

Technology of Robotic Design

8420 18 weeks

8421 36 weeks

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Acknowledgments

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Course Description

Suggested Grade Level: 9 or 10 or 11

Students engage in the study of computers and microprocessors and their applications to manufacturing, transportation, and communication systems. Topics include computer equipment and operating systems, robotics, programming, control systems, and social/cultural impact of these technologies. Problem-solving activities challenge students to design, program, and

interface devices with computer systems. Learning activities include robotics, computer-aided design, computer-aided manufacturing and design, and control of electromechanical devices.

Task Essentials Table

- Tasks/competencies designated by plus icons (⊕) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⊖) are omitted
- Tasks marked with an asterisk (*) are sensitive.

Task Number	8421	8420	Tasks/Competencies
Exploring Robotics and Automation Systems			
39	⊕	⊕	Define <i>robotics, automation, and control systems</i> .
40	⊕	⊕	Investigate careers in robotics, automation, and control systems.
41	⊕	○	Research the history and development of robotics, automation, and control systems.
42	⊕	⊕	Explain the universal systems model (i.e., input, process, output, and feedback).
43	⊕	⊕	Apply direct and indirect measurement systems and coordinate systems.
44	⊕	⊕	Identify open and closed loops in control systems.
Applying the Basics of Control and Distribution of Energy			
45	⊕	⊕	Describe the concepts of voltage, current, and resistance in electricity.
46	⊕	⊕	Describe the difference between alternating and direct current.
47	⊕	⊕	Identify safety precautions and information for electricity (AC and DC), mechanical, hydraulic, and pneumatic systems.
48	⊕	⊕	Explain the primary functions of electronic systems components.
49	⊕	⊕	Identify the primary concepts and components of mechanical systems.
50	⊕	⊕	Explain primary concepts and components of a fluid power system.

51	+	+	Describe the differences between and uses of analog and digital electronics for the control of power distribution systems.
52	+	+	Describe the operation of basic logic circuits.
52	+	+	Measure circuit values with a multimeter.
54	+	+	Identify the primary types of data transmission hardware.
Exploring Microprocessor/Microcontroller (Computer) System Basics			
55	+	+	Describe the function of an operating system.
56	+	+	Describe the essential components of a computing system.
57	+	+	Describe the software applications of computer technology within automation systems.
58	+	+	Describe how computers are used to control automated systems.
59	+	+	Describe a microcontroller.
60	+	+	Describe the function of interfacing robotic systems.
61	+	+	Describe the function of a microcontroller/logic controller.
62	+	○	Describe the fundamentals of computer numeric control (CNC).
63	+	○	Identify microcontrollers and their functions within industry tools, including PLC.
64	+	+	Develop a computer-controlled model solution to a problem.
Manipulating and Controlling Data			
65	+	○	Describe the need for data manipulation and control.
66	+	○	Manipulate data.
67	+	○	Ensure the security of data.
Exploring Communication and Networking			
68	+	+	Explain types of communication/networking and layers.
69	+	○	Describe various types of ports, channels, and controllers for robotic communications.

70	<input checked="" type="radio"/>	<input type="radio"/>	Define a process control network (PCN).
71	<input checked="" type="radio"/>	<input type="radio"/>	Plan a PCN for various systems.
Exploring the Components of Robotics and Automation Systems			
72	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Identify components of safe robotic systems.
73	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe types and functions of sensors and the intelligent systems used to analyze and expand on these functionalities.
74	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe the options for power supplies, silicon-controlled rectifiers (SCRs), solenoid valves, actuators, and motors to control movement systems.
75	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe types and functions of relays.
76	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe various hardware and software used in the industry.
77	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe precision measurement equipment and techniques.
78	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe components or processes that typically require precision measurement.
Assembling an Automated System			
79	<input checked="" type="radio"/>	<input type="radio"/>	Compare open and proprietary hardware components.
80	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Simulate functions of all components of a working automated system.
81	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Assemble an automated system.
82	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Reengineer the design of an existing system.
83	<input checked="" type="radio"/>	<input type="radio"/>	Simulate precision measurements of components in a control system.
84	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Simulate control, robotics, and automation systems.
85	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Install a machine vision system on an existing design.
Programming an Automated System			
86	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Implement basic programming procedures.

87	+	○	Select the most appropriate programming language/platform for application.
88	+	+	Program an automated system.

Legend: + Essential ○ Non-essential - Omitted

Curriculum Framework

Exploring Robotics and Automation Systems

Task Number 39

Define robotics, automation, and control systems.

