of measuring belt tension and give an application of each

Skills

- 1 Calculate pulley ratio
- 2 Calculate the shaft speed and torque of a belt drive system
- 3 Install and align a fractional HP V-belt drive with a finished bore
- 4 Determine the belt deflection force for a given application
- 5 Adjust belt tension using an adjustable mounting base
- 6 Use a belt tension tester to measure belt tension

LAP 5 Introduction to Chain Drives

Objectives

- 1 Describe the function of the three (3) basic components of a chain drive
- 2 Describe how to calculate sprocket ratio and explain its importance
- 3 Describe how to calculate the shaft speed and torque of a chain drive system
- 4 List four (4) types of chain drives and give an application of each
- 5 List four (4) types of roller chain drives and give an application of each
- 6 Describe the operation of a single-strand roller chain drive
- 7 Describe how to install, align and remove a roller chain drive system with adjustable centers
- 8 Describe how to determine allowable chain sag for a given application
- 9 Describe two methods used to adjust chain sag
- 10 Describe how to measure chain sag
- 11 Describe the function and operation of a master link
- 12 Describe two (2) methods of installing a lightweight chain which uses a master link
- 13 Describe the operation of a chain puller

Skills

- 1 Calculate the sprocket ratio
- 2 Calculate the shaft speed and torque of a chain drive system
- 3 Install, align and remove a roller chain drive system with adjustable centers
- 4 Determine allowable chain sag for a given application
- 5 Use a rule and straight edge to measure chain sag
- 6 Adjust chain sag to a specified amount using adjustable centers
- 7 Install and remove a chain with a master link using sprocket teeth
- 8 Install and remove a chain with a master link using a chain puller

Heavy Duty v-Belt Drives Class

LAP 1 Heavy Duty V-Belt Drives

Objectives

- 1 Describe the function of a bushing and list three types
- 2 Describe the construction and operation of a QD bushing and give an advantage
- 3 Describe the construction and operation of a conventional V-Belt Drive
- 4 Describe the construction and operation of a multiple belt v-belt drive
- 5 Describe the construction and operation of a split taper bushing and give an advantage
- 6 Describe the construction and operation of a wedge v-belt drive
- 7 Describe the construction of a taper lock bushing and give an advantage
- 8 Describe the construction and operation of a notched v-belt and give an advantage
- 9 Describe the operation of a variable speed V-belt drive system and give an application
- 10 Describe how to install and align a variable speed v-belt drive system
- 11 Describe five (5) v-belt configurations and give an application of each
- 12 Describe the function of a belt idler pulley and give an application
- 13 Describe the operation of four (4) types of belt idler pulley configurations

Skills

- 1 Install and align a conventional v-belt drive system with a QD bushing
- 2 Install and align a multiple belt v-belt drive system with a split taper bushing
- 3 Install and align a wedge v-belt drive system with a taper-lock bushing
- 4 Install and align a notched v-belt drive system
- 5 Install and align a variable speed v-belt drive system
- 6 Install and align a backslide v-belt idler
- 7 Install and adjust a kiss v-belt idler

LAP 2 V-Belt Selection and Maintenance

Objectives

- 1 Describe how v-belts are specified
- 2 Describe three (3) methods of identifying belt size and type
- 3 Describe the function and operation of v-belt match codes
- 4 Describe how sheaves and bushings are specified
- 5 Describe how sheaves are specified
- 6 Describe how to select a v-belt, bushing, and sheave for an application
- 7 Describe preventive maintenance
- 8 Describe nine (9) maintenance steps for v-belt drives
- 9 Describe how to troubleshoot a v-belt drive system

Skills

- 1 Use a belt code to determine the size and type of v-belt
- 2 Use a belt gauge to determine belt cross section belt size
- 3 Use measurement to determine the size and type

- 4 Use a sheave gage to identify a sheave size
- 5 Identify size and type of sheave and bushing given a sample
- 6 Select a v-belt, bushing, and sheave for a given application
- 7 Troubleshoot a v-belt drive system

Heavy Duty Chain Drives Class

LAP 7 Heavy Duty Chain drives

Objectives

- 1 Describe the operation of four (4) types of sprockets(No Hub, Single Hub, double Hub, and Bushing) and give an application of each
- 2 Describe the operation of a silent chain drive
- 3 Describe how to install and align a silent chain drive system
- 4 Describe the operation of a multiple strand chain drive
- 5 Describe how to install and align a multiple strand chain drive system
- 6 Describe the construction and operation of a taper lock busing and give an advantage
- 7 Define chain pitch, pitch circle, pitch diameter, and pitch length of a chain drive and explain their importance
- 8 Describe how chains are specified
- 9 Describe how sprockets are specified
- 10 Describe how to select the type and size of chain and sprocket for a given application
- 11 Describe four (4) types of chain lubrication methods (manual, drip cup, oil bath or disc, and forced oil stream)
- 12 Describe how to select a lubrication system for a chain drive system
- 13 Describe how to select a lubrication type for a chain drive system
- 14 Describe 10 maintenance steps for chain drives
- 15 Describe how to inspect and troubleshoot a chain drive system
- 16 Describe the operation of a chain breaker

