Individual Test Item Specifications

9410130- Robotic Systems

2015

The contents of this document were developed under a grant from the United States Department of Education. However, the content does not necessarily represent the policy of the United States Department of Education, and you should not assume endorsement by the federal government.

Table of Contents

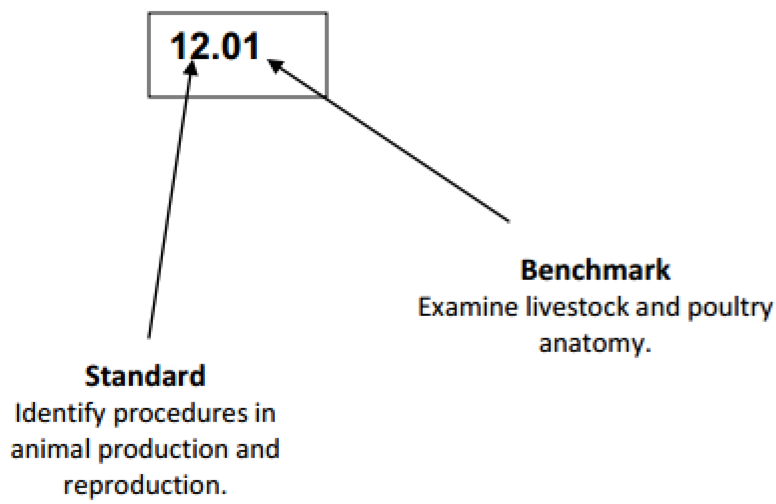
I. Guide to the Individual Benchmark Specifications

Content specific guidelines are given in the *Individual Benchmark Specifications* for each course. The *Specifications* contains specific information about the alignment of items with the Florida Standards. It identifies the manner in which each benchmark is assessed, provides content limits and stimulus attributes for each benchmark, and gives specific information about content, item types, and response attributes.

Benchmark Classification System

- Each Career and Technical Education course has its own set of course standards. The benchmarks are organized numerically, with two numbers separated by a decimal point. The first number is the standard number, and the second number is the benchmark number. You will see these numbers on the Item Specifications for each course.

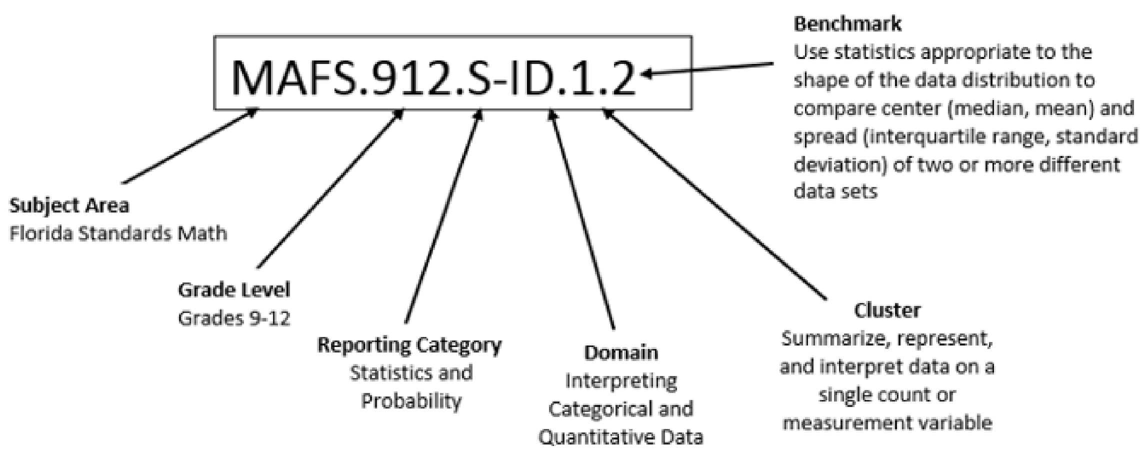
An example, from Agritechnology 1:



The image above describes the components of a Career and Technical Education Standard and Benchmark classification system.

Each MAFS benchmark is labeled with a system of letters and numbers.

