

# Manufacturing Systems I

**8426 18 weeks**

**8425 36 weeks**

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## Acknowledgments

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# Course Description

**Suggested Grade Level:** 9 or 10 or 11 or 12

This course provides an orientation to careers in various fields of manufacturing. Emphasis will be placed on manufacturing systems, safety, materials, production, business concepts, and the manufacturing process. Students participate in individual and team activities to create products that demonstrate critical elements of manufacturing.

*As noted in [Superintendent's Memo #058-17 \(2-28-2017\)](#), this Career and Technical Education (CTE) course must maintain a maximum pupil-to-teacher ratio of 20 students to one teacher, due to safety regulations. The 2016-2018 biennial budget waiver of the teacher-to-pupil ratio staffing requirement does not apply.*

## 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	8425	8426	Tasks/Competencies
Introducing Manufacturing Systems			
39	⊕	⊕	Research careers in manufacturing.
40	⊕	⊕	Differentiate among types of manufacturing.
41	⊕	⊕	Demonstrate metrology used in manufacturing.
42	⊕	⊕	Explain the importance of manufacturing.
43	⊕	⊕	Explain the effect of supply and demand on manufacturing.
44	⊕	⊕	Describe societal, economic, and environmental effects of manufacturing.
45	⊕	⊕	Describe societal, economic, and environmental influences on manufacturing.
46	⊕	⊕	Explain considerations of green, or clean, manufacturing.

47	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Assess the product life cycle.
Understanding the History of Manufacturing			
48	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Outline the history of manufacturing.
49	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe the development of U.S. manufacturing.
50	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Predict future manufacturing trends.
Practicing Safety			
51	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Use required personal protective equipment (PPE).
52	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Implement a safety plan.
53	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Maintain safe working practices in the production laboratory.
54	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Operate lab equipment according to instructor guidelines.
Exploring Materials and Processes			
55	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe additive processes.
56	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe subtractive processes.
57	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Distinguish among materials used in the manufacturing process.
58	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Differentiate among properties of materials.
59	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Classify methods of altering materials.
60	<input checked="" type="radio"/>	<input type="radio"/>	Demonstrate methods of altering materials.
61	<input checked="" type="radio"/>	<input type="radio"/>	Demonstrate methods of combining materials.
62	<input checked="" type="radio"/>	<input type="radio"/>	Use materials to make a product.
Understanding Production Processes			
63	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Explain the product-development process.
64	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Describe the engineering design process.
65	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Apply technology to produce a prototype.
66	<input checked="" type="radio"/>	<input checked="" type="radio"/>	Use the engineering design process to plan production.

67	⊕	○	Describe the stages/processes of tooling up for production.
68	⊕	⊕	Describe production planning in manufacturing.
69	⊕	⊕	Describe rapid prototyping/modeling.
70	⊕	⊕	Evaluate the process and the prototype.
Demonstrating Manufacturing Processes			
71	⊕	⊕	Participate in a production line activity.
72	⊕	⊕	Evaluate the production process.
Exploring Business Concepts			
73	○	○	Identify the three basic forms of business ownership.
74	○	○	Explain the effect of corporate citizenship.
75	○	○	Identify levels of management.
76	○	○	Describe the effect of labor and human resources issues on manufacturing.
77	○	○	Identify the parts of a marketing plan.
78	○	○	Explain fiscal responsibilities associated with operating a successful enterprise.
Exploring Green Manufacturing			
79	⊕	⊕	Exercise environmentally conscious manufacturing.
80	⊕	⊕	Explain environmental considerations when designing a product.
81	⊕	⊕	Identify energy efficiency, conservation, and pollution prevention.

Legend: ⊕ Essential ○ Non-essential ⊖ Omitted

## Curriculum Framework

### Introducing Manufacturing Systems

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## **Task Number 39**

### **Research careers in manufacturing.**

#### **Definition**

Research should include

- typical manufacturing jobs/careers
- training and education needed
- industry certifications
- current pay rate
- employment projections
- common career paths
- job requirements
- working conditions.

Many websites offer career exploration resources, including

- [Dream it. Do it. Virginia.](#)

#### **Process/Skill Questions**

- What manufacturing industries are located in your geographic area?
- What types of jobs might be available in a manufacturing industry?
- What jobs in a company might be directly related to the production of products?
- What level of education is required for various manufacturing occupations?

#### **ITEEA National Standards**

##### **19. Manufacturing Technologies**

#### **TSA Competitive Events**

##### **Essays on Technology**

##### **Technology Bowl**

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## **Task Number 40**

### **Differentiate among types of manufacturing.**

#### **Definition**

Differentiation should include

- mass production
- batch production
- custom production.

#### **Process/Skill Questions**

- What type of manufacturing process do major automobile makers use?
- What are some products that might be custom made?
- What does *continuous manufacturing* mean? What might be made using that type of production?
- Which type of manufacturing is the most cost-effective?

#### **ITEEA National Standards**

##### **19. Manufacturing Technologies**

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

#### **TSA Competitive Events**

##### **Essays on Technology**

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## **Task Number 41**

### **Demonstrate metrology used in manufacturing.**

#### **Definition**

Demonstration should include measuring length, area, volume, and weight, using

- Society of Automotive Engineers (SAE) units (including fractions to decimals and vice versa)
- Système Internationale (SI) units

and converting SAE units to SI units and vice versa.