Skills

- 1 Install and align a silent chain drive system
- 2 Install and align a multiple strand chain system using a taper lock bushing
- 3 Identify the characteristics of a chain and sprocket given a specification
- 4 Select a chain and sprocket for a given application
- 5 Select a lubrication system for a chain drive system
- 6 Lubricate a chain drive using a manual method
- 7 Troubleshoot a chain drive system
- 8 Cut a chain using a chain breaker

Industrial Electrical Systems

LAP 1 Basic Electrical Circuits

Objectives

- 1 Define electricity and give an application
- 2 Describe the two types of electrical current and give an application of each
- 3 Describe the function and operation of a circuit tester
- 4 Describe the function of the four basic components of an electric circuit
- 5 Describe the operation of two types of power supplies and give their schematic symbols
- 6 Describe the function of an electrical schematic
- 7 Describe the operation of a manual switch
- 8 Describe the operation of N.O. and N.C. contacts and give their schematic symbols
- 9 Describe the function of three types of manual switch operators and give an application of each
- 10 Describe the operation of three types of manual switch operators and give their schematic symbols
- 11 Describe the function of five types of electrical output devices and give an application of each
- 12 Describe the operation of five types of electric output devices and give their schematic symbols

Skills

- 1 Use an AC tester to check a wall outlet for electricity
- 2 Connect and operate a power supply
- 3 Connect and operate a circuit using three types of manual switches
- 4 Connect and operate an electrical circuit with a resistor
- 5 Connect and operate an electrical circuit with a buzzer
- 6 Connect and operate an electrical circuit with a solenoid
- 7 Connect and operate an electrical circuit with a motor

LAP 2 Electrical Measurements

Objectives

- 1 Define voltage and give its units of measurement
- 2 Describe the function of two types of voltmeters and give their schematic symbol
- 3 Describe how to use a voltmeter to measure voltage
- 4 Describe the function of two multimeters: analog and digital
- 5 Define series and parallel circuits
- 6 Describe the voltage characteristics in series and parallel circuits
- 7 Define current and give its units of measurement
- 8 Describe the function of two types of ammeters and give their schematic symbol
- 9 Describe how to use an ammeter to measure current
- 10 Describe the current characteristics in series and parallel circuits
- 11 Define resistance and give its units of measurement
- 12 Describe the function of two types of ohmmeters and give their schematic symbol
- 13 Describe how to use an ohmmeter to measure resistance
- 14 Describe the resistance characteristics in series and parallel circuits

15 Describe two methods of measuring continuity

Skills

- 1 Use an analog voltmeter to measure the voltage at a point referenced to ground
- 2 Use a DMM to measure the voltage of a point referenced to ground
- 3 Use a DMM to measure voltage drops in series and parallel circuits
- 4 Use a DMM to measure the electrical current
- 5 Use a DMM to measure current in series and parallel circuits
- 6 Use a DMM to measure the resistance of a component
- 7 Measure the resistance in series and parallel circuits
- 8 Test the continuity of wires using a DMM

LAP 3 Circuit Analysis

Objectives

- 1 State the formula for calculating series resistance and give an application
- 2 State Ohm's Law, explain its importance and give an application
- 3 State Krichhoff's voltage law for a series circuit and give an application
- 4 Define power and give its units of measurement
- 5 State a formula for calculating the total power used in an electrical circuit
- 6 State Kirchhoff's Current Law and give an application
- 7 State a formula for calculating total parallel resistance
- 8 Describe the function of two types of circuit protection and give an application of each
- 9 Describe the operation of a fuse and give its schematic symbol
- 10 Describe the operation of two types of circuit breakers and give their schematic symbols

Skills

- 1 Calculate series resistance given each load's resistance
- 2 Use Ohm's Law to calculate voltage, current, and resistance in a series circuit
- 3 Calculate the total power used by a series circuit
- 4 Calculate the main line current in a parallel circuit
- 5 Calculate the total parallel resistance
- 6 Calculate the total power used in a parallel circuit
- 7 Operate a circuit using a fuse
- 8 Test and replace a fuse
- 9 Operate a circuit using a circuit breaker
- 10 Test and reset a circuit breaker

LAP 4 Inductance and Capacitance

Objectives

- 1 Define electromagnetism and give an application
- 2 Describe the functions of four electromagnetic devices
- 3 Define inductance and give its units of measurement
- 4 Describe the operation of an inductor and give its schematic symbol