Definition

Definition should include the following terms and a description of how they are interrelated:

- *Robotics*—the branch of technology that deals with the design, construction, operation, structural disposition, manufacture, and application of robots
- *Automation systems*—the method of robotics control that offers sensory feedback and information processing through control systems, reducing the need for human intervention
- *Control systems*—a device or set of devices that work in concert with other applications of information technology to manage, command, direct, or regulate the behavior of mechanisms and processes

Process/Skill Questions

- What is a robotics system?
- How do control systems relate to robotics technology?
- How are control systems and automation systems interrelated?
- Where are robotics, automation, and control systems found in daily activities?
- How might robotics, automation, and control systems be used in the future?
- What are some societal effects of robotics, automation, and control systems?

ITEEA National Standards

1. The Characteristics and Scope of Technology

17. Information and Communication Technologies

19. Manufacturing Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

System Control Technology

Task Number 40

Investigate careers in robotics, automation, and control systems.

Definition

Investigation should include the use of a variety of resources (e.g. Internet, periodicals) to learn about occupations such as

- applications integrator
- automated manufacturing technician
- calibration technician
- computer hardware engineer
- computer numerical control programmer (CNC programmer)
- electro-mechanical technician
- human factors engineer
- industrial engineer
- industrial engineering technician
- logistician
- manufacturing systems engineer
- materials handler
- mechanical engineer
- mechanical engineering technician
- occupational health and safety specialist

- precision inspector, tester, or grader
- production manager
- programmer SPC (statistical process control) coordinator
- quality control technician SPC coordinator
- safety engineer
- secondary school teacher
- systems analyst
- technical writer.

Process/Skill Questions

- What training/education is required in your selected career?
- What opportunities are available in the current job market?
- How are the selected occupations similar/different? Explain.

ITEEA National Standards

17. Information and Communication Technologies

19. Manufacturing Technologies

4. The Cultural, Social, Economic, and Political Effects of Technology

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

System Control Technology

Task Number 41

Research the history and development of robotics, automation, and control systems.

Definition

Research should include automation and control systems advances in the following sectors:

- Communications
- Manufacturing
- Robotics

Process/Skill Questions

- What are some major inventions and developments in robotic technology that affect current society?
- How did the evolution of manufacturing influence robotic technology?
- What are the implications of new communication technologies in robotics?

ITEEA National Standards

7. The Influence of Technology on History

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Debating Technological Issues

Essays on Technology

System Control Technology

Task Number 42

Explain the universal systems model (i.e., input, process, output, and feedback).

Definition

Explanation should include

- inputs (resources)—
 - people
 - materials
 - information

- tools and machines
- energy
- capital
- time
- process—the way the input is changed to arrive at the output
- output—product or end result
- feedback—information provided about how the process is working.

Process/Skill Questions

- How do input, process, output, and feedback make up a system?
- What are examples of the systems model?
- What are the strengths and weaknesses of the universal systems model?
- What are the implications of a failed systems model in manufacturing?

ITEEA National Standards

2. The Core Concepts of Technology

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

System Control Technology

Video Game Design

Task Number 43

Apply direct and indirect measurement systems and coordinate systems.

Definition

Application should include selecting the appropriate system and measurement methods (e.g., standard, metric), using

- direct measurement—reading and interpreting from a measuring device (e.g., micrometer, caliper, scales)
- indirect measurement—calculating (i.e., using algebraic expression) the measurement of an unknown, based on other known dimensions/measurements.

Process/Skill Questions

- How is indirect measurement used in everyday life?
- How do direct measurement and indirect measurement differ?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Computer-Aided Design (CAD), Engineering

Engineering Design

Flight Endurance

Geospatial Technology (Virginia only)

Principles of Technology (Virginia only)

System Control Technology

Task Number 44

Identify open and closed loops in control systems.

Definition

Identification should include

- defining *open-loop system*—a system without a feedback mechanism (e.g., bicycle, irrigation sprinkler system)
- defining *closed-loop system*—a system with a feedback mechanism (e.g., aquarium pump, hot water heating system, computer mouse, joystick on a video game)
- describing why one system would be preferred over the other.

Process/Skill Questions

- What are the differences between open-loop systems and closed-loop systems?
- What are some examples of open-loop and closed-loop systems?
- What are the strengths of a closed-loop system?
- How are open-loop systems used in everyday life?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

System Control Technology

Applying the Basics of Control and Distribution of Energy

Task Number 45

Describe the concepts of voltage, current, and resistance in electricity.

Definition

Description should include definitions of *voltage*, *current*, and *resistance* and a summary of their interrelationship, as stated in Ohm's law.

Process/Skill Questions

- What effect does resistance have on voltage and current in a circuit?
- How are voltage, current, and resistance measured?
- What is the interrelationship of voltage, current, and resistance?
- What happens in a circuit when there is a break or interruption in current flow?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 46

Describe the difference between alternating and direct current.

Definition

Description should include differences such as

- source
- purpose

- wave composition
- safety precautions for working with each type of current.

