Robotics Production Technician Program

Program Outline, Learning Outcomes & Worker Standards

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Computer Operating Systems

Learning Objectives

1. List the two primary functions of a microprocessor.
2. Define the terms "bits" and "words."
3. List external devices to the microprocessor that are considered input or output devices.
4. Describe the difference between RAM and ROM memory.
5. List the two primary functions of the timing device of a microprocessor.
6. Give examples of mass storage devices.
7. Identify which type of logic signal is produced by a gate circuit as various combination of inputs are applied.
8. Convert binary to decimal values.
9. Describe the functions of combination logic circuits.
10. Explain the function of storage registers, the address assigned to each one, and how many memory cells they must have for various word lengths.
11. Describe the function of bus-lines.
12. List the functions of a mother-board.
13. Describe the function of the subsystem inside the CPU.
14. Explain the entire operation of a microprocessor as it adds two binary numbers.
15. Describe the advantage of using machine language and advanced software languages when programming a microprocessor.

Worker Standards - Basic Technical Knowledge and Skills

Basic Technical Knowledge and Skills

Identify the terms that require familiarization to work with computer operating systems.

1. Knowledge of the following terms:
    a. bits
    b. words
    c. RAM
    d. ROM
    e. CPU
    f. ALU
    g. bus-line
    h. firmware
    i. software
    j. program
    k. address
    l. data
    m. microcomputer
    n. microcontroller
    o. machine language

p. mother-board

2. Provide a working definition of data that is processed by the circuitry of computer operating systems.
    a. Knowledge of the binary numbering system used by the internal circuitry of computer systems.
    b. Skill in converting values between binary and decimal numbering systems.
    c. Knowledge of how binary values are represented by dc voltages.
    d. Skill in counting binary values as they increment or decrement.
3. Describe the functions performed by logic and memory devices in a microprocessor.
    a. Knowledge of the various logic gates used within the internal circuitry of a digital control system.
    b. Skill in determining the logic state produced at the output of various logic gates based on the types of logic states applied to their inputs.
    c. Knowledge of the various combination circuits made up of logic gates.
    d. Skill in determining the logic states or binary numbers produced at the outputs of combination circuits based on the types of logic states applied to the inputs.
4. Using a block diagram of a microcomputer, identify the role that each block performs.
    a. Knowledge of the various types of storage devices that are used by the CPU.
    b. Skill in identifying how the different types of storage devices are used to store data, such as instructions, data as it is being processed, or large quantities of information.
    c. Knowledge of the function I/O devices performs.
    d. Skill in identifying the external devices used to enter input data and to read output data connected to I/O devices.
    e. Knowledge of the CPU and the logic functions it performs.
    f. Knowledge of the timing device used to synchronize the circuits of a microcomputer.
    g. Skill in determining how to increase the operating speed and memory capacity of microcomputer systems.
5. Describe how the microprocessor executes the addition of two numbers to produce a sum.
    a. Knowledge of the functions each sub-system of a microprocessor performs to add two numbers.
    b. Skill in programming a microprocessor to add two numbers.
    c. Knowledge of how data is manipulated and processed one step at a time inside a microcomputer.
    d. Skill in altering a program to change an operation performed by a microprocessor.
    e. Knowledge of why machine language is faster than modern user-friendly programming languages.
    f. Knowledge of how data moves over address busses, data lines, and control bus lines.

Computer Control Systems

Learning Objectives

1. Identify the characteristics of motion control and process control and the different control requirements of each one.
2. List the difference between open-loop and closed-loop systems, such as the control elements and control signal that they have in common, and which ones they don't have in common.
3. Discuss how an error signal is created in a closed-loop system.
4. Identify the following elements and signals in figure 2-6.
    a. Set point Signal
    b. Feedback Signal
    c. Error Signal
    d. Controller Element
    e. Sensor
    f. Actuator
    g. Controlled Variable
5. Define the term "home position", and list the voltage levels required for the set point and feedback signals to be in or out of the home position.
6. Identify how the number of "degrees of freedom" corresponds to the number of motors and pivotal joints that are required.
7. Explain the operation of the robotic arm in Fig. 2-6 of the handout.

Worker Standards - Basic Technical Knowledge and Skills

Identify the terms that require familiarization to work with automated control systems.

1. Knowledge of the following terms:
    a. Set point
    b. Home position
    c. Error
    d. Feedback
    e. Actuator
    f. Controlled variable
    g. Sensing element
    h. Open-loop
    i. Closed-loop