- 5 Describe the effect of an inductor in a DC circuit and give an application
- 6 Describe the effect of an inductor in a AC circuit and give an application
- 7 State the formulas for calculating total series inductance and inductive reactance
- 8 State the formulas for calculating total parallel inductance and inductive reactance
- 9 Define capacitance and give its units of measurement
- 10 Describe the operation of a capacitor and give its schematic symbol
- 11 Describe the functions of three types of capacitors
- 12 Describe the effect of a capacitor in a DC circuit and give an application
- 13 Describe the effect of a capacitor in an AC circuit and give an application
- 14 State the formulas for calculating total series capacitance and capacitive reactance
- 15 State the formulas for calculating total parallel capacitance and capacitive reactance
- 16 Describe the function of a fluorescent light fixture
- 17 Describe the function of a RC timing circuit in a time-delay relay
- 18 Describe the function of capacitors and inductors in electric power supplies

Skills

- 1 Connect and operate a relay in a circuit
- 2 Calculate the total load on an AC circuit with inductors
- 3 Discharge a capacitor
- 4 Test a capacitor with a DMM
- 5 Measure the voltage across a charged capacitor
- 6 Calculate the total load on an AC circuit with capacitors
- 7 Calculate the time to charge and discharge a capacitor

LAP 5 Combination Circuits

Objectives

- 1 Define a series-parallel circuit
- 2 Describe a method for identifying the series and parallel sections of a circuit
- 3 Describe the seven steps for solving a combination circuit
- 4 Describe how switches are used in combination circuits and give an application
- 5 Describe the function of a variable resistor and give an application
- 6 Describe the function of a voltage divider and give an application
- 7 Describe the operation of three types of voltage dividers
- 8 Explain the effect of a short circuit
- 9 Describe the four steps for troubleshooting a short circuit
- 10 Describe the three basic steps for troubleshooting an open circuit

Skills

- 1 Trace the current path in a combination circuit
- 2 Solve a combination circuit
- 3 Connect and operate a basic lighting circuit
- 4 Connect and operate a ceiling fan circuit
- 5 Connect and operate a rheostat as a light dimmer
- 6 Design a voltage divider network

- 7 Connect and operate a voltage divider network
- 8 Locate a short circuit
- 9 Locate an open circuit

LAP 1 Introduction To Industrial Motor Control

Objectives

- 1 Explain the importance of the equipment ground connection.
- 2 List 10 basic rules of electrical safety.
- 3 Describe the purpose of the lockout/tagout system used in industry.
- 4 Describe the operation of three-phase power.
- 5 Describe the two most common three-phase voltage systems.
- 6 Explain the function of neutral.
- 7 Describe the operation of grounded and ungrounded systems.
- 8 Describe two devices used to disconnect power to a circuit.
- 9 Explain why time-delay fuses are used with motor starting circuits.
- 10 Describe three important factors to consider with overcurrent protection devices.
- 11 Describe the operation of a three-phase motor.
- 12 Describe the operating data on a motor's nameplate.
- 13 Define service factor and explain its importance.
- 14 Explain why dual-voltage motors should always be run on the highest available voltage.

Skills

- 1 Perform a lockout/tagout.
- 2 Use a voltmeter to verify supply voltage.
- 3 Use an ohmmeter to check the condition of a fuse.
- 4 Connect a dual-voltage three-phase motor for low voltage operation.
- 5 Connect a dual-voltage three-phase motor for high voltage operation.

LAP 2 Manual Motor Control And Overload Protection

Objectives

- 1 Describe five functions of motor control.
- 2 Describe the four basic requirements for a typical motor installation.
- 3 Define motor controller and motor starter.
- 4 Describe the functions of two categories of motor starters.
- 5 Describe the functions of two types of manual starters.
- 6 Describe the operation of a manual motor starter.
- 7 Define low-voltage protection and describe its importance.
- 8 Describe how low-voltage protection is accomplished in a manual starter.
- 9 Describe the function of three types of overloads and give an application of each.
- 10 Describe the operation of two types of thermal overloads.
- 11 Describe the operation of a magnetic overload.

Skills

- 1 Connect and operate a simple motor control circuit.
- 2 Start and stop a motor using a manual starter.
- 3 Set the trip level of a bimetallic overload.
- 4 Select the correct heaters for a NEMA overload.

LAP 3 Control Transformers

Objectives

- 1 Describe the operation of a transformer and give its schematic symbol.
- 2 Define turns ratio and describe how it is calculated.
- 3 Describe how the turns ratio determines the secondary voltage of a transformer.
- 4 Describe the function of the four basic components of an electrical control circuit.
- 5 Describe the function of an electrical schematic diagram.
- 6 Describe the function of a control transformer.
- 7 Describe the operation of a control transformer and give its schematic symbol.
- 8 Describe how to test a transformer.
- 9 Describe how to size a transformer.
- 10 Describe the most common application of a control transformer.