- The four letters in the *first position* of the label identify the **Subject**.
- The number(s) in the *second position* represents the **Grade Level**.
- The letter(s) in the *third position* represents the **Category**.
- The number in the fourth position shows the **Domain**.
- The number in the *fifth position* identifies the **Cluster**.
- The number in the last position identifies the specific **Benchmark**.



The image above describes the components of a Florida Standard and Benchmark classification system.

Definitions of Benchmark Specifications

The *Individual Benchmark Specifications* provides standard-specific guidance for assessment item development for the Florida Department of Education Career and Technical Education item banks. For each benchmark assessed, the following information is provided.

Reporting Category	is a grouping of related benchmarks that can be used to summarize and report achievement.
Standard	refers to the standard statement presented in the Florida Standards.
Benchmark	refers to the benchmark statement presented in the Florida Standards. In some cases, two or more related benchmarks are grouped together because the assessment of one benchmark addresses another benchmark.
Item Types	are used to assess the benchmark or group of benchmark.
Cognitive Complexity	ideal level at which item should be assessed.
Benchmark Clarifications	explain how achievement of the benchmark will be demonstrated by students. In other words, the clarification statements explain what the student will do when responding to questions.
Content Limits	define the range of content knowledge and that should be assessed in the items for the benchmark.
Stimulus Attributes	define the types of stimulus materials that should be used in the items, including the appropriate use of graphic materials and item context or content.
Response Attributes	define the characteristics of the answers that a student must choose or provide.
Content Focus	defines the content measured by each test item. Content focus addresses the broad key terms and concepts associated with the examples found in the standards, benchmarks, or benchmark clarifications.
Sample Items	are provided for each type of question assessed. The correct answer for all sample items is provided.

II. Individual Benchmark Specifications

Standard	27.0 Describe the approaches, challenges, and problem-solving methodologies involved with integrating artificial intelligence into robotic systems. – The student will be able to:
Benchmark	27.02 Describe an intelligent agent and relate its role to the operation of robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students will be able to explain what an intelligent agent is, what their defining features are, and what their purpose is in programming and robotics. Also be able to identify the path of information flow from sensors, through the agent and out actuators.
Content Focus	Intelligent agent, sensor, actuator, logic
Content Limits	Content is limited to the basic characteristics common to all intelligent agents covered in standard 27.03, and their very general applications in robotics.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Short Answer: What is the correct order of information flow through a logical agent in a physical robot? Answer: Sensor - Agent – Actuator Rubric: 2 Points: The student correctly orders all three components of the information flow through a logical agent in a physical robot. 1 Point: The student correctly orders two components of the information flow through a logical agent in a physical robot. 0 Points: The student does not correctly orders all three components of the information flow through a logical agent in a physical robot.

Standard	27.0 Describe the approaches, challenges, and problem-solving methodologies involved with integrating artificial intelligence into robotic systems. – The student will be able to:
Benchmark	27.03 Discuss the classes of intelligent agents and their application in the design of robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students will be able to identify an intelligent agent class by its defining characteristics or identify characteristics that belong to each intelligent agent class. For extended response, students should be able to compare and contrast the characteristics of each class of agents
Content Focus	Intelligent agent, goal based agent, model based agent, simple reflex agent, utility based agent
Content Limits	Students should have a basic understanding of the characteristics of each of the four main intelligent agent classes (goal based agent, model based agent, simple reflex agent, utility based agent) and how they are alike and different.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Short Answer: Which class of intelligent agent returns an action not based on input but based on achieving its objective? It may use multiple correct responses to a given condition? Answer: goal based agent Rubric: 2 Points: The student has a thorough understanding of the concept by providing a detailed explanation. 1 Point: The student has a partial understanding of the concept exhibited by providing an incomplete explanation. 0 Points: The student does not have an understanding of the concept and does not provide an explanation.