   j. Disturbance
   k. DAC
   l. Analog signal
   m. Digital signal
   n. Joystick
   o. Degrees of freedom
2. Describe the differences and similarities between an open-loop and closed-loop system.
   a. Knowledge of the elements and their functions in an open-loop and closed-loop system.
   b. Skill in troubleshooting an open-loop system.
   c. Knowledge of how open-loop systems can be automated, and their limitations.
   d. Knowledge of determining how and where an error signal is produced.
3. Describe how a closed-loop system performs automated control operations.
   a. Knowledge of the functions performed by each element of a closed-loop system.
   b. Knowledge of control, measurement, and manipulation of controlled variables in a closed-loop system.
   c. Skill in troubleshooting a closed-loop system.
   d. Knowledge of how signals are produced by elements of a closed-loop system and how they affect the next element as they are applied as input signals.
   e. Skill at determining how set point signals changes or disturbances will affect the operation of a closed-loop system.
   f. Knowledge of identifying practical devices that perform the functions of each element.
4. Explain how industrial control systems are categorized.
   a. Knowledge of motion control and process control systems.
   b. Skill in determining how error signals are typically created in motion and process control systems.
   c. Knowledge of the characteristics of motion control and process control systems.
   d. Skill in identifying the categories under which actual production processes are classified.
5. Describe the operation of a robotic arm.
   a. Knowledge of the electronic devices that control the movement of a robotic arm.
   b. Skill in determining the direction that the robotic are will move when the set point signal is changed.
   c. Knowledge of the summing Op Amp, differential Op Amp, potentiometer and DAC operation.
   d. Knowledge of how the signals produced by the electronic devices of a robotic arm will vary as the set point is changed.
   e. Skill at troubleshooting a defective robot.
6. Explain how military robots are controlled and monitored.
   a. Knowledge of the devices used to program or manually provides input data that affect the movements of a military robot.
   b. Skill at programming or manually controlling the movement of a military robot.
   c. Knowledge of the devices used to monitor the movement of a robot.

Power Systems

Learning Objectives

1. List the three basic components of a battery.
2. List the factors that determine the voltage and current capacity of a battery.
3. Explain the difference between primary and secondary batteries.
4. Describe two different ways that batteries are classified.
5. Explain the two factors that cause batteries to lose their charge.
6. Define specific gravity that is measured by a hydrometer when testing a lead-acid battery.
7. List the factors that make lithium batteries attractive for many applications.
8. Describe the rules that must be followed to recharge a battery, and explain how current flows within the battery.
9. Explain what happens during the chemical reaction between the two electrodes and the electrolyte that produces a negative potential at one terminal, and a positive potential at the other terminal.
10. List the precautions that must be followed during the charging cycle of a lithium-ion battery.
11. Explain the function of the following devices, components and circuits:
    a. Diode Capacitor Generator
    b. Rectifier Filter
    c. Define duty cycle.
12. Given a dc reference voltage, determine the average DC voltage for various duty cycles of a pulse width modulation (PWM) signal.
13. Describe the standard procedure on how to perform a load test on a battery.

Worker Standards - Basic Technical Knowledge and Skills

Identify the terms that require familiarization to work with power sources of military robots.

1. Knowledge of the following terms:
    a. Duty cycle
    b. PWM
    c. Primary battery
    d. Secondary battery
    e. Specific gravity
    f. Hydrometer
    g. Electrolyte
    h. Electrodes
    i. Dry cell
    j. Wet cell
    k. Load

l. Polarization

2. Describe the classifications of batteries used to supply power to portable devices.
    a. Knowledge of the differences between primary batteries, secondary batteries, wet cells, and dry cells.
    b. Skill in recharging a secondary battery.
    c. Knowledge of the cell materials used to create a voltage for the various types of batteries.
3. Describe the physical properties and reactions associated with a battery.
    a. Knowledge of the three basic components of a battery.
    b. Knowledge of the chemical reactions that create a voltage for primary and secondary batteries.
    c. Skill in determining the level of the charge a lead acid battery by measuring specific gravity with a hydrometer.
    d. Knowledge of the factors that contribute to the reduction of a battery's charge and voltage.
    e. Skill in determining the types of batteries to use for specific applications.
4. Determine the factors that contribute to the voltage and current capacities of batteries.
    a. Knowledge of how cells or batteries connected in series can affect the voltage levels of a battery at its terminals.
    b. Skill in connecting batteries in series to produce a desired voltage.
    c. Knowledge of how cells or batteries connected in parallel can affect the current level supplied by a battery.
    d. Skill in connecting batteries in parallel to provide a desired level of current.
    e. Knowledge of the types of metals that are used for electrodes in a battery to create a voltage.
    f. Knowledge of the types of chemical that are used for the electrolyte in a battery to create a voltage.
5. Explain how AC voltages are generated to produce electrical power and how they are converted to direct current voltages for portable devices.
    a. Knowledge of how magnetic induction by a generator produces an AC voltage.
    b. Skill in measuring the amplitude and frequency of an AC voltage.
    c. Knowledge of the four factors that determine the voltage amplitude produced by an AC generator.
    d. Knowledge of how diodes rectify AC voltages and pulsating DC voltages are filtered by capacitors.
    e. Skill in troubleshooting defective rectifier and filter circuits due to faulty diodes and capacitors.
6. Describe the process of producing a variable DC voltage using pulse width modulation.
    a. Knowledge of how electrical power can be varied by changing the duty cycle of a DC voltage.
    b. Skill in calculating the average DC voltage of a PWM signal based on its duty cycle.
    c. Knowledge of the DC source for a PWM circuit and the device that controls the duty cycle by rapidly turning switching devices on and off.
7. Explain the way in which batteries used by military robots can be tested to determine their charge before the robot is deployed.

a. Knowledge of the load test procedure used to determine the remaining longevity of a battery.
b. Skill in performing a battery load test.