Process/Skill Questions

- What are some of the sources for alternating current and direct current?
- What are some of the purposes/uses for alternating current and direct current?
- What are some of the benefits and drawbacks of using alternating current and direct current?
- What are some of the safety precautions for working with alternating current and direct current?
- Why do computer systems convert AC to DC?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

Principles of Technology (Virginia only)

System Control Technology

Task Number 47

Identify safety precautions and information for electricity (AC and DC), mechanical, hydraulic, and pneumatic systems.

Definition

Identification should include

- safety hazards
- lock-out and tag-out procedures

- personal responsibility and decision-making
- safety procedures for operating and maintaining equipment.

Process/Skill Questions

- How are lock-out and tag-out procedures enforced?
- What is an employee's personal responsibility for safety?
- How does maintenance of equipment address safety issues?

Task Number 48

Explain the primary functions of electronic systems components.

Definition

Explanation should include the primary functions of some of the following components:

- Resistors
- Switches
- Conductors
- Semiconductors
- Capacitors
- Potentiometers
- Inductors
- Transformers
- Diodes
- Transistors
- Energy source
- Output devices

Process/Skill Questions

- What basic components are required to complete a circuit?
- What are the functions of each primary component?
- What are the implications of a faulty component in an electronic system?
- What role does the energy source play in an electronic system?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 49

Identify the primary concepts and components of mechanical systems.

Definition

Identification should include

- concepts such as
 - energy transmission to perform usable work
 - gear teeth and pitch
 - motion reversal
 - compound gear reduction
 - drive train design
 - lifting mechanisms
- components such as
 - sensors
 - motors and gearboxes
 - spur gears
 - bevel gears
 - sprockets
 - pulleys.

Process/Skill Questions

- What is the function of a sprocket?
- Are all drive train designs similar? Explain.
- What concept is related to the pulley? Explain.

Task Number 50

Explain primary concepts and components of a fluid power system.

Definition

Explanation should include

- energy transmission to perform usable work
- pressure
- valves
- pistons
- pumps
- compressors
- means of transmitting fluid (e.g., tubing).

Process/Skill Questions

- What happens when pressure is applied to fluids?
- What are the two types of fluid power systems?
- What role does a compressor play in transmitting power?

Task Number 51

Describe the differences between and uses of analog and digital electronics for the control of power distribution systems.

Definition

Description should include examples of the differences between analog and digital systems, such as

- satellite and FM radio
- analog vs. digital clock
- satellite and antenna
- landline and smart phones
- MP3 and cassette
- VHS and DVD/MiniDV.

Process/Skill Questions

- What are the benefits and drawbacks of using analog systems? Of using digital systems?
- How do analog and digital transmission systems differ?

- What is the process for converting analog to digital?
- What are some examples of digital and analog transmissions in everyday life?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 52

Describe the operation of basic logic circuits.

Definition

Description should include

- a definition of a *logic gate*—a device that performs a logical operation on one or more logic inputs, producing a single logic output
- the differences between types of logic gates
- how logic gates create a circuit.

Process/Skill Questions

- What are the basic types of logic gates?
- What are their characteristics, and how do they differ?
- What are the functions of various types of logic gates?
- What are the symbols for each type of logic gate?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 53

Measure circuit values with a multimeter.

Definition

Measurement should include

- amperage
- voltage
- continuity.

Process/Skill Questions

- What is a multimeter?
- How do analog and digital multimeters compare in use, accuracy, and performance?
- How can multimeters and similar test equipment be used to measure circuit characteristics?
- How do actual and virtual test equipment values compare?
- How can multimeters be used to measure circuit characteristics of voltage and current?
- Why does test equipment require calibration?
- What is the process for testing devices with a multimeter?
- How does one interpret readings from a multimeter?

ITEEA National Standards

13. Assess the Impact of Products and Systems

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 54

Identify the primary types of data transmission hardware.

Definition

Identification should include

- copper
- fiber-optic
- wireless (e.g., radio frequency, satellite, infrared).

Process/Skill Questions

- What are the benefits and drawbacks of using each method of data transmission?
- How has the development of data transmission methods affected society?
- What is data transmission, and why is it important?
- How is data transmission measured?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Exploring Microprocessor/Microcontroller (Computer) System Basics

Task Number 55

Describe the function of an operating system.

Definition

Description should include

- definition of *operating system*
- the process and function of file management
- the process and function of application management.

Process/Skill Questions

- How do various operating systems handle file management?
- How are applications affected by different operating systems?
- What are some examples of operating systems?
- How does an operating system work? What are the main components and their functions?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 56

Describe the essential components of a computing system.

Definition

Description should include the characteristics and functions of components, including

- processor
- memory
- input devices
- output devices
- storage devices.

Process/Skill Questions

- What is the purpose/function of each component in a computing system?
- How do various components interact to produce a working system?
- What are the differences between software and hardware?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 57

Describe the software applications of computer technology within automation systems.