Standard	27.0 Describe the approaches, challenges, and problem-solving methodologies involved with integrating artificial intelligence into robotic systems. – The student will be able to:
Benchmark	27.05 Discuss the methodologies and tools used in resolving systems integration challenges in robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand the basic electronic components and tactics used to integrate otherwise incompatible components.
Content Focus	Level shifter, analog to digital converter (ADC), USB to serial converter, PWM to analog output
Content Limits	Content is limited to the use of common integration components like serial converters, ADCs, and level shifters; and strategies for producing analog voltage output from digital electronics.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	When two serial devices are communicating to each other, what term is used to describe the speed at which they "talk"? A. ADC B. baud rate C. com rate D. Tx/Rx Correct Answer: B

Standard	28.0 Describe the role of specialized sensors in the design and operation of robotic systems. – The student will be able to:
Benchmark	28.01 Explain how Global Positioning System (GPS) sensors are used in robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should understand the basics of how a Global Positioning System (GPS) works including the scientific theories that support them. Students should know what information a GPS signal can tell them and what it can't, and how the information is typically displayed in reference to the latitude and longitude system. Also the students should understand the proper application of the sensor in robotic systems and its limitations.
Content Focus	GPS, latitude, longitude, time differential, relativity, coordinates, position, heading, bearing
Content Limits	Content is limited to the theoretical operation of GPS systems and should not include any mapping, knowledge of specific latitude and longitude coordinates, speed or distance calculations, or geometry.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Which navigational data point derived from a gps sensor is inaccurate or impossible when the robot is stationary? A. heading B. position C. speed D. time Correct Answer: A

Standard	28.0 Describe the role of specialized sensors in the design and operation of robotic systems. – The student will be able to:
Benchmark	28.02 Discuss the application of laser range finders to the operation of robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand what raw information laser rangefinders measure, what information they typically can report, and their appropriate applications in robotics, including physical mounting details and environmental concerns that affect performance.
Content Focus	Laser diode, laser rangefinder, angle of reflection
Content Limits	Content is limited to the theoretical operation of this sensor and its mounting and programming consideration; questions should not include any calculations based on this sensor or questions regarding specific types, brands, or uses.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	What factor from the operating environment in a heavy manufacturing facility would most interfere with a laser range finder? A. dust B. heat C. noise D. vibration Correct Answer: A

Standard	28.0 Describe the role of specialized sensors in the design and operation of robotic systems. – The student will be able to:
Benchmark	28.03 Describe the types and uses of optical sensors in robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand what raw information that optical sensors measure, what information they typically can report, and their appropriate applications in robotics, including physical mounting details and environmental concerns that affect performance.
Content Focus	Optical sensor, laser rangefinder, infrared line tracker, infrared rangefinder, light sensor, color sensor, infrared motion detector
Content Limits	Content is limited to the theoretical operation of this sensor and its mounting and programming consideration; questions should not include any calculations based on this sensor or questions regarding specific types, brands, or uses.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	How many light sensors are typically employed to make up a integrated color sensor array? A. 1 B. 2 C. 3 D. 4 Correct Answer: C

Standard	28.0 Describe the role of specialized sensors in the design and operation of robotic systems. – The student will be able to:
Benchmark	28.04 Describe the ways in which gyroscopes are used in robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand what raw information gyroscopes measure, what information they typically can report, and their appropriate applications in robotics, including physical mounting details that affect performance.
Content Focus	Gyroscope, gyro, rotation, center of rotation, angular position, angular velocity, angular acceleration
Content Limits	Content is limited to the theoretical operation of this sensor and its mounting and programming consideration; questions should not include any calculations based on this sensor or questions regarding specific types, brands, or uses.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Explain why a gyroscopic sensor should be mounted as close to the center of rotation of a two wheeled balancing robot as possible. Answer: All positions have the same angular motion, but the center of rotation has less linear acceleration to interfere with the gyro's reading. Rubric: 2 Points: The student has a thorough understanding of the concept by providing a detailed explanation. 1 Point: The student has a partial understanding of the concept exhibited by providing an incomplete explanation. 0 Points: The student does not have an understanding of the concept and does not provide an explanation.