Sensors

Learning Objectives

1. Define the following terms related to a closed-loop system:
2. Set point feedback signal measuring device (sensors) error controlled variable
3. Identify which of the following types of waves are electromagnetic:
    a. IR (Infrared) Gamma Rays
    b. X-Ray Ultrasonic
4. Explain what happens to the frequency and wave length of electromagnetic waves emitted from an object when its temperature increases or decreases.
5. Define the term "Roentgen," and identify what kind of electromagnetic wave it pertains to.
6. Identify examples of organic and inorganic gases.
7. Explain how carbon monoxide is formed during combustion.
8. Explain how a gas analyzer works to detect harmful gases and chemical agents.
9. Identify examples of biological and chemical warfare agents, and describe how they are detected.
10. Describe how infrared cameras are able to detect images.
11. Explain the operation of photonic sensors.

Worker Standards - Basic Technical Knowledge and Skills

Identify the terms that require familiarization to work with the sensing devices of industrial and military robots.

1. Knowledge of the following terms:
    a. Roentgen
    b. Measuring device
    c. Set point
    d. Error
    e. Feedback
    f. Controlled variable
    g. Radiation
    h. Gamma rays

i. Inorganic gasses
j. Organic gasses
k. Bio-chemical agents

2. Describe the functions of sensors.
    a. Knowledge of what sensors do in a closed-loop system.
    b. Knowledge of what sensors measure in industrial applications.
    c. Knowledge of sensors used by military robots.
    d. Skill in identifying what types of sensors should be used to make particularly types of measurements by a military robot.
3. Explain the operation of the sensors that are used by military robots to detect high temperatures or to detect objects in its path.
    a. Knowledge of how ultrasonic sensors detect objects to prevent the robot from colliding with objects.
    b. Knowledge of how infrared sensors measure dangerous temperatures for a distance.
    c. Skill in using a laser for measuring the exact location of a heat source.
4. Describe how radioactivity is produced and the types of sensors that measure radioactive strength.
    a. Knowledge of the condition elements are in to create gamma rays.
    b. Knowledge of how the transition radiation detector measures the amount of gamma radiation energy.
    c. Knowledge of how X-rays detect objects inside a sealed container or en enclosed package.
5. Describe the various types of bio-chemical agents and gasses that are harmful to humans and the sensors that detect them.
    a. Knowledge of how organic, inorganic, and combustible gasses differ.
    b. Knowledge of bio-chemical warfare agents that are detected by a military robot.
    c. Knowledge of how an infrared gas analyzer detects various combustible, organic, and inorganic gasses and bio-chemical agents.
    d. Knowledge of determining the response of the military robot when it detects a harmful agent.
6. Describe the various types of sensors that provide vision for the person operating a military robot.
    a. Knowledge of what IR cameras are used for.
    b. Knowledge of what kind of measurements photonic sensors are used to make.

Communication Systems

When we describe communications, it's often convenient to use a "systems" approach, in which we consider the entire system that enables us to communicate. We can break these systems down further into their basic building blocks or components. To understand communications, it's important to be able to work at both the systems level and the component level. To create a basic communications system, we need three things—a transmitter to send the message, media over which to send the message, and a receiver of the information. Any communication system can be modeled with these core components. Listening to a radio station is an example of one-way broadcast communications—a signal intended for many recipients. The radio station has a very powerful transmitter and antenna or broadcast tower at its facility. The transmission medium in this case is the air around us, and the receiver is your radio. When you tune your radio to your favorite station, you are tuning the receiver to the specific frequency of that radio station. Other forms of communication are two-way, and require the ability to both receive and transmit messages at both the source and destination. Communication with a robot – whether it's wired or wireless – is typically two-way communication, which requires both the robot and the controller to be able to send and receive information and signals.

Learning Objectives

1. Describe a basic communications system consisting of three things—a transmitter to send the message, media over which to send the message, and a receiver of the information.
2. Know and understand electronic communication systems that include a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
3. Define and explain the function of:
    a. Transceiver
    b. RFID
    c. SWR (standing wave ratios)
    d. Analog vs. digital
    e. RF

f. Electrical signal over copper
g. Pulses of light over fiber
h. Modulation vs. demodulation
i. Coding & decoding
j. Antennas