Definition

Description should include the functions of various computer technology components/processes within automation, including

- data storage
- data transmission
- computer/system control.

Process/Skill Questions

- What are the benefits and drawbacks of using computer technology to manage information?
- How might one conduct research to discover new and useful applications for a design? What are the best resources?
- How might one make a designed application available for others to use?
- What are secondary storage devices?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 58

Describe how computers are used to control automated systems.

Definition

Description should include the roles of computers in a variety of automated systems, including

- traffic lights
- computer numeric control (CNC) machines

- robotics
- automotive systems
- computer integrated manufacturing (CIM) systems
- security systems
- heating, ventilation, and air-conditioning (HVAC) systems.

Process/Skill Questions

- What are the benefits and drawbacks of using computers to control automated systems?
- How have computer-controlled automated systems affected society?
- What are some examples of computer-controlled automated systems in your own household?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 59

Describe a microcontroller.

Definition

Description should include small computer on a chip or integrated circuit containing processor core, memory, and programmable input/output peripherals.

Process/Skill Questions

- What are some examples of microcontrollers?
- How does one communicate with a microcontroller?
- What are examples of input and output devices?

Task Number 60

Describe the function of interfacing robotic systems.

Definition

Description should include

- explaining the purpose of interfacing robotic systems so that the robot can communicate with its environment
- identifying and explaining the function of common input/output (I/O) ports (e.g., digital input ports, digital output ports)
- selecting external devices that can be connected to an input, such as contact or proximity sensors, or safety devices (e.g., motion detectors, door switches)
- selecting external devices that can be connected to an output (e.g., warning light, drive motor, relay or pneumatic actuator, another robot)
- relating machine vision systems to interfacing systems and explaining the purpose (e.g. part orientation, measurement collection, part inspection) of using vision systems in robotics.

Process/Skill Questions

- What is an interface, and what is its relationship to robotics?
- What external devices can be connected to a robot's digital input and output ports?
- What are the applications of machine vision systems? What are the benefits?
- What are the basic components and their functions in a typical vision system?

ITEEA National Standards

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 61

Describe the function of a microcontroller/logic controller.

Definition

Description should include

- defining *controller* as the brain of the robot or the center of a robotic system that coordinates all movements of the mechanical system
- outlining the functions performed by a microcontroller:
 - microcontroller receives input from various sensors and input devices, such as a radio-controlled (RC) transmitter and the computer processes that input with a program stored in the controller memory
 - computer responds by activating pneumatics, motors, sensors, or other actuators
- comparing features of different types of controllers, such as a peripheral interface controller (PIC) and a programmable logic controller (PLC)
- choosing the right microcontroller for a robotic project
- providing examples of microcontrollers used in industry applications.

Process/Skill Questions

- How does a microcontroller work?
- Where might one find microcontrollers at work in everyday life?
- Where might one find microcontrollers at work in industrial settings?
- What are the differences between a microcontroller and a microprocessor?
- What are the benefits of using microcontrollers?
- How have microcontrollers affected society?

ITEEA National Standards

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 62

Describe the fundamentals of computer numeric control (CNC).

Definition

Description should include

- defining *G code* and *M code*
- using coordinates
- explaining and demonstrating the use of computer-aided design (CAD) software and computer-aided manufacturing (CAM) software
- comparing CNC and robotics and defining the interrelationship.

Process/Skill Questions

- How is a CNC machine tool different from a conventional machine tool? How is it similar?
- What is the difference between proprietary control and open-architecture control?
- What is machine zero?
- What are some of the advantages of conversational control over standard control?
- What are the benefits of having computers generate complicated numeric control (NC) code?
- What are some of the general trends within the CAD/CAM industry?

ITEEA National Standards

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

Task Number 63

Identify microcontrollers and their functions within industry tools, including PLC.

Definition

Identification should include

- how a microcontroller interacts with a computer
- examples (e.g., CNC machine, robotic arm, robotic welder, and the microcontroller as the component or brain that drives the action of the tool).

Process/Skill Questions

- How is programming a PLC controller different from programming a robotic controller?
- What are G and N codes? What are the differences between G codes and N codes?
- Under what circumstances might a CNC machine be a better choice than a robot?

ITEEA National Standards

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Computer-Aided Design (CAD), Engineering

Principles of Technology (Virginia only)

System Control Technology

Task Number 64

Develop a computer-controlled model solution to a problem.

Definition

Development should include

- analyzing the problem
- planning and designing a functional system
- identifying components (e.g., input, output, process, hardware, software)
- building a model
- programming the model
- explaining the program and mechanical features of the model.

Process/Skill Questions

- How does a computer, microcontroller, or programmable logic controller control an output device?
- What are the unique features of the program and model solution?
- If the target is not met, how can one redesign the solution to improve its performance?
- How can one justify the efficiency of the solution?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

17. Information and Communication Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Computer-Aided Design (CAD), Engineering

Principles of Technology (Virginia only)

System Control Technology

Manipulating and Controlling Data

Task Number 65

Describe the need for data manipulation and control.