Skills

- 1 Calculate the turns ratio of a transformer.
- 2 Calculate the secondary voltage of a transformer.
- 3 Connect and operate a control transformer.
- 4 Test a control transformer.
- 5 Size a control transformer.

LAP 4 Control Ladder Logic

Objectives

- 1 Describe the function of three types of electrical control systems and give an application each.
- 2 List and describe the three steps of a control process.
- 3 Describe the function of an indicator lamp and give an application.
- 4 Describe the operation of a pushbutton switch and give its schematic symbol.
- 5 Describe the operation of a selector switch and give its schematic symbol.
- 6 Describe the function of a ladder diagram.
- 7 Describe the function of four components of a ladder diagram.
- 8 Describe six rules of drawing a ladder diagram.
- 9 Describe how to determine the operation of a circuit given a ladder diagram.
- 10 List six elements of control logic.
- 11 Describe the operation of AND logic and give an application.
- 12 Describe the operation of OR logic and give an application.
- 13 Describe the operation of NOT logic and give an application.
- 14 Describe the operation of NOR logic and give an application.
- 15 Describe the operation of NAND logic and give an application.

Skills

- 1 Connect and operate a basic electrical control circuit which uses a pushbutton switch.
- 2 Connect and operate a basic electric control circuit which uses a selector switch.
- 3 Draw a ladder diagram of a control circuit.
- 4 Determine the operation of a control circuit given a ladder diagram.
- 5 Connect and operate a control circuit given a ladder diagram.
- 6 Connect and operate an AND logic circuit.
- 7 Connect and operate an OR logic circuit.
- 8 Connect and operate a NOT logic circuit.
- 9 Connect and operate a NOR logic circuit.
- 10 Connect and operate a NAND logic circuit.
- 11 Design a multiple start/stop pushbutton station control circuit.

LAP 5 Control Relays And Motor Starters

Objectives

- 1 Describe the function of a control relay and give an application.
- 2 Describe the operation of a control relay and give its schematic symbol.
- 3 Describe the operation of two types of control relays and give an application of each.
- 4 Describe how detached symbology is used to show a control relay on a ladder diagram.
- 5 Describe the operation of memory logic and give an application.
- 6 Describe the operation of a magnetic motor starter.
- 7 Describe the operation of a two-wire motor control circuit and give an application.
- 8 Describe the operation of a three-wire motor control circuit and give an application.
- 9 Describe the function of a push-to-test pilot light and give an application.
- 10 Describe the operation of a push-to-test pilot light and give its schematic symbol.

Skills

- 1 Connect and operate a control relay in a circuit.
- 2 Connect and operate a memory logic circuit.
- 3 Connect and operate a magnetic motor starter connected to a three-phase motor.
- 4 Connect and operate a two-wire motor control circuit.
- 5 Connect and operate a three-wire motor control circuit.
- 6 Design a multiple operator station three-wire control circuit.
- 7 Connect and operate a three-wire control circuit with a push-to-test pilot light.

LAP 6 Introduction To Troubleshooting

Objectives

- 1 Describe two levels of troubleshooting and give an application of each
- 2 Describe three methods of testing components and give an application of each
- 3 Describe how to test an indicator lamp
- 4 Describe how to test a manual switch
- 5 Describe how to test a control relay

- 6 Describe how to test a motor contactor
- 7 Describe how to test an overload relay
- 8 Describe how to test a 3-phase motor.

Skills

- 1 Test an indicator lamp
- 2 Test a manual switch
- 3 Test a control relay
- 4 Test a motor contactor
- 5 Test an overload relay
- 6 Test a 3-phase motor
- 7 Test a control transformer

LAP 7 **Systems Troubleshooting**

Objectives

- 1 Describe a six step troubleshooting sequence
- 2 Describe four methods of systems level troubleshooting and give an advantage of each
- 3 Describe five types of in-circuit component tests
- 4 Describe how to test and analyze circuit signals

Skills

- 1 Perform and analyze circuit signal tests
- 2 Use the symptom and cause troubleshooting method to isolate a bad component
- 3 Use the output-back troubleshooting method to isolate a bad component
- 4 Use the half-split troubleshooting method to isolate a bad component
- 5 Use the shotgun troubleshooting method to isolate a bad component
- 6 Troubleshoot a two-wire control system
- 7 Troubleshoot a three-wire control system

LAP 8 Reversing Motor Control

Objectives

- 1 State the NEMA and IEC standard for reversing the rotation of a three-phase motor.
- 2 List two common control methods used to reverse a three-phase motor.
- 3 Describe the function and operation of a drum switch.
- 4 Describe the function and operation of a reversing magnetic motor starter.
- 5 Describe the function of interlocking control and give an application.
- 6 Describe three interlocking methods used in reversing motor control.
- 7 Describe the function of manual and automatic modes and give an application of each.
- 8 Describe the operation of two types of motor jogging circuits.
- 9 Describe the operation of a Hand-Off-Automatic motor control circuit.