Standard	28.0 Describe the role of specialized sensors in the design and operation of robotic systems. – The student will be able to:
Benchmark	28.05 Describe the operation of an accelerometer and the ways in which accelerometers are used in robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand what raw information accelerometers measure, what information they typically can report, and their appropriate applications in robotics, including physical mounting details that affect performance.
Content Focus	Accelerometer, acceleration, speed, position, center of rotation, displacement
Content Limits	Content is limited to the theoretical operation of this sensor and its mounting and programming consideration; questions should not include any calculations based on this sensor or questions regarding specific types, brands, or uses.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Explain why an accelerometer sensor should be mounted as far from the center of rotation of a two wheeled balancing robot as possible. Answer: The center of rotation has the least linear acceleration, so the further from that center you are, the more acceleration there is to measure. Rubric: 2 Points: The student has a thorough understanding of the concept by providing a detailed explanation. 1 Point: The student has a partial understanding of the concept exhibited by providing an incomplete explanation. 0 Points: The student does not have an understanding of the concept and does not provide an explanation.

Standard	29.0 Describe the use of specialized electronic applications used in robotic systems. – The student will be able to:
Benchmark	29.01 Explain the various methods for controlling robotic systems and the form of electronic feedback system needed for the appropriate sensor.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should be able to identify the three primary robot control structures, tele-op control (direct user control), autonomous control (programming and sensor control), and hybrid control (combination of sensor/programming and user control)
Content Focus	Tele-op control, hybrid control, autonomous operation, autonomous programming, sensor feedback
Content Limits	Content is limited to the definitions of tele-op, hybrid, and autonomous control, and how each control type interacts with sensors and programming.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	If you wanted to control the motion of an autonomous wheeled robot with a sensor that rotates continuously on the axle and tells the total distance and direction traveled, which sensor would you select? A. a line tracker B. a potentiometer C. a quadrature encoder D. a rangefinder Correct Answer: C

Standard	29.0 Describe the use of specialized electronic applications used in robotic systems. – The student will be able to:
Benchmark	29.02 Describe the concept of Fail Safe and how such components are integrated into robotic systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should be able to explain what a Fail Safe is, why one is used in robotic applications, and what triggers its response. Students should also be able to suggest appropriate Fail Safe responses given the operating environment.
Content Focus	Fail Safe, signal loss, interference
Content Limits	Content is limited to the general application of a Fail Safe and a limited number of general environments with different Fail Safe responses such as a flying craft, a heavy industrial robot, or a mobile robot that operates around people.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Short Answer: In what situation would "immediately stopping all motors and actuators", not be an appropriate Fail Safe response? Answer: with flying robots such as quadcopters Rubric: 2 Points: The student has a thorough understanding of the concept by providing a detailed explanation. 1 Point: The student has a partial understanding of the concept exhibited by providing an incomplete explanation. 0 Points: The student does not have an understanding of the concept and does not provide an explanation.

Standard	29.0 Describe the use of specialized electronic applications used in robotic systems. – The student will be able to:
Benchmark	29.03 Explain the fundamentals of LC, RC, and LCR circuitry and describe their use in robotic control and feedback systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should be able to explain what LC, RC, and LCR circuits are, what they are used for, and what their characteristics are. Students should also know the components that make these circuits up and be able to identify them from written description or imagery.
Content Focus	LC circuit, RC circuit, LCR circuit, resistor, capacitor, oscillator, inductor
Content Limits	Content is limited to identifying LC, RC, and LCR circuits from pictures, diagrams, or written descriptions, and the basic understanding of their use in robotics.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: What is the electrical component that is at the center of an LCR circuit ? A. capacitor B. diode C. inductor D. resistor Correct Answer: A

Standard	29.0 Describe the use of specialized electronic applications used in robotic systems. – The student will be able to:
Benchmark	29.04 Describe the electronic operation and application of electrically, pneumatically, and hydraulically controlled robot systems.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand the fundamental concepts behind electrical, pneumatic, and hydraulic actuator systems, including their characteristics, benefits, deficits, selection criteria, how they are controlled, and theoretical sizing for hydraulic and pneumatic pistons.
Content Focus	Actuator, hydraulic, pneumatic, electrical, linear, piston, bore, force, valve, servo
Content Limits	Content is limited to the general properties of hydraulic, pneumatic, and electrical linear actuators, and their strengths and weaknesses. No mathematical calculations other than basic area X pressure = force, and finding the area of a round piston.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Short Answer: How much force could a 6 inch diameter hydrauilc piston generate if it was opperated at 2000 psi? Answer: 56,549 pounds of force Rubric: 2 Points: The student correctly answers 56,549 lbs. 1 Point: The student approximates 56,549 lbs, but numerical answer is not correct. 0 Points: The student does not approximate 56,549 lbs.