Definition

Description should include

- explaining the importance of data management to automate the operation of processes and machinery without human interaction (applications range from simple on/off actuator control to advanced closed-loop control with multiple inputs and outputs)
- explaining how the integration of the data helps to maintain process-quality specifications to improve productivity and reduce the chance of making costly errors
- identifying measurement as one of the functions of an automated system, along with control and manipulation
- describing various types of instrumentation equipment used for measuring, controlling, and manipulating process variables, such as temperature, pressure, flow, or level
- providing examples of industrial control systems in the following industrial areas:
 - Electrical power and electronics
 - Water and water treatment
 - Oil and natural gas
 - Chemicals
 - Transportation
 - Pharmaceuticals
 - Pulp and paper
 - Food and beverages
 - Discrete manufacturing (e.g., automotive, aerospace, durable goods)

Process/Skill Questions

- How is data manipulated in an industrial control system?
- What are the functions performed by an instrument used in process control?
- What are some industrial applications that require precise measurement and control of temperature, pressure, flow, or level?

ITEEA National Standards

13. Assess the Impact of Products and Systems

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

System Control Technology

Task Number 66

Manipulate data.

Definition

Manipulation may include

- explaining how data can be taken from different types of devices, such as computers, sensors, motors, and the environment
- describing how all information acquired is processed and stored so it can be used to improve and analyze different events
- defining *data acquisition* (DAQ) as the process of using a computer to measure an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound
- identifying the parts of a DAQ system (e.g., sensors, DAQ measurement hardware, a computer with programmable software).

Process/Skill Questions

- Why is data acquisition important?
- What are the advantages of PC-based DAQ systems, compared to traditional measurement systems?
- How is DAQ used in control and automation?
- What is supervisory control and data acquisition (SCADA)? What is its role in data acquisition?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Computer-Aided Design (CAD), Engineering

System Control Technology

Video Game Design

Task Number 67

Ensure the security of data.

Definition

Ensuring the security of data should include

- selecting and following an appropriate protocol for storing data
- selecting or creating data storage
- performing maintenance on storage
- protecting the privacy of users
- maintaining the integrity of data (e.g., preventing hacking, performing systems maintenance).

Process/Skill Questions

- How is an industrial control system related to an information technology (IT) system?
- What are some possible sources of threats to an industrial control system?
- What are some potential vulnerabilities that may be found in a typical control system?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

17. Information and Communication Technologies

TSA Competitive Events

Video Game Design

Exploring Communication and Networking

Task Number 68

Explain types of communication/networking and layers.

Definition

Explanation may include

- listing the hierarchy of industrial networks (e.g., enterprise, control bus, device bus, sensor bus networks) and describing the typical functions of each
- listing the network topologies typically used for industrial communications (e.g., bus, star, ring, combination topologies) and describing the operation of each
- describing various methods used to transmit data in an industrial network.

Process/Skill Questions

- What are the different types of networks?
- How do networks expedite the transfer of data in an information system?
- How do industrial networks and enterprise networks differ from one another?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Webmaster

Task Number 69

Describe various types of ports, channels, and controllers for robotic communications.

Definition

Description should include identifying the appropriate port, channel, and controller for each operation.

Process/Skill Questions

- What resources are necessary for telecommunication?
- How do you determine the most appropriate channel for communication?
- What are some applications for telecommunication?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

System Control Technology

Video Game Design

Task Number 70

Define a process control network (PCN).

Definition

Definition should include

- describing the difference between standard network and PCN
- identifying the communications network used to transmit instructions and data between control and measurement units and supervisory control and data acquisition (SCADA) equipment.

Process/Skill Questions

- What is a process control network (PCN)?
- What is the difference between a standard network and a PCN?
- How does a PCN relate to a communications network?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Task Number 71

Plan a PCN for various systems.

Definition

Plan should identify the application (e.g., manufacturing line control, monitoring efficiency, temperatures, quality control) and the components:

- Cables
- Network interface cards
- Patch panel
- Hub/switch
- Jacks and outlets

- Computers
- Cabling tool kits
- Wi-Fi accessories

Process/Skill Questions

- What are the steps to constructing and configuring a network?
- What are the Institute of Electrical and Electronics Engineers (IEEE) Standards for structure cables?
- What are the limitations of the various types of networking media?
- How do Wi-Fi accessories benefit a network?

ITEEA National Standards

11. Apply the Design Processes

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Exploring the Components of Robotics and Automation Systems

Task Number 72

Identify components of safe robotic systems.