Worker Standards - Basic Technical Knowledge and Skills

1. Working with Systems and Components
    a. Skill in using a "systems" approach to describe communications.
    b. Skill to break communications systems into their basic building blocks or components.
    c. Skill to work at both the component level and at the systems level.
    d. Knowledge to explain the function of a transmitter in a communication system.
    e. Knowledge to explain the function of media in a communication system.
    f. Knowledge to explain the function of a receiver in a communication system.
    g. Skill to model any communication system with transmitter, media, and receiver.
    h. Knowledge of a communication system abstracted as input, communication process, output, and feedback.
    i. Knowledge that the communications process in a communication system consists of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.
    j. Knowledge that a modem or modulator/demodulator is an example of an encoder/decoder in a communication system.
    k. Skill in identifying the communication channel.
2. Knowledge of Communications Systems
    a. Knowledge that electronic communication relies on radio waves, pulses of light, or electrical signals to carry messages.
    b. Skill to select the appropriate communication medium (electrical signals, pulses of light, or radio waves).
    c. Knowledge that the destination (the robot) consists of hardware, software, and circuitry to decode the message, receive it, and perform the requested action.
    d. Knowledge that a receiver that also has the ability to transmit back information is called a transceiver.
    e. Knowledge that we can send signals and electronic communications either as analog or digital.
3. Working with digital bits and bytes
    a. Knowledge of the binary number system, ones and zeros, and the relationship to digital signaling.
    b. Knowledge that in a digital signal every pulse is called a binary digit or bit, which can have either a value of 1 or 0.
    c. Knowledge that eight bits combine to form a byte, which is the fundamental unit for carrying a single piece of information.
    d. Knowledge of the importance of binary numbers for communication between computers and electronics.
    e. Skill in converting from bytes to kilobytes, megabytes, gigabytes, and even terabytes.
    f. Skill in converting from our standard base 10 numbering system to binary, and back-and-forth.
    g. Skill to explain the difference between an analog signal and a digital signal.

h. Skill to identify the amplitude, period, and frequency of an analog waveform.
i. Skill to measure and then explain the frequency of a waveform in hertz (Hz).
j. Skill to convert from frequency to period and from period to frequency.
k. Knowledge of the relationship between the wavelength of a signal and the frequency.
l. Skill to convert from wavelength to frequency and from frequency to it.
m. Knowledge that frequency and wavelength are inversely proportional and related by the speed of light.
n. Knowledge that the term phase refers to the starting point of the wave and a phase change is a change in that starting point.
o. Skill to determine, based upon our communication medium, the appropriate type of signaling to use, either analog or digital.
p. Knowledge the analog signals provide higher quality information and can convey minor detail with less energy and effort then digital signals.
q. Knowledge that analog signals are more difficult to transmit then digital signals, which are relatively immune to noise and interference.
r. Knowledge that the inefficiency in digital signaling is more than made up for by the gains in reliability.

4. Describe the role of a modem in a communication system
   a. Knowledge that the term modem is a contraction for modulator/demodulator, the device that encodes and decodes information.
   b. Knowledge that modulation can be used to increase efficiency, reliability, and data carrying capacity.
   c. Skill to determine if a modem is required and to be able to select the appropriate modem.
   d. Knowledge that communication can be tethered (fiber optic, copper) or untethered (wireless).
   e. Knowledge that while wireless communication provides some benefits there are also some associated complications.
5. Carrier waves and modulation
   a. Knowledge of the role of a carrier wave and modulation in a communication system.
   b. Skill to differentiate between a carrier signal and the actual message.
   c. Skill to identify various types of modulation including amplitude modulation and frequency modulation.
   d. Skill to describe the process of modulation and its purpose.
   e. Skill to differentiate between a carrier wave and a messenger wave.
   f. Skill to describe the processes of amplitude modulation and frequency modulation.
   g. Knowledge of the difference between digital modulation and analog modulation.
   h. Skill to describe analog modulation versus digital modulation.
   i. Knowledge of the term standing wave ratio (SWR) and its relationship to the performance of a radio.
   j. Skill to describe how SWR is measured and determine a suitable value for SWR.
   k. Knowledge of the various reasons for a poor SWR value.
   l. Skill to identify and troubleshoot potential causes for a poor SWR value.
   m. Knowledge of the practical implications of SWR.
6. Radio frequency identification (RFID)
   a. Knowledge of what RFID is.

b. Knowledge of the role of a transponder in an RFID tag.
c. Knowledge of the role of the interrogator or RFID reader an RFID system.
d. Skill to determine applications of RFID in a communication system of a robot.
e. Knowledge of the abilities and limitations of an RFID system.
f. Skill to differentiate between the three types of RFID tags.