Standard	29.0 Describe the use of specialized electronic applications used in robotic systems. – The student will be able to:
Benchmark	29.05 Compare and contrast various sources for powering robotic systems, including solar cells, batteries, and radioisotope thermoelectric generators (RTGs).
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should understand the fundamentals of electrical energy systems including the ability to compare and contrast their strengths and weaknesses in areas such as power density, energy capacity, cost, operating environment, safety issues, and practicality
Content Focus	Solar cells, batteries, radioisotope thermoelectric generators (rtgs), watts per square meter, watt-hours per kilogram, watt-hours per cubic meter, life cycle cost, rate of energy flow versus quantity of energy29.0 Describe the use of specialized electronic applications used in robotic systems. – The student will be able to:
Content Limits	Content is limited to general understanding of power versus energy, and simple calculations involving watts, time, watt-hours, and joules. Also basic knowledge of battery capacity and solar panel ratings.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: The Curiosity Mars rover was not powered by solar panels as the past Mars rovers were; instead it used a radioisotope thermoelectric generator (RTG). What is the most probable reason that the type of power source was selected? A. the RTG is more cost effective than solar panels B. the RTG is more environmentally friendly to manufacture C. the RTG is simpler than a folding solar array D. the RTG provides more power than solar panels Correct Answer: D

Standard	30.0 Demonstrate an understanding of engineering technologies impacted by the evolution of robotics. – The student will be able to:
Benchmark	30.02 Compare and contrast the operation of reactive, behavior-based, and deliberative robot controllers.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students will understand the characteristics of, similarities of, and differences between reactive, behavior based, and deliberative robot controllers.
Content Focus	Reactive robot controller, deliberative robot controller, behavior based robot controller
Content Limits	Content is limited to identifying a robot controller type based on a description of its properties, or recommending a robot controller type based on the system's requirements.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: *This type of control structure tightly links sensory inputs to effector outputs, which allows for very rapid response to inputs*. Which type of robot control structure best fits the preceeding description? A. behavior-based B. deliberative C. hybrid D. reactive Correct Answer: D

Standard	31.0 Demonstrate an understanding of underlying principles of environmental physics related to robotic technology. – The student will be able to:
Benchmark	31.01 Describe thermal dynamics and discuss its practical application to robotics, particularly as it relates to motor and gear selection.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students will understand how simple machines can exchange distance/speed for force but cannot change the amount of work done. As it relates to gear ratios and selection, a transmission can trade torque for RPM but not increase the power of the motor.
Content Focus	Torque, rpm, power, transmission, simple machine, first law of thermal dynamics, force, work
Content Limits	Content may include any simple machine example including gear ratios, but is limited to simple exchange ratios to demonstrate an understanding of the role of the first law of thermodynamics in maintaining the amount of work done.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: You have a motor that produces 200 Newton-meters of torque at 100 revolutions per minute. After you put its work through a transmission the final RPM is 25, assuming 100% efficiency, what would be the final torque after the transmission? A. 25 Newton-meters B. 50 Newton-meters C. 200 Newton-meters D. 800 Newton-meters Correct Answer: D

Standard	31.0 Demonstrate an understanding of underlying principles of environmental physics related to robotic technology. – The student will be able to:
Benchmark	31.02 Describe the concept of pressure and relate its implications on robotic assemblies, include methods and forms or measurement.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand the difference between pressure and force, how pressure is measured (units), and the types of sensors that are commonly used to measure pressure. Also students should understand the correct application of force sensors and measurement in robotics.
Content Focus	Force, pressure, PSI, Pascal, Newtons/square meter, membrane, resistive
Content Limits	Content is limited to differentiating between force and pressure, basic pressure calculations using force and area, and an understanding of the units that are used to measure force and pressure.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	A sensor pad on a robotic finger is measuring 3.4 PSI over an area of .75 square inches. What is the total force that finger is exerting on an object? A. 2.55 lbs B. 2.65 lbs C. 3.18 lbs D. 3.32 lbs Correct Answer: A