Definition

Identification should include

- power-on lights

- lighted power switch, covered or lockout-capable in off position
- beepers and lights on axis movement
- cover pinch points
- bumper stops on moving vehicles
- object detection in movement direction, auto slowdown
- switches/fuses/circuit breakers for circuit isolation and disabling motion control while leaving CPU and human machine interface (HMI) active
- ring terminals and hot wires on female side of connectors.

Process/Skill Questions

- What role do power-on lights play in safety?
- What are cover pinch points?
- Why should motion control be disabled when CPU and HMI are active?

Task Number 73

Describe types and functions of sensors and the intelligent systems used to analyze and expand on these functionalities.

Definition

Description should include

- the function of the sensor (i.e., to gather information)
- types of sensors, including
 - touch
 - biometric
 - rotational
 - color
 - distance
 - photoelectric
 - inductive
 - magnetic
 - capacitive
 - analog vs. digital
- intelligent system analysis
 - vision systems for classification and sorting, including bar code readers
 - measurement of the shape, position, and number of items
 - measurement of the waste of resources
 - measurement of the quality of the end product or result
 - measurement for proportional-integral-differential (PID) control.

Process/Skill Questions

- What is the purpose of a sensor?
- How do sensors function?
- When would a sensor component be applied in a robotics or automation system?
- Why would a photoelectric sensor be included in a robotics or automation system?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 74

Describe the options for power supplies, silicon-controlled rectifiers (SCRs), solenoid valves, actuators, and motors to control movement systems.

Definition

Description should include

- fluid (e.g., pneumatic, hydraulic)
- electromechanical systems
- power supplies
- type of movement (e.g., rotation, linear).

Process/Skill Questions

- What are the power options in a robotics or automation system?

- Under what circumstances might it be more appropriate to use pneumatic fluid power?
- Under what circumstances might it be more appropriate to use hydraulic fluid power?
- What are typical limitations in movement systems?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

Principles of Technology (Virginia only)

System Control Technology

Task Number 75

Describe types and functions of relays.

Definition

Description should include

- types of relays (i.e., double-pole, single-pole, switches)
- functions of relays (i.e., to control power).

Process/Skill Questions

- What is the function of a relay?
- What are the different types of relays? Under what circumstances should one type be chosen over another?
- When might a double-pole relay be the logical choice?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 76

Describe various hardware and software used in the industry.

Definition

Description should include the industry type and examples of hardware and software used.

Process/Skill Questions

- What are some examples of industry hardware in the robotics and automation systems?
- What are some examples of industry software in the robotics and automation systems?
- What is the relationship between industry-standard hardware and software?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Principles of Technology (Virginia only)

System Control Technology

Task Number 77

Describe precision measurement equipment and techniques.

Definition

Description should include

- the goals of precision measurement (i.e., reproducibility and repeatability, or reliability)
- standard equipment (e.g., micrometer, caliper, and precision rule)
- techniques used in the industry.

Process/Skill Questions

- What is the difference between precision measurement and non-precision measurement?
- What types of applications would require the use of precision measurement equipment and techniques?
- Why are precision measurement equipment and techniques crucial to industry?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

Principles of Technology (Virginia only)

System Control Technology

Task Number 78

Describe components or processes that typically require precision measurement.

Definition

Description should include

- size requirements
- weight requirements
- density, rate, velocity
- material requirements.

Process/Skill Questions

- Which precision measurement tools are used to measure size requirements?
- Which precision measurement tools are used to measure weight?
- Which precision measurement tools are used to measure density, speed, rate or velocity?
- What components in a robotics or automation system require the use of a precision measurement tool?
- What processes in a robotics or automation system require precision measurement?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

Principles of Technology (Virginia only)

System Control Technology

Assembling an Automated System

Task Number 79

Compare open and proprietary hardware components.

Definition

Comparison should include

- requirements of the system
- cost requirements
- tolerance requirements
- security issues
- accessibility
- government regulations.

Process/Skill Questions

- What is the difference between open and proprietary hardware components?
- What would happen if government did not provide standards and regulation for hardware component production?
- How do the components interact with the real-world physics of the system to determine system performance?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

Principles of Technology (Virginia only)

System Control Technology

Task Number 80

Simulate functions of all components of a working automated system.

Definition

Simulation should include defining all components and selecting the appropriate simulation software.

Process/Skill Questions

- What components are needed to conduct a successful basic simulation?
- How can you determine the appropriate software needed for the system?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

Principles of Technology (Virginia only)

Scientific Visualization (SciVis)

System Control Technology

Video Game Design

Task Number 81

Assemble an automated system.

Definition

Assembly should include the following process:

- Plan—design
- Do—put it together
- Check—evaluate it
- Act—adjust

Process/Skill Questions

- How do automated systems affect everyday life?
- What are the steps of the engineering design process?
- How does the engineering design process apply to assembling an automated system?
- What could happen if one step of the engineering design process were skipped?

ITEEA National Standards

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

System Control Technology

Task Number 82

Reengineer the design of an existing system.