Measurement tools may include

- machinist rule
- U.S. ruler
- tape measure
- metric ruler
- architect or engineer scale
- weight scale
- micrometer
- calipers (digital, dial, and Vernier)
- dial indicator/gauge blocks
- measurement cups.

### **Process/Skill Questions**

- Why is there more than one system of measuring units?
- What are calipers used to measure?
- What are the consequences of failing to accurately convert units of measure?
- What unit of measure is most often used in U.S. manufacturing?

### **ITEEA National Standards**

#### **19. Manufacturing Technologies**

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

### **TSA Competitive Events**

#### **Computer Integrated Manufacturing (CIM)**

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## **Task Number 42**

### **Explain the importance of manufacturing.**

#### **Definition**

Explanation should include that manufacturing

- provides for large-scale consumer needs and wants
- is responsible for the origins of products
- offers varied levels of employment.

### **Process/Skill Questions**

- What is the difference between needs and wants?
- Where do the things you buy come from?
- How can the varied levels of employment be helpful to potential employees?

### **Economics and Personal Finance Standards of Learning**

#### **EPF.2**

The student will demonstrate knowledge of the role of producers and consumers in a market economy by

- describing how consumers, producers, workers, savers, investors, and citizens respond to incentives;
- explaining how businesses respond to consumer sovereignty;
- identifying the role of entrepreneurs;
- comparing the costs and benefits of different forms of business organization, including sole proprietorship, partnership, corporation, franchise, and cooperative;
- describing how costs and revenues affect profit and supply;
- describing how increased productivity affects costs of production and standard of living;
- examining how investment in human capital, capital goods, and technology can improve productivity;
- describing the effects of competition on producers, sellers, and consumers;
- explaining why monopolies or collusion among sellers reduces competition and raises prices; and
- illustrating the circular flow of economic activity.

### **ITEEA National Standards**

#### **1. The Characteristics and Scope of Technology**

#### **6. The Role of Society in the Development and Use of Technology**

#### **7. The Influence of Technology on History**

## **Task Number 43**

# **Explain the effect of supply and demand on manufacturing.**

## **Definition**

Explanation should include

- effects on product pricing
- effects on product availability
- effects on labor.

## **Process/Skill Questions**

- How does price vary with availability?
- How does demand affect production?
- How does supply affect production?

## **Economics and Personal Finance Standards of Learning**

### **EPF.3**

The student will demonstrate knowledge of the price system by

- a. examining the laws of supply and demand and the determinants of each;
- b. explaining how the interaction of supply and demand determines equilibrium price;
- c. describing the elasticity of supply and demand; and
- d. examining the purposes and implications of price ceilings and price floors.

## **ITEEA National Standards**

### **19. Manufacturing Technologies**

#### **6. The Role of Society in the Development and Use of Technology**

#### **7. The Influence of Technology on History**

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## **Task Number 44**

# **Describe societal, economic, and environmental effects of manufacturing.**

## **Definition**

Description should include the ways in which manufacturing can affect

- health
- ecosystems
- culture
- economics
- community (local and global)
- labor
- regulations
- politics
- ethics.

### **Process/Skill Questions**

- In what ways does manufacturing affect the environment?
- What are some effects that manufacturing has on society?
- When might politics be a consideration in manufacturing? Ethics? Economics?
- How is manufacturing related to national security?

### **Economics and Personal Finance Standards of Learning**

#### **EPF.1**

The student will demonstrate knowledge of basic economic concepts and structures by

- a. describing how consumers, businesses, and government decision makers face scarcity of resources and must make trade-offs and incur opportunity costs;
- b. explaining that choices often have long-term unintended consequences;
- c. describing how effective decision making requires comparing the additional costs (marginal costs) and additional benefits (marginal benefits);
- d. identifying factors of production;
- e. comparing the characteristics of market, command, tradition, and mixed economies; and
- f. identifying Adam Smith and describing the characteristics of a market economy.

#### **EPF.2**

The student will demonstrate knowledge of the role of producers and consumers in a market economy by

- a. describing how consumers, producers, workers, savers, investors, and citizens respond to incentives;
- b. explaining how businesses respond to consumer sovereignty;
- c. identifying the role of entrepreneurs;
- d. comparing the costs and benefits of different forms of business organization, including sole proprietorship, partnership, corporation, franchise, and cooperative;

- e. describing how costs and revenues affect profit and supply;
- f. describing how increased productivity affects costs of production and standard of living;
- g. examining how investment in human capital, capital goods, and technology can improve productivity;
- h. describing the effects of competition on producers, sellers, and consumers;
- i. explaining why monopolies or collusion among sellers reduces competition and raises prices; and
- j. illustrating the circular flow of economic activity.

## **ITEEA National Standards**

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

### **5. The Effects of Technology on the Environment**

### **6. The Role of Society in the Development and Use of Technology**

## **TSA Competitive Events**

### **Essays on Technology**

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## **Task Number 45**

### **Describe societal, economic, and environmental influences on manufacturing.**

#### **Definition**

Description should include the ways in which manufacturing can be affected by

- health
- ecosystems
- culture
- economics
- community (local and global)
- labor
- regulations
- politics
- ethics.

## Process/Skill Questions

- How does culture affect manufacturing?
- Why is manufacturing subject to regulation?
- What effect do health and safety concerns have on manufacturing?