Standard	31.0 Demonstrate an understanding of underlying principles of environmental physics related to robotic technology. – The student will be able to:
Benchmark	31.03 Distinguish between tolerance and allowance.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand the difference between tolerance and allowance and their use in engineering design and manufacturing. Students should also understand the reason each is required in design.
Content Focus	Tolerance, allowance, interference, clearance, expansion, precision, contraction, accuracy
Content Limits	Content is limited to the theoretical understanding the difference between tolerance and allowance and the correct use for each one; no mathematical calculations.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: What is it called when you intentionally design a slight gap between two highly machined parts that are designed to slide into one another? A. clearance B. deviation C. error D. tolerance Correct Answer: D

Standard	32.0 Demonstrate an understanding of the impact of robotics on the manufacturing process. – The student will be able to:
Benchmark	32.01 Describe the essential steps in the conventional manufacturing process, identifying those susceptible to being performed by industrial robots.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should be able to list the basic steps in the conventional manufacturing process, and identify those that are most and least likely to be performed or adopted by industrial robotics.
Content Focus	Conventional manufacturing process, automation, industrial robotics, machining, design, packaging, quality control, marketing.
Content Limits	Content is limited to identifying the steps in the manufacturing process most likely to be replaced with automation, and an understanding of the characteristics of those jobs that make them easily replaced.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: Which one of these steps in the manufacturing process is least likely to be performed by an automated robot? A. machining B. packaging C. painting D. quality control Correct Answer: D

Standard	32.0 Demonstrate an understanding of the impact of robotics on the manufacturing process. – The student will be able to:
Benchmark	32.03 Explain the impact of 3D printing on rapid prototyping.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should understand the fundamentals of additive manufacturing and how its characteristics make rapid prototyping easier.
Content Focus	Rapid prototyping, additive manufacturing, 3D printing, CAD, modeling software, .STL, .THING,. OBJ
Content Limits	Content is limited to understanding the basic principles of 3D printing, the CAD drawings that are used to create the prints, and generally why this has been a major influence in rapid prototyping. There should not be any brand or material specific questi
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: Which of these is not a benefit of 3D printing? A. consumer assessability B. inexpensive one-off production C. rapid mass production D. rapid prototyping Correct Answer: C

Standard	32.0 Demonstrate an understanding of the impact of robotics on the manufacturing process. – The student will be able to:
Benchmark	32.04 Describe the process and methodology for creating a rapid prototype of an interactive robot.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand the fundamentals of the rapid prototyping process, typically following the steps: design, creation in 3D modeling software, component production in a rapid prototyper (additive or subtractive) and final assembly.
Content Focus	Rapid prototyping, additive manufacturing, subtractive manufacturing, 3D printing, milling machine, CNC, CAD, CAM, modeling software, .STL, .THING,. OBJ, G code
Content Limits	Content is limited to additive and subtractive manufacturing processes, specifically plastic 3D printers and 3-axis milling machines. Students should know the basic vocabulary of each and the electronic file types employed by each machine type.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: Which of these is a possible file type that can be uploaded into a 3D printer to produce a robotic prototype? A. .gif B. .pnp C. .stl D. .xls Correct Answer: C

Standard	33.0 Demonstrate an understanding of topographical and environmental considerations in robotic assembly design. – The student will be able to:
Benchmark	33.01 Describe various robot design considerations related to the intended operating environment or medium.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	M - H
Benchmark Clarification	Students will understand generally how operating environment affects robotic design and component selection. Students will also understand the key challenges presented by specific environments, such as explosive gas, underwater, heavy mining, surgical operating rooms, and outer space.
Content Focus	Marine/deep underwater robots, medical robots, mining/logging robots, space exploration robots, hazardous environment robots
Content Limits	Content is limited to general questions concerning operating environment and its effect on structure and sensor selection. Key considerations for each environment should be general and commonly accepted.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Short Answer: List two major design considerations when working with deep diving robotic submarines. Answer: extreme pressure and immersion in a conductive liquid Rubric: 2 Points: The student lists two major considerations when working with deep diving robotic marines. 1 Point: The student lists one major consideration when working with deep diving robotic marines. 0 Points: The student does not list a consideration when working with deep diving robotic marines.