Definition

Reengineering should include

- analyzing the existing system design by determining its function, process, and components
- defining the problem
- devising a solution to improve the system
- implementing the modification or new design solution
- evaluating the solution
- troubleshooting.

Process/Skill Questions

- How might reengineering an existing system provide the solution to the identified problem?
- What is the difference between engineering and reengineering an automated system?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

System Control Technology

Task Number 83

Simulate precision measurements of components in a control system.

Definition

Simulation should include defining all essential measurements and selecting the appropriate simulation software.

Process/Skill Questions

- What is an essential measurement?
- How do essential measurements drive the selection of the software for the system?

ITEEA National Standards

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

System Control Technology

Task Number 84

Simulate control, robotics, and automation systems.

Definition

Simulation should include selecting the appropriate software to complete a simple task that solves an identified problem.

Process/Skill Questions

- What are the most common industrial uses of robotic systems?
- What are the significant differences between industrial robots and consumer robots?

ITEEA National Standards

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

17. Information and Communication Technologies

19. Manufacturing Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

System Control Technology

Task Number 85

Install a machine vision system on an existing design.

Definition

Installation should include

- integrating the system to improve efficiency and/or add new functionality
- analyzing the existing system design by determining the function, process, and components
- defining the problem and solution for the improvement
- implementing the modification or new design solution
- evaluating the solution
- troubleshooting.

Process/Skill Questions

- How do machine vision systems enable automated systems to complete manual tasks?
- How do improvements in machine vision effect the efficiency or application of automated systems and robots?

Programming an Automated System

Task Number 86

Implement basic programming procedures.

Definition

Implementation should include

- designing a program, using an algorithm, pseudocode, and/or a flowchart
- coding the program, using a programming language
- executing the program with sample data
- debugging the program
- documenting the program with comments.

Process/Skill Questions

- Why are flowcharts used in programming?
- What role does the engineering design process play in programming robots?
- How does program documentation help programmers, engineers, and other technical professionals?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

System Control Technology

Task Number 87

Select the most appropriate programming language/platform for application.

Definition

Selection should be based on type of

- hardware

- controller
- system (e.g., robot, automation, control).

Process/Skill Questions

- What programming languages are typically used with industrial robots?
- What are the key similarities and differences among all programming languages used with industrial robots?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

Engineering Design

System Control Technology

Task Number 88

Program an automated system.

Definition

Programming should include

- selecting the appropriate programming language and method to solve a problem
- using the language to program an automated system/robot to perform a specific task.

Process/Skill Questions

- What is the identified problem?
- What is the projected solution?
- How will the program solve the identified problem?

ITEEA National Standards

17. Information and Communication Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

System Control Technology

SOL Correlation by Task

39	Define <i>robotics, automation, and control systems</i> .	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5
40	Investigate careers in robotics, automation, and control systems.	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5 History and Social Science: VUS.13
41	Research the history and development of robotics, automation, and control systems.	English: 9.8, 10.8, 11.8 History and Social Science: VUS.1, VUS.13, VUS.14, WG.1, WHII.1, WHII.13, WHII.14
42	Explain the universal systems model (i.e., input, process, output, and feedback).	English: 9.5, 10.5, 11.5
43	Apply direct and indirect measurement systems and coordinate systems.	English: 9.5, 10.5, 11.5 Mathematics: A.1
44	Identify open and closed loops in control systems.	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5
45	Describe the concepts of voltage, current, and resistance in electricity.	English: 9.5, 10.5, 11.5 Mathematics: A.8 Science: PH.11
46	Describe the difference between alternating and direct current.	English: 9.5, 10.5, 11.5 Mathematics: T.3 Science: PH.11

47	Identify safety precautions and information for electricity (AC and DC), mechanical, hydraulic, and pneumatic systems.	English: 9.5, 10.5, 11.5
48	Explain the primary functions of electronic systems components.	English: 9.5, 10.5, 11.5 Science: PH.11
49	Identify the primary concepts and components of mechanical systems.	English: 9.5, 10.5, 11.5 Science: PH.7
50	Explain primary concepts and components of a fluid power system.	English: 9.5, 10.5, 11.5 Science: PH.7
51	Describe the differences between and uses of analog and digital electronics for the control of power distribution systems.	English: 9.5, 10.5, 11.5
52	Describe the operation of basic logic circuits.	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5 Mathematics: G.1, COM.8 Science: PH.11
53	Measure circuit values with a multimeter.	Science: PH.11
554	Identify the primary types of data transmission hardware.	English: 9.5, 10.5, 11.5
55	Describe the function of an operating system.	English: 9.5, 10.5, 11.5
56	Describe the essential components of a computing system.	English: 9.5, 10.5, 11.5 Mathematics: COM.16
57	Describe the software applications of computer technology within automation systems.	English: 9.5, 10.5, 11.5
58	Describe how computers are used to control automated systems.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.13, VUS.14, WHIL.14
59	Describe a microcontroller.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.13, VUS.14, WHIL.14
60	Describe the function of interfacing robotic systems.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.14
61	Describe the function of a microcontroller/logic controller.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.14
62	Describe the fundamentals of computer numeric control (CNC).	English: 9.5, 10.5, 11.5