7. Transmission
   a. Knowledge that transmission is the process of sending and receiving information through communications channel.
   b. Knowledge that transmission can be classified as point-to-point, or point-to-multipoint.
   c. Knowledge that transmission can also be classified at simplex, half duplex, or full duplex.
   d. Skill to select the appropriate transmission methods for a particular application.
   e. Knowledge of potential transmission flaws, including electromagnetic interference (EMI), crosstalk, attenuation, and latency, and how they might effect a transmission.
   f. Skill to identify and troubleshot potential transmission flaws based on the performance of the communications system.
8. How an antenna works
   a. Knowledge of the conditions that impact the performance of an antenna.
   b. Knowledge of the parameters that characterize an antennas performance.
   c. Skill to identify different types of antennas, including omnidirectional and directional.
   d. Skill to identify and properly select the parameters that characterize an antennas performance.
   e. Skill to select the appropriate antenna for a particular application.
9. Working with Many Channels - Multiplexing
   a. Knowledge of the concept of tuning to a frequency to receive a specific communications channel.
   b. Knowledge that combining multiple channels onto a single medium is called multiplexing.
   c. Knowledge that at the sender we combine channels with a multiplexer and at the receiver, we separate channels into individual conversations with a demultiplexer.
   d. Skill to explain how frequency division multiplexing (FDM) works.
   e. Skill to explain how time division multiplexing (TDM) works.
   f. Skill to identify a potential need for multiplexing in a communications application.
10. Cabling -
    a. Knowledge of the various type of cabling available, including
       - coaxial,
       - twisted-pair,
       - shielded twisted-pair,
       - unshielded twisted-pair,
       - RJ-45 and RJ-11,
       - single-mode fiber,
       - multi-mode fiber, and
       - serial cables and connectors.
    b. Skill selecting and specifying the appropriate cabling for a particular application.

Cameras, Photonics and Light Sources

Learning Objectives

1. Define photonics
2. List some photonic devices used in robotics
3. Name two main types of digital camera technologies used in robotics
4. List one main advantage of using CMOS camera technology versus CCD camera technology in robotics
5. List the types of data transmission used in robotic cameras
6. List some laser applications used in robotics
7. Describe one major handling precaution for CCD & CMOS camera sensor devices
8. Discuss precautions that need to be taken, and why, when bending leads of semiconductor devices
9. Discuss precautions that need to be taken, and why, when soldering leads of semiconductor devices
10. To maintain clean optics, describe one major handling precaution to take when handling photonic devices
11. Discuss key points of laser safety
12. Discuss why you should never look into the aperture of a laser, even if you think it is not powered-on
13. Be able to properly clean the CCD or CMOS sensor of a digital camera

Worker Standards - Basic Technical Knowledge and Skills

1. Knowledge of the definition of photonics.
2. Knowledge of general types of photonic devices used in robotics.
3. Knowledge of two main types of digital camera technologies used in robotics.
4. Knowledge of one main advantage of using CMOS camera technology versus CCD camera technology in robotics.
5. Knowledge of the types of data transmission used in robotic cameras.
6. Knowledge of some laser applications used in robotics.
7. Skills in the proper handling procedures of CCD & CMOS camera sensor devices.

8. Skills in proper bending of semiconductor devices leads when leads are required to be bent for assembly.
9. Skills in proper soldering of semiconductor devices leads.
10. Knowledge of laser safety guidelines.
11. Skills in proper cleaning of CCD or CMOS sensors in digital cameras.

Robot Mobility and Navigation

Learning Objectives

1. Provide a working definition of GPS.
2. List the three segments of the GPS.
3. Describe the role time plays in GPS positioning.
4. Describe how pseudorange and carrier wave measurements work to determine positions.
5. Describe the two "codes" used to determine position.
6. Discuss GPS errors and biases and how their effects are mitigated.
7. Describe the satellite geometry values (i.e. all of the DOPs).
8. Compare the plane grid system.
9. Compare and contrast UTM and MGRS.

Worker Standards - Basic Technical Knowledge and Skills

1. Provide a working definition of GPS.
    a. Knowledge of the Navigation System Timing and Ranging (NAVSTAR) program
    b. Skill in determining the different capabilities of single-frequency code receivers, single-frequency carrier-smoothed code receivers, single-frequency carrier receivers, and dual-frequency receivers
    c. Knowledge of the generic communication protocols used in GPS, to include the Receiver Independent Exchange Format (RINEX), Radio Technical Commission for Maritime Services (RTCM SC-104), and National Marine Electronics Association (NMEA 0183).
    d. Skill in using an Almanac file to estimate satellite positioning
    e. Knowledge of the difference between an almanac of predicted satellite positions and the ephemeris of recorded locations
    f. Skill in mission planning for a future GPS data collection operation

2. List the three segments of the GPS.
    a. Skill in recognizing the role each segment (User, Space, and Control) plays within the system
    b. Knowledge of how the Master Control Station, Monitoring Stations, and Ground Control Stations work together to maintain the GPS
    c. Skill in determining the satellites in the current GPS constellation
    d. Knowledge of how the Block II, Block IIA, and Block IIR satellites differ in regards to capabilities
3. Describe the role time plays in GPS positioning.
    a. Knowledge of how the GPS measures distance using the travel time of radio signals
    b. Skill in measuring the ranges (distances) from a GPS receiver to satellites based on both the receiver and the satellite clocks
    c. Knowledge of how GPS can be used for time synchronization as it relates to Universal Time Coordinated (UTC)
    d. Skill in the use of GPS Time as a continuous time scale
    e. Knowledge of the ability of a receiver to compensate for a synchronization error in the receiver clock
    f. Knowledge of the GPS navigation message and its capacity to convey information related to satellite health status, clock correction, almanac, and atmospheric data