Skills

- 1 Connect and operate a drum switch to reverse a motor.
- 2 Connect and operate a reversing magnetic motor starter to reverse a motor.
- 3 Design a motor reversing circuit that uses a drum switch and a magnetic starter.
- 4 Connect and operate a reversing motor control circuit with mechanical and auxiliary interlocking.
- 5 Troubleshoot a reversing motor control circuit.
- 6 Design a reversing motor control circuit that uses pushbutton interlocking.
- 7 Connect and operate a circuit to jog a motor.
- 8 Connect and operate a forward/reverse jog control circuit.
- 9 Troubleshoot a control circuit which has manual and automatic modes.
- 10 Connect and operate a Hand-Off-Automatic motor control circuit.
- 11 Design a Hand-Off-Automatic motor control circuit.

LAP 9 Automatic Input Devices 1

Objectives

- 1 Describe the functions of four types of automatic input devices and give an application of each.
- 2 Describe the operation of a limit switch and give its schematic symbol.
- 3 Describe the operation of a float switch and give its schematic symbol.
- 4 Describe the operation of a pump control circuit.
- 5 Describe the operation of a pressure switch and give its schematic symbol.
- 6 Describe how to test an automatic input switch.
- 7 Describe the function of a sequence control circuit and give an application.
- 8 Describe the operation of a sequence control circuit.

Skills

- 1 Connect and operate a limit switch.
- 2 Design an overhead door motor control circuit.
- 3 Connect and operate a float switch.
- 4 Connect and operate a pump control circuit.
- 5 Connect and operate a pressure switch.
- 6 Design a pump control circuit that includes H-O-A operation.

- 7 Test an automatic input switch.
- 8 Connect and operate a sequence control circuit.
- 9 Troubleshoot a sequence control circuit.
- 10 Design a sequence control circuit.

LAP 10 Basic Timer Control: On-Delay And Off-Delay

Objectives

- 1 Describe the function of a time-delay relay and give an application.
- 2 Describe the function of two types of timer relays and give an application of each.
- 3 Describe the operation of an On-Delay timer relay and give its schematic symbol.
- 4 Describe the operation of a timer relay in an unloaded motor start circuit
- 5 Describe the operation of an Off-Delay timer relay and give its schematic symbol.
- 6 Describe the function of a time-delay relay in time-driven sequencing
- 7 Describe how to test a timer relay.

Skills

- 1 Connect and operate an On-Delay timer circuit.
- 2 Design an control circuit to perform an unloaded start of a motor.
- 3 Connect and operate an Off-Delay timer circuit.
- 4 Design a motor control circuit to perform time-driven sequencing.
- 5 Test a timer relay.
- 6 Troubleshoot an On-Delay timer circuit.
- 7 Troubleshoot an Off-Delay timer circuit.

LAP 1 Introduction to Electrical Control Wiring

Objectives

- 1 Describe the function of an electrical print
- 2 Describe the function of electrical print mnemonics
- 3 Describe the function of notes on an electrical print
- 4 Describe how to interpret an electrical print
- 5 Describe the function of an electrical panel
- 6 Describe the function of three types of electrical panels
- 7 Describe the function of electrical terminal blocks
- 8 Describe how to select a terminal block for an application
- 9 Describe how to install a terminal block
- 10 Describe the importance of using wire number labels
- 11 Describe how to label wire numbers on an electrical print
- 12 Describe how to determine the number of wires to run between panels
- 13 Describe the function of wire color coding in electrical control
- 14 Describe how to determine the wire colors needed in an electrical panel

Skills

- 1 Interpret an electrical print
- 2 Select terminal blocks for an application
- 3 Install a terminal block in an electrical panel
- 4 Label wire numbers on an electrical print
- 5 Determine the number of wires to run from a control panel to an operator station
- 6 Determine the wire colors needed for an application

LAP 2 Electrical Control System Wiring

Objectives

- 1 Describe how to terminate panel wires
- 2 Describe how to install wire number labels on a wire
- 3 Describe two methods used to run identify wires which are ran between panels
- 4 Describe how to hand feed wires through conduit
- 5 Describe how to splice motor wires using ring lug connectors
- 6 Describe how to tape motor leads
- 7 Describe the function of panel wire ways
- 8 Describe how to determine wire lengths inside a panel
- 9 Describe two methods to connect wires to terminal screws
- 10 Describe the function of wire bundling
- 11 Describe three common methods of wire bundling