## Economics and Personal Finance Standards of Learning

### EPF.1

The student will demonstrate knowledge of basic economic concepts and structures by

- a. describing how consumers, businesses, and government decision makers face scarcity of resources and must make trade-offs and incur opportunity costs;
- b. explaining that choices often have long-term unintended consequences;
- c. describing how effective decision making requires comparing the additional costs (marginal costs) and additional benefits (marginal benefits);
- d. identifying factors of production;
- e. comparing the characteristics of market, command, tradition, and mixed economies; and
- f. identifying Adam Smith and describing the characteristics of a market economy.

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The student will demonstrate knowledge of the role of producers and consumers in a market economy by

- a. describing how consumers, producers, workers, savers, investors, and citizens respond to incentives;
- b. explaining how businesses respond to consumer sovereignty;
- c. identifying the role of entrepreneurs;
- d. comparing the costs and benefits of different forms of business organization, including sole proprietorship, partnership, corporation, franchise, and cooperative;
- e. describing how costs and revenues affect profit and supply;
- f. describing how increased productivity affects costs of production and standard of living;
- g. examining how investment in human capital, capital goods, and technology can improve productivity;
- h. describing the effects of competition on producers, sellers, and consumers;
- i. explaining why monopolies or collusion among sellers reduces competition and raises prices; and
- j. illustrating the circular flow of economic activity.

## ITEEA National Standards

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

## **5. The Effects of Technology on the Environment**

## **6. The Role of Society in the Development and Use of Technology**

### **TSA Competitive Events**

#### **Essays on Technology**

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## **Task Number 46**

### **Explain considerations of green, or clean, manufacturing.**

#### **Definition**

Explanation should include

- sustainable resources
- energy efficiency
- environmental conservation
- pollution management
- resource management
- waste control.

#### **Process/Skill Questions**

- How does product design relate to the environment?
- How do manufacturers use recycled materials? How do they recycle? How do they design for recycling?
- What is meant by Design for the Environment (DfE)? What is the Environmental Protection Agency's (EPA) role in DfE?
- How can manufacturers reduce their carbon footprint?
- What are some popular materials used in manufacturing for their sustainable qualities?
- What manufacturing materials have been discovered to be hazardous in recent history?
- Who is responsible for managing DfE and EPA locally and statewide?

#### **ITEEA National Standards**

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

### **5. The Effects of Technology on the Environment**

## **6. The Role of Society in the Development and Use of Technology**

### **TSA Competitive Events**

#### **Essays on Technology**

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## **Task Number 47**

### **Assess the product life cycle.**

#### **Definition**

Assessment should review the life of a product from raw materials to disposal, including introduction, growth, maturity, and decline of a product. Related concepts may include

- cradle-to-grave vs. cradle-to-cradle
- maintenance of a product vs. disposal
- recycling and reuse.

#### **Process/Skill Questions**

- Which do you think is more desirable: cradle-to-grave or cradle-to-cradle? Explain.
- What is meant by the notion that we are a "disposal society"?
- What are some examples of reuse?
- What are some benefits of DfE in the productive life cycle of recycling and reuse?

#### **ITEEA National Standards**

##### **11. Apply the Design Process**

##### **6. The Role of Society in the Development and Use of Technology**

##### **9. Engineering Design**

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# **Understanding the History of Manufacturing**

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## **Task Number 48**

### **Outline the history of manufacturing.**

#### **Definition**

Outline should include a summary of the critical stages that manufacturing has undergone (i.e., Industry 1.0, 2.0, 3.0, 4.0).

#### **Process/Skill Questions**

- How did the invention of the steam engine affect manufacturing?
- In what way did the invention of interchangeable parts alter manufacturing? Line production? Automation?
- What are the critical stages of U.S. manufacturing?
- What role has the computer played in the evolution of manufacturing?
- How has the role of robots changed in manufacturing?

#### **ITEEA National Standards**

##### **1. The Characteristics and Scope of Technology**

##### **19. Manufacturing Technologies**

#### **TSA Competitive Events**

##### **Essays on Technology**

##### **Technology Bowl**

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## **Task Number 49**

### **Describe the development of U.S. manufacturing.**

#### **Definition**

Description should include the factors influencing development, including

- materials
- technologies
- energy sources

- safety
- transportation
- communication
- design
- continuous improvement
- management
- employment.

## **Process/Skill Questions**

- How have natural resources contributed to the development of U.S. manufacturing?
- What years are considered the peak (so far) of U.S. manufacturing?
- How is manufacturing developing further through the advent of additive manufacturing, augmented reality, and nanotechnology?
- What new materials are being used in manufacturing?
- What is the most frequently manufactured product in the United States today?

## **ITEEA National Standards**

### **1. The Characteristics and Scope of Technology**

#### **19. Manufacturing Technologies**

## **TSA Competitive Events**

### **Essays on Technology**

### **Technology Bowl**

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## **Task Number 50**

### **Predict future manufacturing trends.**

#### **Definition**

Prediction should be based on an understanding of manufacturing's history and should include

- materials
- technology
- energy sources
- safety
- transportation

- communication
- design
- continuous improvement
- management
- employment.

## **Process/Skill Questions**

- How can understanding an industry's past help predict its future?
- What recent communication developments might lead to new trends in manufacturing?
- How might the push toward cleaner energy influence manufacturing in the future?
- What is *change management*? How do manufacturers address it?
- What type of things are manufacturers doing to minimize waste?
- How has the need for producing quality affected manufacturing?
- How does the Internet of Things (IoT) affect manufacturing?