Standard	33.0 Demonstrate an understanding of topographical and environmental considerations in robotic assembly design. – The student will be able to:
Benchmark	33.02 Explain the correlation between sensor selection and a robot's operating environment, capability, and autonomy.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students will have a strong understanding of the various different types of sensors commonly used in robotics and their strengths and limitations. Students should be able to select an appropriate sensor given a detailed scenario, or select an appropriate application given a specific sensor type. Students should also be able to explain why one sensor is better than another for a given situation.
Content Focus	Contact switch/bumper, encoders, quadrature encoders, ultrasonic rangefinder, laser rangefinder, infrared rangefinder, color sensor, potentiometer, light sensor, sound sensor, infrared line tracking array
Content Limits	Content is limited to the theoretical operation of various common sensors (listed in this blueprint) and their mounting and programming consideration, questions should not include any calculations based on these sensors or questions regarding specific typ
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: Why might you specify a magnetic strip-style line tracking system for a commercial warehouse robot instead of an infrared line tracking system? A. the magnetic strip is cheaper to install in concrete floors B. the magnetic strip is easier to write a program for C. the magnetic strip is safer for human workers D. the magnetic strip is tolerant of dirt and marks on the floor Correct Answer: D

Standard	33.0 Demonstrate an understanding of topographical and environmental considerations in robotic assembly design. – The student will be able to:
Benchmark	33.03 Explain the term obstacle avoidance and relate its importance to the design, mobility, and autonomy of a robot.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should understand obstacle avoidance, the sensors, programming, and actuators involved in its implementation. Also how sensor choice and mechanical design affect obstacle avoidance.
Content Focus	Sensor, obstacle avoidance, rangefinders, bumper switches, swerve drive, holonomic drive, omni wheel, mecanum wheel
Content Limits	Content is limited to the concept and strategies for obstacle avoidance, the appropriate sensors for each strategy, and snippets of programming code. There should not be any calculations involved, and any code samples should be a generic C and simple in f
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: Why might a mobile robot need obstacle avoidance systems even if it was designed to work alone in an empty warehouse and move along a magnetic track? A. in case it needed to be used in other parts of the business B. it prevents collisions with inanimate objects and other robots C. it is a critical component of magnetic line tracking D. it is an ethical requirement that all robots have obstacle avoidance Correct Answer: B

Standard	34.0 Create a program to control a robotic system. – The student will be able to:
Benchmark	34.01 Compare and contrast the popular programming languages used to program robots and discuss their suitability for particular environments.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand the fundamental differences between text based programming languages (C, C#, C++, Java, Python, RobotC, Linux, and Arduino) and graphical programming languages (Lego, MPLab, LabView, Visual Basic, Scratch, and Easy C), and they should be able to explain why one might be preferred over another in different environments.
Content Focus	Text based programming language, graphical programming language
Content Limits	Content is limited to the benefits and deficits of graphical versus text based programming language; it should not call upon a student's knowledge of any specific programming language, but only a general familiarity with the different types.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: What are the advantages of text-based programming languages like C#, .Net, and Java? A. text-based programming allows greater control and flexibility of the program B. text-based programming can be modified more easily by untrained programmers C. text-based programming is the only type used with autonomous robotic applications D. text-based programming only works on common desktop computers Correct Answer: A

Standard	34.0 Create a program to control a robotic system. – The student will be able to:
Benchmark	34.02 Distinguish between USB, fire wire, and serial connections and the availability of those connections on robotic assemblies.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should be able to identify and understand the physical differences between USB, Fire Wire, and various serial ports on a computer and robotic control board. Also students should understand the types of data that can be transmitted through those ports.
Content Focus	USB, Fire Wire, serial, Tx/Rx, SCL/SDA
Content Limits	Content is limited to identifying different ports based on physical appearance, or by the type and labels on the ports. Synchronous serial versus asynchronous serial questions would be appropriate.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: Which one of the terms below is associated with synchronous serial data transfer? A. RX B. SDA C. TX D. UART Correct Answer: B