Skills

- 1 Terminate and label wires at a terminal block
- 2 Run wires between panels
- 3 Splice motor leads using ring lug connectors
- 4 Connect a wire to a terminal screw
- 5 Wire an electrical panel
- 6 Bundle wires in an electrical panel
- 7 Secure wire bundles in an electrical panel
- 8 Wire an electrical machine

INDUSTRIAL CONTSTRUCTION PRACTICES

LAP 1 ELECTRICAL WIRING TECHNIQUES

Objectives

- 1 Describe the two methods of stating electrical wire size
- 2 Describe two methods of measuring the size of a wire
- 3 Describe the function of the National Electrical Code
- 4 Describe two factors to consider when sizing wire for an application
- 5 Describe the operation of three tools used to strip wire
- 6 Describe the function and construction of two types of wiring terminals
- 7 Describe two methods to connect wires to terminal screws
- 8 Describe the function of a 3-wire AC circuit

- 9 Describe the function of a ground in a 3-wire circuit
- 10 Describe the function of an AC electrical plug

Skills

- 1 Determine the gauge of a wire using a micrometer
- 2 Calculate line drop
- 3 Size wire for an application
- 4 Strip insulation from wires using a stripping tool
- 5 Install a spade-lug connector on a wire
- 6 Connect an AC plug to an electrical cord
- 7 Connect wires to a terminal strip

LAP 2 WIRING SYSTEM INSTALLATION

Objectives

- 1 Describe the construction and application of three accepted wiring systems
- 2 Describe the function of an installation plan
- 3 Describe the three factors that determine the number of wires that can be installed in conduit
- 4 Describe the function of a fish tape
- 5 Describe the function and operation of a 3-way switch
- 6 Describe the function of an electrical outlet
- 7 Describe two common methods for splicing wires
- 8 List two common lighting systems and give an application for each
- 9 Describe the function of a service entrance

Skills

- 1 Read and interpret a wiring installation plan
Install flexible metal conduit
- 3 Determine the number of wires that can be installed in one conduit
- 4 Pull wire through conduit
- 5 Install a switch
- 6 Install a duplex outlet
- 7 Splice wires
- 8 Install an incandescent light fixture
- 9 Install a circuit breaker
- 10 Troubleshoot a wiring installation
- 11 Connect the wiring system to the service

LAP 1 INTRODUCTION TO RACEWAYS

Objectives

- 1 Describe the function of a wiring system

- 2 Describe the function of the four basic parts of a wiring system
- 3 Describe the function of conduit and list five types
- 4 Describe three methods by which conduit is cut
- 5 Describe the construction and operation of a hacksaw
- 6 Describe the function of a pipe vise and give three types
- 7 Describe the construction and operation of a bench vise with pipe jaws
- 8 Describe six safety rules to follow when operating the bench vise
- 9 Describe the function of deburring conduit and give four tools that can be used
- 10 Describe the function of an electrical box and give an application
- 11 Describe the function of a conduit body and give an application
- 12 Describe the function of a conduit fitting
- 13 Describe the function and operation of three types of connectors
- 14 Describe the function of a coupling
- 15 Describe the function of a conduit strap and list three types

Skills

- 1 Change a blade on a hacksaw
- 2 Use a bench vise to hold conduit
- 3 Cut EMT conduit to length using a hacksaw
- 4 Deburr conduit
- 5 Calculate conduit length given an application
- 6 Connect EMT between two boxes
- 7 Couple EMT conduit

LAP 2 BASIC CONDUIT BENDING

Objectives

- 1 Describe the function of conduit bending and list three basic types of bends
- 2 Describe the function of a conduit bender and two methods that are used to bend conduit
- 3 Describe four types of benders used with metallic conduit
- 4 Describe the construction and operation of a hand bender
- 5 Define the components of a 90° bend
- 6 Describe bender take-up and its importance in making a 90° bend
- 7 Describe the five steps used to determine bender take up
- 8 Describe the five steps to lay out accurate leg lengths and stub
- 9 Describe the components of an offset bend
- 10 Describe the four steps used to determine and locate the bend centers of an offset bend

Skills

- 1 Determine the take-up of a hand bender lengths
- 2 Lay out and bend EMT with proper leg length and stub up
- 3 Determine the bend centers of an offset bend
- 4 Bend an offset in EMT conduit