63	Identify microcontrollers and their functions within industry tools, including PLC.	English: 9.5, 10.5, 11.5
64	Develop a computer-controlled model solution to a problem.	English: 9.5, 10.5, 11.5 Mathematics: COM.1, COM.2
65	Describe the need for data manipulation and control.	English: 9.5, 10.5, 11.5
66	Manipulate data.	English: 9.5, 10.5, 11.5 Mathematics: COM.14, COM.16
67	Ensure the security of data.	
68	Explain types of communication/networking and layers.	English: 9.5, 10.5, 11.5
69	Describe various types of ports, channels, and controllers for robotic communications.	English: 9.5, 10.5, 11.5
70	Define a process control network (PCN).	
71	Plan a PCN for various systems.	English: 9.5, 10.5, 11.5
72	Identify components of safe robotic systems.	English: 9.5, 10.5, 11.5
73	Describe types and functions of sensors and the intelligent systems used to analyze and expand on these functionalities.	English: 9.5, 10.5, 11.5
74	Describe the options for power supplies, silicon-controlled rectifiers (SCRs), solenoid valves, actuators, and motors to control movement systems.	English: 9.5, 10.5, 11.5
75	Describe types and functions of relays.	English: 9.5, 10.5, 11.5
76	Describe various hardware and software used in the industry.	English: 9.5, 10.5, 11.5
77	Describe precision measurement equipment and techniques.	English: 9.5, 10.5, 11.5
78	Describe components or processes that typically require precision measurement.	English: 9.5, 10.5, 11.5
79	Compare open and proprietary hardware components.	English: 9.5, 10.5, 11.5
80	Simulate functions of all components of a working automated system.	
81	Assemble an automated system.	
82	Reengineer the design of an existing system.	English: 9.5, 10.5, 11.5 Mathematics: COM.17, COM.18
83	Simulate precision measurements of components in a control system.	
84	Simulate control, robotics, and automation systems.	
85	Install a machine vision system on an existing design.	English: 9.5, 10.5, 11.5

86	Implement basic programming procedures.	English: 9.5, 9.6, 9.7, 10.5, 10.6, 10.7, 11.5, 11.6, 11.7 Mathematics: COM.1, COM.2, COM.4, COM.8, COM.9, COM.17, COM.18
87	Select the most appropriate programming language/platform for application.	Mathematics: COM.9
88	Program an automated system.	Mathematics: COM.1, COM.2, COM.3, COM.4, COM.5, COM.7, COM.8, COM.9, COM.10, COM.11, COM.13, COM.14, COM.17, COM.18

Entrepreneurship Infusion Units

Entrepreneurship Infusion Units may be used to help students achieve additional, focused competencies and enhance the validated tasks/competencies related to identifying and starting a new business venture. Because the unit is a complement to certain designated courses and is not mandatory, all tasks/competencies are marked “optional.”

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- College and Work Readiness Assessment (CWRA+)
- National Career Readiness Certificate Assessment
- Robotics Certification Examinations
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Electronics Systems I (8416/36 weeks)
- Electronics Systems I (8417/18 weeks)
- Electronics Systems II (8412/36 weeks)
- Manufacturing Systems I (8425/36 weeks)
- Manufacturing Systems I (8426/18 weeks)

Career Cluster: Information Technology	
Pathway	Occupations
Information Support and Services	Applications Integrator Computer Numerical Control Programmer (CNC Programmer) Systems Analyst

Career Cluster: Manufacturing	
Pathway	Occupations
Health, Safety, and Environmental Assurance	Occupational Health and Safety Specialist Safety Engineer
Logistics and Inventory Control	Logistician Materials Handler
Manufacturing Production Process Development	Electro-Mechanical Technician Industrial Engineer Industrial Engineering Technician

Career Cluster: Manufacturing	
Pathway	Occupations
	Manufacturing Systems Engineer Precision Inspector, Tester, or Grader Production Manager Programmer SPC (Statistical Process Control) Coordinator
Production	Automated Manufacturing Technician
Quality Assurance	Calibration Technician Precision Inspector, Tester, or Grader Quality Control Technician SPC (Statistical Process Control) Coordinator

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	Occupations
Engineering and Technology	Computer Hardware Engineer Electro-Mechanical Technician Human Factors Engineer Industrial Engineer Industrial Engineering Technician Manufacturing Systems Engineer Mechanical Engineer Mechanical Engineering Technician Systems Analyst
Science and Mathematics	Secondary School Teacher Technical Writer