## **ITEEA National Standards**

### **1. The Characteristics and Scope of Technology**

#### **19. Manufacturing Technologies**

## **TSA Competitive Events**

### **Essays on Technology**

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# **Practicing Safety**

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## **Task Number 51**

### **Use required personal protective equipment (PPE).**

#### **Definition**

Use should include

- identifying potential hazards

- understanding safety data sheets (SDS)
- describing equipment that protects against each hazard
- wearing necessary equipment when performing hazardous tasks.

### **Process/Skill Questions**

- What are the names and purposes of five pieces of PPE?
- When would it be necessary to wear PPE?
- When should an SDS be used? How does an SDS benefit the response to a spill or another incident or injury?
- How does facial hair affect the use of some PPE?

### **ITEEA National Standards**

#### **12. Use and Maintain Technological Products and Systems**

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## **Task Number 52**

### **Implement a safety plan.**

#### **Definition**

Implementation should include

- completing a safety proficiency test with a 100% pass rate
- demonstrating safety procedures for each tool and machine used
- adhering to basic safety rules.

### **Process/Skill Questions**

- Why do you have to pass the safety test with 100%?
- What could happen if you don't follow **every** safety rule?
- Why is it important to always have teacher supervision in the lab?

### **ITEEA National Standards**

#### **12. Use and Maintain Technological Products and Systems**

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## **Task Number 53**

# **Maintain safe working practices in the production laboratory.**

## **Definition**

Maintenance should include

- locating and using laboratory safety equipment
- identifying potential hazards in the laboratory
- demonstrating safe work habits with each type of equipment and material
- adhering to Occupational Safety and Health Administration (OSHA) standards as required by the teacher.

## **Process/Skill Questions**

- What are the risks of unsafe behavior in the laboratory?
- How would safety rules help prevent these risks?
- How should one respond to an emergency in the laboratory?

## **ITEEA National Standards**

### **12. Use and Maintain Technological Products and Systems**

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## **Task Number 54**

### **Operate lab equipment according to instructor guidelines.**

#### **Definition**

Operation should include

- following posted safety rules for each piece of equipment
- using guards as required
- passing a proficiency demonstration with the instructor.

#### **Process/Skill Questions**

- How are the posted safety rules for any two pieces of equipment in your room similar and different?
- Why are guards necessary?
- How would you know if you are using a piece of equipment improperly?

- What should always be done to the electrical service prior to performing maintenance on a machine?

## **ITEEA National Standards**

### **12. Use and Maintain Technological Products and Systems**

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# **Exploring Materials and Processes**

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## **Task Number 55**

### **Describe additive processes.**

#### **Definition**

Description should include

- equipment used
- materials used
- examples of additive processes, such as
  - 3D printing
  - coating
  - molding.

#### **Process/Skill Questions**

- What are some examples or products produced by additive processes?
- What materials are commonly used in 3D printing?
- What equipment is used for additive processing?
- What is the role of software in the additive process?
- What are the limitations of additive processing?

## **ITEEA National Standards**

### **19. Manufacturing Technologies**

#### **2. The Core Concepts of Technology**

## **TSA Competitive Events**

### **Computer Integrated Manufacturing (CIM)**

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## **Task Number 56**

### **Describe subtractive processes.**

#### **Definition**

Description should include

- equipment used
- materials used
- examples of subtractive processes, such as
  - sawing
  - milling
  - grinding.

#### **Process/Skill Questions**

- What are some examples of products produced by subtractive processes?
- What equipment is used for subtractive processing?
- What is the role of software in subtractive processing?
- What are the limitations of subtractive manufacturing?

#### **ITEEA National Standards**

##### **19. Manufacturing Technologies**

##### **2. The Core Concepts of Technology**

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## **Task Number 57**

### **Distinguish among materials used in the manufacturing process.**

#### **Definition**

Distinction should include various types of

- woods
- metals
- chemicals
- polymers
- glasses
- ceramics
- fibers
- composites

and the origin of each.

### **Process/Skill Questions**

- What materials used in manufacturing can you identify in your immediate surroundings?
- What are some examples of hardwoods and softwoods and products made from each?
- What are some examples of metal alloys?

### **ITEEA National Standards**

#### **19. Manufacturing Technologies**

#### **2. The Core Concepts of Technology**

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

### **TSA Competitive Events**

#### **Technology Bowl**

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## **Task Number 58**

### **Differentiate among properties of materials.**

#### **Definition**

Differentiation should include

- mechanical
- physical

- chemical.

### **Process/Skill Questions**

- Why are the properties of materials important in manufacturing?
- What are some mechanical properties of materials? Physical? Chemical?
- How are a material's thermal properties tested?
- How do mechanical properties affect design?
- What materials must have extra considerations when exposed to the elements? Which are best suited to being exposed to the elements?

### **ITEEA National Standards**

#### **19. Manufacturing Technologies**

##### **2. The Core Concepts of Technology**

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

### **TSA Competitive Events**

#### **Technology Bowl**

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## **Task Number 59**

### **Classify methods of altering materials.**

#### **Definition**

Classification may include

- forming
- separating
- casting and molding
- conditioning
- finishing.

### **Process/Skill Questions**

- What are ways to change the shapes of materials?

- How can metal be altered to use for products such as beams, wire, soft drink cans, and engine blocks?
- How can plastics/polymers be altered to make products such as containers, fabric, and pipes?
- How do materials become products (e.g., trees to chairs)?
- What are some ways metal can be formed? Wood? Polymers?
- What materials can be molded?
- How does rapidly heating or cooling affect a metal's strength?