Introduction to Lean Manufacturing

Learning Objectives

1. General knowledge of lean manufacturing concepts
2. Understanding of differences between traditional and lean systems
3. Knowledge of the different types of waste
4. Understanding of the key measures of a lean system and why they are important
5. Understanding of various lean system strategies
6. Knowledge of lean manufacturing methodology

Worker Standards - Basic Technical Knowledge and Skills

1. General Knowledge of lean manufacturing concepts.
    a. Knowledge of the need for lean manufacturing
    b. Knowledge of employee involvement in lean manufacturing
    c. Knowledge of obstacles to improvement
2. Understanding of differences between traditional and lean systems.
    a. Knowledge of traditional versus lean manufacturing
    b. Knowledge of management's roles and responsibilities
3. Knowledge of the different types of waste.
    a. Skill in the identification of waste
4. Understanding of key measures of a lean system and why they are important.
    a. Knowledge of traditional measures
    b. Skill in lean manufacturing measures
5. Understanding of various lean system strategies.
    a. Knowledge of continuous improvement or Kaizen events
    b. Knowledge of standard work
    c. Knowledge of value stream mapping and value chain management
    d. Knowledge of pull systems, Kanban, leveling and theory of constraints (TOC)
    e. Knowledge of one piece flow and small lot production
    f. Knowledge of workplace organization (WPO), 5S and visual management
    g. Knowledge of containerization, transportation and milk run
    h. Knowledge of process capability and Six Sigma
    i. Knowledge of error proofing
    j. Knowledge of plant, machine, and office layout
    k. Knowledge of operator autonomous maintenance and planned maintenance

l. Knowledge of quick change over and set up reduction
m. Skill in employee involvement
n. Knowledge of lead time reduction

6. Understanding of lean manufacturing methodology to include:
   a. organization assessment,
   b. implementation planning,
   c. train everyone,
   d. form employee teams,
   e. team employs the tools and concepts of lean manufacturing,
   f. implement changes in the cell,
   g. keep records of all events,
   h. measure the key attributes,
   i. start before any changes are made,
   j. audit the results, and recognize performance.

Safety

Provides baseline knowledge and skills needed to maintain a safe and productive work environment and ensure the safe use of equipment in the workplace.

Section 1: OSHA Standards

Section 2: Safety Inspections

Section 3: Hazard Communications-MSDS

Section 4: Personal Protective Equipment

Section 5: Respiratory Protection

Section 6: Fire Safety

Section 7: Hand and Power Tool Safety

Section 8: Lockout/Tagout Safety

Section 9: Ergonomics

Section 10: Bloodborne Pathogens

Learning Objectives

1. Examine the purpose of OSHA.
2. Identify the elements of the OSHA Program.
3. Describe employer and employee duties and responsibilities under OSHA.
4. Discuss the elements of the OSHA General Duty Clause.
5. Describe how OSHA determines which facilities to inspect.
6. Discuss how facilities prepare for inspections.
7. Describe the inspection process.
8. Discuss the inspection process, how the inspection will be concluded, what happens if a citation is given and/or penalties assessed, and what actions are required to abate violations.
9. Describe how assessing potential hazards in the workplace is affected by housekeeping practices.
10. Identify what causes slips, trips, and falls.
11. Discuss methods of training to prevent slips, trips, and falls.
12. Describe how, when, and where chemicals are encountered.
13. Identify, employee training, storage, and use of chemicals.
14. Decipher chemical hazards, exposure, burns, hazard identification, and product warning labels.
15. Examine the employee's right-to-know about hazardous chemicals in use.
16. Describe the use of Material Safety Data Sheets (MSDS).
17. Discuss exposure guidelines and who establishes them.
18. Describe how to conduct a hazard assessment inspection.
19. Identify proper selection of necessary PPE for hazards.
20. Describe function, use, and maintenance of PPE and respirators.
21. Examine OSHA Requirements for Respiratory Protection, hazards associated with the use of respirator protection, and company program requirements for respirator safety.
22. Identify types of respirators.

23. Demonstrate the proper method for placement and removal (donning and doffing), ensuring proper fit, cleaning, maintenance, and storage of respirators.
24. Identify evacuation plans, exit routes and hazards that hinder evacuation.
25. Describe the proper fire extinguishing agents to use on different classes of fires.
26. Discuss the four classes of fires, their prevention, and associated hazards.
27. Examine training requirements and applicable standard relating to exits, fire extinguishers, and storage and handling of flammable and combustible materials.
28. Identify the requirements, elements of the applicable standards, and the written plan for emergency response.
29. Describe chemical hazards, exposure, burns, hazard identification, and their importance to emergency response teams.
30. Understand electricity, what it is, how it works, as well as the hazards that exist and the safety precautions that must be observed when working with and around electrical equipment.
31. Discuss methods of training to prevent electrical hazards.
32. Describe the hazards that exist when working with and around tools.
33. Identify the procedures for working with and around tools, including inspecting and cleaning, as well as proper and improper use.
34. Determine the requirements and need of a hazardous energy control program.
35. Discuss proper selection of devices for control of hazardous energy.
36. Identify uses of devices intended to control hazardous energy.
37. Examine proper training methods for hazardous energy control.
38. Examine your workplace for better ergonomic stations.
39. Determine how ergonomics will improve the workplace.
40. Identify the types, signs, and symptoms of MSDs.
41. Discuss the mismatch between the physical requirements of the job and the human body, and loss of workdays as a result of MSDrelated injuries.
42. Examine the following as it applies to BBPs:
    a. Potential exposures and modes of transmission.
    b. Requirements of the employee and employer.
    c. Protection from exposure through safe work practices.
43. Discuss the following elements of BBP programs:
    a. Exposure control plan.
    b. Regulated medical waste.
44. Determine the safety steps required when an employee is exposed to a BBP.
45. Describe the following requirements as they pertain to BBPs:
    a. Proper labeling of waste.
    b. Recordkeeping.
    c. Training elements required by the OSHA.