- 5 Construct a raceway of EMT conduit

LAP 3 ADVANCED RACEWAYS

Objectives

- 1 Describe the similarities and differences between intermediate metallic and rigid conduit
- 2 Describe three tools used to cut intermediate metallic and rigid conduit
- 3 Describe two tools used to bend IMC and rigid conduit
- 4 Describe the construction and operation of a mechanical bender
- 5 Describe the method used to thread IMC and rigid conduit
- 6 Describe the connectors and couplings used with IMC and rigid conduit
- 7 Describe how flexible metal conduit is cut
- 8 Describe the connectors used with flexible metal conduit

Skills

- 1 Cut intermediate metallic conduit
- 2 Change the shoe of a mechanical bender
- 3 Bend IMC with a mechanical bender
- 4 Thread IMC conduit
- 5 Connect and couple IMC given an application
- 6 Cut flexible metal conduit
- 7 Connect flexible metal conduit

LAP 4 CONDUCTORS, DISCONNECTS, AND OVERCURRENT PROTECTION

Objectives

- 1 Describe the function of a conductor and list its two components
- 2 Describe the factors that affect conductor selection
- 3 Describe five common classifications of insulation and give an application of each
- 4 Define conductor ampacity and describe the physical characteristics that affect it
- 5 Describe how distance affects wire selection
- 6 Describe the function of a disconnect and give an application
- 7 Describe three commonly used types of disconnects and give an application of each
- 8 Describe how to size a disconnect
- 9 Describe the function of overcurrent protection and list two types
- 10 Describe how to size circuit protection

Skills

- 1 Select wire size and type for an application
- 2 Select a disconnect for an application
- 3 Select circuit protection for an application

LAP 5 CONDUIT SIZING AND WIRE PULLING TECHNIQUES

Objectives

- 1 Describe percentage of fill and its importance in raceway selection
- 2 Describe two methods used to select raceway diameter
- 3 Describe the 7 steps used to determine conduit size when
- 4 Describe why electrical codes limit the number of conductors in an electrical box
- 5 Describe how to select the correct size electrical box
- 6 Describe how conduit bodies are selected
- 7 Describe three methods used to pull conductors
- 8 Describe the function of a bus bar and give an application
- 9 Describe the function of a bus plug

Skills

- 1 Use NEC tables to select the proper size raceway for same size/type conductors conductors are of different size and/or types
- 2 Determine conduit size when conductors are of different size and/or types
- 3 Determine electrical box size when conductors are the same size
- 4 Determine electrical box size when conductors are of different sizes
- 5 Pull conductors using fish tape
- 6 Connect a bus plug to a bus bar
- 7 Design and install a wiring system given specifications

COMPUTER TECHNOLOGY / PLC's

LAP 1 Introduction to Programmable Controllers

Objectives

- 1 Describe the function of a programmable logic controller and give an application
- 2 List six advantages of a PLC
- 3 Describe the functions of the five basic components of a PLC
- 4 Name three methods of entering a PLC program and give an advantage of each
- 5 Describe the basic operation of a PLC
- 6 Explain why PLCs use ladder diagrams
- 7 Identify and describe the function of the parts of a SCL-500 discrete I/O address
- 8 Describe the function and operation of input/output diagrams
- 9 Describe the operation of XIC and XIO input instructions
- 9 Describe the operation of an OTE instruction
- 10 Describe the basic operation of PLC ladder logic

Skills

- 1 View a directory of processor files using PLC software
- 2 Restore a PLC processor file using PLC programming software
- 3 Monitor a PLC processor file using PLC programming software
- 4 Run a PLC processor file using PLC programming software
- 5 Stop a PLC processor file using PLC programming software

LAP 2 Basic PLC Programming

Objectives

- 1 List five types of numbering systems and explain their importance to PLC's
- 2 Describe the operation of the Decimal numbering system and give an application
- 3 Describe the operation of the Binary numbering system and give an application
- 4 Describe the SCL-500's memory organization
- 5 Describe the operation of the SCL-500's Input and Output Data tables
- 6 Describe the function of seven types of processor files
- 7 Describe three advantages of PLC software
- 8 Describe how an input device can reference multiple input instructions
- 9 Describe how input device logic affects input instruction logic
- 10 Describe how a PLC controls multiple outputs at the same time

Skills

- 1 Convert between Decimal and Binary
- 2 View the status of the SCL-500's Input and Output Data tables
- 3 Create a PLC project using PLC software
- 4 Configure the I/O for a PLC project using PLC software
- 5 Enter a basic PLC program using PLC software

- 6 Save a PLC program to disk using PLC software
- 7 Edit a PLC program using PLC software
- 8 Generate and print out a ladder logic report using PLC software
- 9 Describe how the input device logic affects input instruction logic
- 10 Describe how a PLC controls multiple outputs at the same time