## **ITEEA National Standards**

### **12. Use and Maintain Technological Products and Systems**

### **19. Manufacturing Technologies**

## **TSA Competitive Events**

### **Technology Bowl**

## **Task Number 60**

### **Demonstrate methods of altering materials.**

#### **Definition**

Demonstration may include

- molding
- casting
- bending
- cutting
- drilling
- grinding
- sanding
- conditioning
- laser cutting.

#### **Process/Skill Questions**

- What processes can be used on sheet metal? On wood? On acrylic?
- Given a particular saw in the lab, for what type of cut is it best suited?
- How can molding be demonstrated in the lab?

## **ITEEA National Standards**

### **12. Use and Maintain Technological Products and Systems**

#### **TSA Competitive Events**

##### **Computer Integrated Manufacturing (CIM)**

##### **Dragster Design**

##### **Transportation Modeling**

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## **Task Number 61**

### **Demonstrate methods of combining materials.**

#### **Definition**

Demonstration may include

- welding
- bonding
- laminating
- mixing
- fastening
- coating.

#### **Process/Skill Questions**

- How can a variety of materials be used in one product?
- What products can you list that are made of more than one material?
- What products can you list that are made of only one material?
- In what scenario would gluing be the best method for combining two pieces of wood?  
Nailing? Bolting? Screwing?

## **ITEEA National Standards**

### **12. Use and Maintain Technological Products and Systems**

#### **TSA Competitive Events**

**Computer Integrated Manufacturing (CIM)**

**Transportation Modeling**

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## **Task Number 62**

**Use materials to make a product.**

### **Definition**

Use should include making a product that uses four or more altering or combining methods.

### **Process/Skill Questions**

- How does one determine which materials are most appropriate for a product?
- How does one determine which manufacturing system would be best for a product?

### **ITEEA National Standards**

**12. Use and Maintain Technological Products and Systems**

**19. Manufacturing Technologies**

### **TSA Competitive Events**

**Computer Integrated Manufacturing (CIM)**

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## **Understanding Production Processes**

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## **Task Number 63**

**Explain the product-development process.**

### **Definition**

Explanation may include

- establishing the need for a product
- researching, developing, and designing
- conducting marketing surveys.

### **Process/Skill Questions**

- Why would someone purchase your product?
- How does one determine the best design for a product?
- How does one ensure that the data in a marketing survey is valid and reliable?
- How does one determine a fair price for a product?
- What role does transportation play in the product development process?

### **ITEEA National Standards**

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

#### **8. The Attributes of Design**

### **TSA Competitive Events**

#### **Animatronics**

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## **Task Number 64**

### **Describe the engineering design process.**

#### **Definition**

Description should include

- the concept that the engineering design process is a systematic, creative process for solving problems concerning real objects, products, systems, and environments
- the engineering design loop.

#### **Process/Skill Questions**

- How can design problems be identified?
- What are the types of problems that concern product developers?
- Why is it important to identify criteria and constraints?

- What techniques are used to refine a design?
- How can a design be evaluated?
- What is *quality control*?
- Why should final solutions be re-evaluated? How is this done?
- What are the basic requirements of design?
- What are *ergonomics*?
- What are *functional requirements*?
- What are the benefits of following a process when designing a product?

## **ITEEA National Standards**

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

### **11. Apply the Design Process**

### **8. The Attributes of Design**

### **9. Engineering Design**

## **TSA Competitive Events**

### **Dragster Design**

### **Engineering Design**

## **Task Number 65**

### **Apply technology to produce a prototype.**

#### **Definition**

Application should include

- development of ideas
- documentation of planning
- prototype production (rapid prototyping/modeling).

#### **Process/Skill Questions**

- What methods are commonly used for producing a prototype?
- What things are learned in the making of a prototype?

- What does the term *rapid prototyping* mean?

## **ITEEA National Standards**

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

### **19. Manufacturing Technologies**

### **8. The Attributes of Design**

## **TSA Competitive Events**

### **Computer Integrated Manufacturing (CIM)**

### **Transportation Modeling**

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## **Task Number 66**

### **Use the engineering design process to plan production.**

#### **Definition**

Plan may include

- working drawings
- bill of materials
- standard operating procedure (SOP)
- operation sheet, flow-process chart, operation-process chart, Gantt chart
- plan layout.

#### **Process/Skill Questions**

- What is the difference between orthographic and isometric drawings?
- What is included in the bill of materials?
- How do the flow-process chart, operation-process chart, and operation sheet interrelate?
- What is spatial reasoning? How is it applied to the design process?
- What are the differences between an SOP and an operation sheet?
- How do manufacturing process methods relate to the process plan production?

## **ITEEA National Standards**

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

### **8. The Attributes of Design**

#### **TSA Competitive Events**

#### **Computer Integrated Manufacturing (CIM)**

#### **Dragster Design**

#### **Engineering Design**

#### **Transportation Modeling**

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## **Task Number 67**

### **Describe the stages/processes of tooling up for production.**

#### **Definition**

Description should include

- purpose of tooling up
- tooling design and development concepts
- application of mathematics principles to jigs, fixtures, and templates
- tooling-up automated systems.

#### **Process/Skill Questions**

- What is the purpose of tooling up?
- What are the differences among a jig, a fixture, and a template?
- What are the qualities of good tooling design?
- What things must be considered when purchasing tooling for production?
- How do a product's materials factor into the tooling plan?