Standard	34.0 Create a program to control a robotic system. – The student will be able to:
Benchmark	34.03 Distinguish between holonomic and non-holonomic motion planning relative to feedback and control applications.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=
Cognitive Complexity Level	L - M
Benchmark Clarification	Students should understand what holonomic drive means, its defining characteristics, the various ways it is commonly achieved, and how it affects motion planning relative to a non-holonomic drive robot. Also students should understand how sensor feedback is used and how it is different than in non-holonomic drive.
Content Focus	Swerve drive, holonomic drive, omni wheel, mecanum wheel, four wheel omni "+" arrangement, four wheel omni "x" arrangement, three wheel, omni, encoder, line tracker, magnetic strip
Content Limits	Content is limited to the definition of holonomic drive and how it relates to degrees of freedom of motion on a 2D plane. Basic math calculations for distance and speed and identifying key component in code regarding holonomic drive; any code samples shou
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: In an "X" style holonomic-drive robot using standard omni wheels, what is the maximum forward velocity if the edge of the omni wheel is moving at 10 feet per second? A. 5.00 ft/sec B. 7.07 ft/sec C. 8.66 ft/sec D. 10.0 ft/sec Correct Answer: B

Standard	34.0 Create a program to control a robotic system. – The student will be able to:
Benchmark	34.04 Describe the process of motion planning and the variations in the underlying algorithm or approach.
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should understand the characteristics of the physical components of motion planning such as output actuators, input sensors, physical setups, and gearing issues. Also, students should understand the programming components and algorithms commonly used in robotic motion planning.
Content Focus	Actuator, motor, sensor, encoder, quadrature encoder, counts, millisecond delay timing, wheel circumference, angular rotation
Content Limits	Content is limited to basic math calculations for distance, speed, and time, and identifying key components in code regarding different forms of motion control; any code samples should be generic C and simple in form.
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Multiple Choice: How far would a robot travel forward if it rolled its 6 inch diameter wheels through 720˚ of rotation? A. 6.00 inches B. 12.0 inches C. 18.8 inches D. 37.7 inches Correct Answer: D

Standard	35.0 Demonstrate an understanding of technologies for communication with and among robotic systems. – The student will be able to:
Benchmark	35.04 Describe the various forms of sensor-based feedback typically obtainable from a robotic assembly and explain their application and associated challenges (e.g., EMI, bandwidth, etc.) in specific robotic applications (e.g., surgery, hazardous environm
Item Types **(MC)-Multiple Choice** **(SA)-Short Answer** **(P)-Performance** **(ER)-Extended Response**	(MC)=X (SA)=X (P)= (ER)=X
Cognitive Complexity Level	M - H
Benchmark Clarification	Students should understand the characteristics of common robotics sensors, including what they measure, how they operate, the complexity of the data they return, the type of data they return, their operating limitations, operating environment considerations, and programming considerations.
Content Focus	Passive sensor, active sensor, digital sensor, analog sensor, smart sensor, operating environments, bandwidth
Content Limits	Content is limited to knowledge or characteristics of active versus passive sensors, analog versus digital, and the reason behind the selection of each type for a given application. Questions should not include any calculations based on these sensors or q
Stimulus Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Response Attributes	Selected response, constructed response, short answer, essay, fill in the blank, vocabulary, performance rubrics, examples and non examples, simulations, demonstrations
Sample Item	Short Answer: Why might a scientist require the use of only passive sensors in an experimental setup? Answer: passive sensor do not emit any energy or affect the environment, they only receive information. Rubric: 2 Points: The student has a thorough understanding of the concept by providing a detailed explanation. 1 Point: The student has a partial understanding of the concept exhibited by providing an incomplete explanation. 0 Points: The student does not have an understanding of the concept and does not provide an explanation.