Worker Standards - Basic Technical Knowledge and Skills

1. Work in a safe and productive manufacturing workplace
2. Perform safety and environmental inspections
3. Perform emergency drills and participate in emergency teams
4. Identify unsafe conditions and take corrective action
5. Provide safety orientation for all employees

6. Train personnel to use equipment safely
7. Suggest processes and procedures that support safety of work environment
8. Fulfill safety and health requirements for maintenance, installation, and repair
9. Monitor safe equipment and operator performance
10. Utilize effective, safety-enhancing workplace practices

Quality Practices and Measurement

Develops foundational knowledge and skills needed to maintain quality and implement continuous improvement processes, and ensure that product and process variances meet quality standards.

Section 1: Introduction to Quality

Section 2: Managing Quality

Section 3: Measuring Process Quality

Section 4: Quality Improvement and Assessment

Section 5: Nonconforming Products & Corrective Action

Section 6: Problem Solving

Learning Objectives

1. Identify and describe elements of a quality management system used in manufacturing.
2. Determine the need for continuous quality improvements.
3. Examine the cost of poor quality.
4. Examine the use of graphical data.
5. Identify and describe the concepts used to measure the quality of a manufacturing process.
6. Demonstrate the use of measurement principles and equipment.
7. Identify and describe statistical process control (SPC) tools used in manufacturing.
8. Identify and describe mistake-proofing methods.
9. Demonstrate mean and median computations, and the development and use of run and control charts to control process quality.
10. Describe a quality management system audit and the assurances it provides.
11. Describe the root cause failure analysis process and how to facilitate the process.
12. Identify and describe corrective and preventive actions.
13. Identify and describe the CAPA (Corrective and Preventive Action) System process.
14. Identify the steps in documenting a CAPA Report.
15. Identify and describe the components of the Toyota Quality System House and the ISO 9000 Process.
16. Identify manufacturing quality awards.
17. Describe a typical benchmarking process.
18. Describe the design of experiment process.
19. Identify and describe the elements of a process capability study.
20. Describe the objective of measurement system analysis.
21. Identify and describe the steps for creative problem solving.
22. Identify the reasons for performing inspections.
23. Describe the importance of acceptance sampling.
24. Identify possible ways of disposing of nonconforming products.
25. Identify the contents of an inspection plan.
26. Discuss the role of a production technician in a quality circle.
27. Discuss how gathering data relates to the problem-solving process.
28. Discuss the use of check sheets, pie charts, and bar charts in the problem-solving process.
29. Identify and describe the key elements of a fishbone diagram.

Worker Standards - Basic Technical Knowledge and Skills

1. Participate in periodic internal quality audit activities
2. Check calibration of gages and other data collection equipment
3. Suggest continuous improvements
4. Inspect materials and product/process at all stages to ensure they meet specifications
5. Document the results of quality tests
6. Communicate quality problems.
7. Take corrective actions to restore or maintain quality
8. Record process outcomes and trends
9. Identify fundamentals of blueprint reading
10. Use common measurement systems and precision measurement tools

Manufacturing Processes and Production

Develops foundational knowledge and skills needed for the production of products to meet customer needs while ensuring the manufacturing process meets business requirements.

Section 1: Introduction to Manufacturing

Section 2: Introduction to Industry

Section 3: The Production Process

Section 4: Manufacturing Essentials

Section 5: Manufacturing Instruments

Section 6: Quality Tools

Section 7: Six Sigma

Section 8: Lean Manufacturing

Section 9: Business Basics

Section 10: Supply Chain

Leaning Objectives

1. Describe early manufacturing processes.
2. Discuss mass production and how it revolutionized manufacturing.
3. Identify the types of manufacturing methodologies.
4. Identify manufacturing sub-industries.
5. Discuss the manufacturing operating environment.
6. Discuss current and future manufacturing processes.
7. Identify examples of manufactured products.
8. Identify various production processes.
9. Examine production volume.
10. Describe stages of production.
11. Discuss documentation.
12. Demonstrate continuous improvement processes.
13. Examine the skills essential to manufacturing.
14. Identify manufacturing instruments.
15. Describe use of instruments.
16. Discuss control of instruments.
17. Examine various hand-held tools and gauges.
18. Discuss material requirements planning (MRP) and enterprise resource planning (ERP).
19. Understand the difference between the traditional manufacturing company and the Lean manufacturing company.
20. Identify the various tools used in Lean manufacturing companies.
21. Discuss the principles of Lean manufacturing.
22. Describe the benefits and use of Six Sigma on the production floor.
23. Describe the use of Six Sigma tools by the production technician.
24. Describe the attributes of a successful Six Sigma team.