#### **ITEEA National Standards**

#### **19. Manufacturing Technologies**

#### **8. The Attributes of Design**

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## **Task Number 68**

### **Describe production planning in manufacturing.**

#### **Definition**

Description should include

- primary vs. secondary processes
- material acquisition
- process methods (e.g., forming, separating, combining)
- packaging and distribution
- automation in these processes.

#### **Process/Skill Questions**

- What is the difference between a primary and secondary process?
- What are some combining processes?
- What are some forming processes?
- How is additive manufacturing changing how production planning is done today?

#### **ITEEA National Standards**

##### **19. Manufacturing Technologies**

##### **TSA Competitive Events**

##### **Computer Integrated Manufacturing (CIM)**

##### **Technology Bowl**

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## **Task Number 69**

### **Describe rapid prototyping/modeling.**

#### **Definition**

Description should include new methods of producing prototypes or models more quickly than traditional methods. New methods may include

- 3D printing
- modeling and simulation software
- generating stereo-lithography (.STL) files.

### **Process/Skill Questions**

- What are .STL files used for?
- What are the most common brands of modeling and simulation software?
- Why has 3D printing become so popular? What are its limitations?

### **ITEEA National Standards**

#### **11. Apply the Design Process**

#### **9. Engineering Design**

### **TSA Competitive Events**

#### **Computer Integrated Manufacturing (CIM)**

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## **Task Number 70**

### **Evaluate the process and the prototype.**

#### **Definition**

Evaluation should include prototype testing and quality control that will result in needed improvements and successes in the process.

#### **Process/Skill Questions**

- How can a prototype shape the manufacturing process?
- What is a manufacturing bottleneck?
- Why are inspection stations needed?
- What factors should be considered when evaluating a prototype?
- What determines whether a production process is effective?

### **ITEEA National Standards**

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

**11. Apply the Design Process**

**12. Use and Maintain Technological Products and Systems**

**19. Manufacturing Technologies**

**2. The Core Concepts of Technology**

**TSA Competitive Events**

**Computer Integrated Manufacturing (CIM)**

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# **Demonstrating Manufacturing Processes**

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## **Task Number 71**

**Participate in a production line activity.**

### **Definition**

Participation should include

- demonstration of specific task(s)
- following standard operating procedure (SOP)
- explanation of how each task relates to the entire production line.

### **Process/Skill Questions**

- What are some jobs that need to be assigned to set up the production line?
- What time factors need to be considered in a production line?
- What are some examples of steps in a production line?
- How does following a standard operating procedure affect safety and efficiency?

### **ITEEA National Standards**

**12. Use and Maintain Technological Products and Systems**

## **19. Manufacturing Technologies**

### **TSA Competitive Events**

#### **Computer Integrated Manufacturing (CIM)**

#### **Transportation Modeling**

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## **Task Number 72**

### **Evaluate the production process.**

#### **Definition**

Evaluation should include

- description of how the individual tasks affect the production line as a whole
- identification of bottlenecks in the process
- inspection of production output
- suggestions for improving the production process.

#### **Process/Skill Questions**

- How well did your task(s) fit into the production of the product? What caused you difficulty?
- What did you notice in the production that could be improved?
- How could the product be produced more efficiently?
- Did the product meet the customer specifications?
- What is in-process quality control?
- What role does mathematics play in the evaluation of the production process?
- How does employee attendance affect production?

#### **ITEEA National Standards**

#### **12. Use and Maintain Technological Products and Systems**

#### **13. Assess the Impact of Products and Systems**

#### **19. Manufacturing Technologies**

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# Exploring Business Concepts

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## Task Number 73

### Identify the three basic forms of business ownership.

#### Definition

Identification should include

- proprietorship
- partnership
- corporation.

#### Process/Skill Questions

- What does it mean to be self-employed?
- What is a proprietorship?
- What is a partnership?
- What is a corporation?
- What are some advantages and disadvantages of each of these?

### Economics and Personal Finance Standards of Learning

#### EPF.2

The student will demonstrate knowledge of the role of producers and consumers in a market economy by

- a. describing how consumers, producers, workers, savers, investors, and citizens respond to incentives;
- b. explaining how businesses respond to consumer sovereignty;
- c. identifying the role of entrepreneurs;
- d. comparing the costs and benefits of different forms of business organization, including sole proprietorship, partnership, corporation, franchise, and cooperative;
- e. describing how costs and revenues affect profit and supply;
- f. describing how increased productivity affects costs of production and standard of living;
- g. examining how investment in human capital, capital goods, and technology can improve productivity;
- h. describing the effects of competition on producers, sellers, and consumers;

- i. explaining why monopolies or collusion among sellers reduces competition and raises prices; and
- j. illustrating the circular flow of economic activity.

## **ITEEA National Standards**

### **19. Manufacturing Technologies**

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

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

## **TSA Competitive Events**

### **Technology Bowl**

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## **Task Number 74**

### **Explain the effect of corporate citizenship.**

#### **Definition**

Explanation should include

- company goals
- fiduciary responsibilities
- goals related to society
- environmental issues at the local, national, and global levels.

#### **Process/Skill Questions**

- Why is it important for a company to have goals?
- What are the consequences when a company is not a good steward of the environment?
- What are specific examples of good stewardship? Poor stewardship?
- What is the role of a corporation within the community?
- How can being a good steward of the environment be part of a successful business model?