LAP 3 PLC Motor Control

Objectives

- 1 Describe two methods by which a PLC output can control a motor
- 2 Describe how to draw a PLC output diagram for a motor application
- 3 Describe how input instructions can be controlled by PLC output instructions
- 4 Describe the function and operation of PLC seal-in logic
- 5 Describe the function and operation of a program interlock and give an application
- 6 Describe how a program interlock is used for safety
- 7 Describe the function of the PLC program documentation and give an application

Skills

- 1 Design a PLC program to jog two motors
- 2 Design a PLC program to control the start/stop of two motors
- 3 Design a PLC program to interlock two motors
- 4 Design a PLC program that uses a safety interlock to control the operation of a machine
- 5 View project documentation and use it to operate a PLC program
- 6 Document a PLC program file

LAP 4 Discrete I/O Interfacing Allen-Bradley SCL-500 Family

Objectives

- 1 Describe four features used to select a PLC discrete input module
- 2 List and describe the five features used to select a PLC discrete output module
- 3 Describe the effect of leakage current on an AC output module operation
- 4 Explain how to interface to a discrete electronic sensor with NPN or PNP output
- 5 Describe how to interface a PLC to a machine controller

Skills

- 1 Connect and test a limit switch to a PLC discrete input module
- 2 Connect and test the operation of a solenoid valve to a PLC output
- 3 Connect and test the operation of a motor starter to a PLC
- 4 Connect and test the operation of an electronic sensor to a PLC input module
- 5 Connect and test the operation of a PLC input module to a robot output module
- 6 Connect and test the operation of a PLC discrete output module to a robot input module
- 7 Develop an interface wiring diagram to interface a PLC to a machine controller

LAP 5 Introduction to PLC Troubleshooting

Objectives

- 1 Define event-driven sequencing
- 2 Describe the operation of a reciprocating actuator PLC program
- 3 Describe the function of an internal output instruction and give an application
- 4 Describe the operation of a continuous cycle reciprocating program
- 5 Describe the operation of a basic multiple actuator sequence program

Skills

- 1 Design a reciprocating actuator sequence PLC program
- 2 Design a continuous cycle clamp and drill sequence PLC program

LAP 6 PLC Systems Troubleshooting

Objectives

- 1 Describe the functions of the seven steps used to design a PLC program
- 2 Describe the operation of a PLC program with manual and automatic modes
- 3 Describe three methods of stopping a PLC-controlled machine

Skills

- 1 Design a PLC program using a seven-step design process
- 2 Design a motor control program which uses both manual and automatic modes
- 3 Design a PLC program which has both Halt and Cycle Stop functions

LAP 7 Event Sequencing

Objectives

- 1 Describe the function of two types of timer instructions and give an
- 2 Describe the operation of a retentive timer on-delay instructions
- 3 Describe the function and application of two types of non-retentive timer instructions
- 4 Describe the operation of the non-retentive timer on-delay instruction
- 5 Describe the operation of an off-delay timer instruction
- 6 Define time-driven sequencing and give three applications
- 7 Describe the operation of a time-driven sequence program

Skills

- 1 Enter and edit a PLC program that uses a RTO instruction
- 2 Enter and edit a PLC program that uses a TON instruction
- 3 Enter and edit a PLC program that uses a TOF instruction
- 4 Design a PLC program that provides low voltage starting of an electric motor
- 5 Design a PLC program that uses a time-driven sequence to control an actuator
- 6 Design a PLC program to control a plastic injection molding machine

LAP 8 Application Development

Objectives

- 1 Describe the functions of the seven steps used to design a PLC program
- 2 Describe the operation of a PLC program with manual and automatic modes
- 3 Describe three methods of stopping a PLC controlled machine
- 4 Describe how to determine a discrete I/O address in a local I/O chassis

Skills

- 1 Design a PLC program using a seven-step design process
- 2 Troubleshoot a PLC program with manual and automatic modes
- 3 Design a motor control program which uses both manual and automatic modes
- 4 Design a PLC program which has both a Halt and Cycle-Stop functions
- 5 Troubleshoot a PLC program which has both Halt and Cycle-Stop functions
- 6 Determine the address of a discrete I/O address in a local I/O chassis

LAP 9 Counter Instructions

Objectives

- 1 Describe the functions of two types of PLC counter instructions
- 2 Describe the operation of an count up instruction
- 3 Describe the operation of a count down instruction
- 4 Describe the function of the OTL and OTU instructions and give an application
- 5 Describe the operation of the OTL and OUT instructions

Skills

- 1 Enter and edit a PLC program that uses a count up instruction
- 2 Design a PLC program to control the number of production cycles
- 3 Enter and edit a PLC program that uses an Up/Down-Counter instruction
- 4 Design a PLC program that controls a conveyor queue station
- 5 Enter and edit a program that uses the OTL and OUT instructions
- 6 Design a clamp and drill application which uses the latch/unlatch instructions