25. Examine the Six Sigma DMAIC model, how it is applied and how it is part of the production technician's work responsibilities.
26. Identify what a Six Sigma rating means in a variety of business processes.
27. Calculate cycle time and takt time.
28. Describe Lean Six Sigma as an integrated improvement tool.
29. Describe basic business principles.
30. Describe business departments and their responsibilities.
31. Describe the application of business principles in delivering products and improving profitability.
32. Examine the concepts of accounting, finance, product marketing, economics, operations management, and human resources management.
33. Identify the key elements of accounting, product marketing, human resources management, product improvement projects, and how they all relate to the production floor.
34. Know the basic principles of the supply chain and supply chain management as they pertain to manufacturing production and
35. processes, as well as the answers to the following:
    a. What is a supply chain?
    b. What information is a key part of the supply chain?
    c. How is the supply chain changing?
    d. What are some supply chain management challenges?
    e. How does the supply chain affect the production technician?
36. Examine the concepts of the supply chain, supply chain management, the value chain and its relationship to lean manufacturing.
37. Identify the key processes that are part of supply chain management.

Worker Standards - Basic Technical Knowledge and Skills

1. Identify customer needs
2. Determine resources available for the production process
3. Set up equipment for the production process
4. Set team production goals
5. Make job assignments
6. Coordinate work flow with team members and other work groups
7. Communicate production and material requirements and product specifications
8. Perform and monitor the process to make the product
9. Document product and process compliance with customer requirements
10. Prepare final product for shipping or distribution

Maintenance Awareness

Provides the core knowledge of preventive maintenance and enhances existing skills in the identification and performance of equipment maintenance used in the production process.

Section 1: Tools and Their Uses

Section 2: Bearing Maintenance

Section 3: Industrial Print Reading

Section 4: Electrical Fundamentals

Section 5: Fluid Power Fundamentals

Section 6: Electrical Motor Fundamentals

Section 7: Machine Basics

Section 8: Total Productive Maintenance

Section 9: Pump Maintenance

Section 10: Preventive Maintenance

Section 11: Machine Maintenance

Learning Objectives

1. Examine the concept of troubleshooting within select manufacturing maintenance areas.
2. Identify equipment failures in select manufacturing maintenance areas.
3. Describe root cause analysis methods for select manufacturing maintenance areas.
4. Discuss preventive and predictive maintenance methods for select manufacturing maintenance areas.
5. Examine the concept of industrial print reading.
6. Identify the elements of industrial print reading as they pertain to maintaining manufacturing processes and equipment.
7. Describe the different types of industrial prints and the use of each type of industrial print reading in manufacturing processes.
8. Discuss the practical use of industrial prints in manufacturing processes.
9. Examine electricity to determine current, voltage, resistance, and power.
10. Identify Ohm's Law formulas and Power Law formulas.
11. Describe the differences in basic resistive electrical circuits.
12. Discuss the different Ohm's and Power Law formulas and use them.
13. Examine the two types of fluid power systems.
14. Identify fluid power loop types and fluid power laws.
15. Describe methods of troubleshooting fluid power systems.
16. Discuss the factors that affect fluid power system efficiency.
17. Examine the concept and components of simple/compound machines and conveyor systems.
18. Identify the purpose and functions of simple/compound machines and conveyor systems.
19. Describe components and mechanical advantage of simple/compound machines.
20. Discuss terms associated with simple/compound machines and conveyor systems.
21. Discuss the maintenance requirements of conveyor systems.

22. Discuss the purpose and functions of machining.
23. Examine the concepts and function of preventive maintenance.
24. Examine two styles of preventive maintenance.
25. Identify three types of preventive maintenance.
26. Describe an effective preventive maintenance program.
27. Discuss the benefits of an effective preventive maintenance program.
28. Discuss the three most common maintenance software packages used in the manufacturing industry.
29. Examine the concepts of total productive maintenance (TPM).
30. Identify the goals of TPM.
31. Describe the eight pillars of TPM.
32. Describe the four types of maintenance.

Worker Standards - Basic Technical Knowledge and Skills

1. Perform preventive maintenance and routine repair
2. Monitor indicators to ensure correct operations
3. Perform all housekeeping to maintain production schedule
4. Recognize potential maintenance issues with basic production systems, including knowledge of when to inform maintenance personnel about problems with:
    a. Electrical systems
    b. Pneumatic systems
    c. Hydraulic systems
    d. Machine automation systems
    e. Lubrication processes
    f. Bearings and couplings
    g. Belts and chain drives