## **ITEEA National Standards**

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

## 6. The Role of Society in the Development and Use of Technology

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### **Task Number 75**

#### **Identify levels of management.**

##### **Definition**

Identification should include

- management structure
- departmental divisions.

##### **Process/Skill Questions**

- What management structures exist?
- What areas require management?
- What are the primary responsibilities of management?

##### **ITEEA National Standards**

##### **19. Manufacturing Technologies**

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

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### **Task Number 76**

#### **Describe the effect of labor and human resources issues on manufacturing.**

##### **Definition**

Description should include

- benefits
- unions
- hiring practices

- independent contractors
- training
- labor costs.

### **Process/Skill Questions**

- What is the purpose of a union?
- What does it mean to be an equal opportunity employer?
- Why are benefits important?
- What are the risks and benefits associated with being self-employed?

### **ITEEA National Standards**

#### **19. Manufacturing Technologies**

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

### **TSA Competitive Events**

#### **Essays on Technology**

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## **Task Number 77**

### **Identify the parts of a marketing plan.**

#### **Definition**

Identification should include

- market research
- competition
- marketing plan strategies or channels
- marketing plan budget
- marketing goals
- marketing Ps (i.e., product, price, place, promotion, and sometimes people).

### **Process/Skill Questions**

- What factors go into determining product price?
- How do companies promote their products?
- What are some effective marketing strategies?

- How does a local manufacturing company address the marketing Ps for a particular product launch?

## **ITEEA National Standards**

### **19. Manufacturing Technologies**

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

### **TSA Competitive Events**

#### **Promotional Design**

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## **Task Number 78**

### **Explain fiscal responsibilities associated with operating a successful enterprise.**

#### **Definition**

Explanation should include

- capital requirements
- determining financial overhead
- stock price
- break-even charts
- maintaining records.

#### **Process/Skill Questions**

- Why do we need a break-even chart?
- What is the purpose of startup capital?
- What are the consequences of not keeping and maintaining accurate records?
- What is expense capitalization, and why is it important to a healthy enterprise?

## **Economics and Personal Finance Standards of Learning**

### **EPF.2**

The student will demonstrate knowledge of the role of producers and consumers in a market economy by

- a. describing how consumers, producers, workers, savers, investors, and citizens respond to incentives;
- b. explaining how businesses respond to consumer sovereignty;
- c. identifying the role of entrepreneurs;
- d. comparing the costs and benefits of different forms of business organization, including sole proprietorship, partnership, corporation, franchise, and cooperative;
- e. describing how costs and revenues affect profit and supply;
- f. describing how increased productivity affects costs of production and standard of living;
- g. examining how investment in human capital, capital goods, and technology can improve productivity;
- h. describing the effects of competition on producers, sellers, and consumers;
- i. explaining why monopolies or collusion among sellers reduces competition and raises prices; and
- j. illustrating the circular flow of economic activity.

## **ITEEA National Standards**

### **19. Manufacturing Technologies**

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

#### **6. The Role of Society in the Development and Use of Technology**

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# **Exploring Green Manufacturing**

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## **Task Number 79**

### **Exercise environmentally conscious manufacturing.**

#### **Definition**

Exercising environmentally conscious manufacturing should include

- role playing management's function in environmentally conscious engineering
- using computer-aided design (CAD) to design an environmentally conscious product
- determining waste reduction in the production process.

## Process/Skill Questions

- What does the term *cradle-to-grave* mean when applied to manufacturing? *Cradle-to-cradle*?
- What are some common methods for reducing waste in the production process?
- How has the advent of computer-aided manufacturing lead to reduced waste in manufacturing?
- What responsible methods are used for disposing of waste generated by the manufacturing process?

## ITEEA National Standards

### 19. Manufacturing Technologies

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

#### 5. The Effects of Technology on the Environment

## TSA Competitive Events

### Computer-Aided Design (CAD), Engineering

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## Task Number 80

### Explain environmental considerations when designing a product.

#### Definition

Explanation should include

- design for recycling
- pollution prevention techniques
- knowledge of hazardous materials
- analysis of industry's use of recycling and pollution techniques.

## Process/Skill Questions

- What are the benefits to manufacturers of following Design for the Environment (DfE) principles?

- What is perfluorooctanoic acid (PFOA), and what is the status of the current debate around its use, regulation, and remediation?
- As nanotechnology moves from the laboratory to the manufacturing floor, what environmental considerations might need to be addressed?

## **ITEEA National Standards**

### **5. The Effects of Technology on the Environment**

### **9. Engineering Design**

## **TSA Competitive Events**

### **Computer Integrated Manufacturing (CIM)**

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## **Task Number 81**

### **Identify energy efficiency, conservation, and pollution prevention.**

#### **Definition**

Identification should be made by performing a cost comparison of technology products.

#### **Process/Skill Questions**

- Why must manufacturers think in the long term when transforming to more energy efficient production practices?
- What conservation measures have you observed in your locality?
- What does it mean to be Energy Star certified?

## **ITEEA National Standards**

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

### **5. The Effects of Technology on the Environment**

## **TSA Competitive Events**

### **Essays on Technology**

## SOL Correlation by Task

39	Research careers in manufacturing.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8  History and Social Science: GOVT.8, GOVT.14, GOVT.15, VUS.8, VUS.13, VUS.14, WG.17, WHII.8
40	Differentiate among types of manufacturing.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.8, WHII.8
41	Demonstrate metrology used in manufacturing.	Science: CH.1, ES.1
42	Explain the importance of manufacturing.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.14
43	Explain the effect of supply and demand on manufacturing.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: GOVT.14, GOVT.15, VUS.8, WHII.4, WHII.8
44	Describe societal, economic, and environmental effects of manufacturing.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14  Science: PH.4
45	Describe societal, economic, and environmental influences on manufacturing.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.8, VUS.13, VUS.14  Science: PH.4
46	Explain considerations of green, or clean, manufacturing.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.14, WG.17, WHII.14
47	Assess the product life cycle.	English: 9.5, 10.5, 11.5, 12.5
48	Outline the history of manufacturing.	English: 9.6, 9.7, 10.6, 10.7, 11.6, 11.7, 12.6, 12.7

		History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14
49	Describe the development of U.S. manufacturing.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.8, VUS.13, VUS.14
50	Predict future manufacturing trends.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14
51	Use required personal protective equipment (PPE).	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.8, WHII.8  Science: CH.1
52	Implement a safety plan.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: VUS.8, WHII.8
53	Maintain safe working practices in the production laboratory.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: GOVT.16, VUS.8, VUS.14, WHII.8, WHII.14  Science: CH.1
54	Operate lab equipment according to instructor guidelines.	History and Social Science: VUS.8, VUS.14, WHII.8, WHII.14
55	Describe additive processes.	English: 9.5, 10.5, 11.5, 12.5
56	Describe subtractive processes.	English: 9.5, 10.5, 11.5, 12.5
57	Distinguish among materials used in the manufacturing process.	English: 9.5, 10.5, 11.5, 12.5
58	Differentiate among properties of materials.	English: 9.5, 10.5, 11.5, 12.5  Science: PH.1
59	Classify methods of altering materials.	English: 9.5, 10.5, 11.5, 12.5
60	Demonstrate methods of altering materials.	
61	Demonstrate methods of combining materials.	
62	Use materials to make a product.	
63	Explain the product-development process.	English: 9.6, 9.7, 9.8, 10.6, 10.7, 10.8, 11.6, 11.7, 11.8, 12.6, 12.7, 12.8  Mathematics: AFDA.8, PS.8*  Science: PH.4

64	Describe the engineering design process.	English: 10.3, 10.5, 11.3, 11.5, 12.5 Science: PH.1
65	Apply technology to produce a prototype.	English: 9.5, 9.6, 10.5, 10.6, 11.5, 11.6, 12.5, 12.6 Science: PH.1, PH.2
66	Use the engineering design process to plan production.	Science: PH.1
67	Describe the stages/processes of tooling up for production.	English: 9.5, 10.5, 11.5, 12.5
68	Describe production planning in manufacturing.	English: 9.5, 10.5, 11.5, 12.5
69	Describe rapid prototyping/modeling.	English: 9.5, 10.5, 11.5, 12.5
70	Evaluate the process and the prototype.	
71	Participate in a production line activity.	English: 9.5, 10.5, 11.5, 12.5 History and Social Science: VUS.8, WHII.8
72	Evaluate the production process.	English: 9.5, 10.5, 11.5, 12.5 History and Social Science: VUS.8, WHII.8
73	Identify the three basic forms of business ownership.	English: 9.5, 10.5, 11.5, 12.5 History and Social Science: GOVT.14, GOVT.15
74	Explain the effect of corporate citizenship.	English: 9.5, 10.5, 11.5, 12.5 History and Social Science: GOVT.3, GOVT.16
75	Identify levels of management.	English: 9.5, 10.5, 11.5, 12.5
76	Describe the effect of labor and human resources issues on manufacturing.	English: 9.5, 10.5, 11.5, 12.5 History and Social Science: GOVT.14, GOVT.15, VUS.8, WG.7, WG.14, WG.15, WHII.8
77	Identify the parts of a marketing plan.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8
78	Explain fiscal responsibilities associated with operating a successful enterprise.	English: 9.5, 10.5, 11.5, 12.5
79	Exercise environmentally conscious manufacturing.	History and Social Science: GOVT.14, GOVT.15, VUS.14, WG.16, WG.17, WHII.14
80	Explain environmental considerations when designing a product.	English: 9.5, 10.5, 11.5, 12.5 History and Social Science: VUS.14, WG.16, WG.17, WHII.14

81	Identify energy efficiency, conservation, and pollution prevention.	English: 9.5, 10.5, 11.5, 12.5  History and Social Science: GOVT.14, GOVT.15, VUS.14, WG.4, WG.16, WG.17, WHIL.14
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## 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

- Additive Manufacturing Fundamentals Examination
- Certified Production Technician (CPT) Program Examinations
- College and Work Readiness Assessment (CWRA+)
- Manufacturing Specialist Certification Examination
- Manufacturing Technician Level I Certification Examination
- National Career Readiness Certificate Assessment
- 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.*

- Construction Technology (8431/36 weeks)
- Construction Technology (8432/18 weeks)
- Manufacturing Systems II, Advanced (8427/36 weeks)
- Materials and Processes Technology (8433/36 weeks)
- Materials and Processes Technology (8478/18 weeks)
- Production Systems (8446/18 weeks)
- Production Systems (8447/36 weeks)
- Sustainability and Renewable Technologies (8414/36 weeks)
- Technology of Robotic Design (8420/18 weeks)
- Technology of Robotic Design (8421/36 weeks)

<b>Career Cluster: Manufacturing</b>	
<b>Pathway</b>	<b>Occupations</b>
<b>Health, Safety, and Environmental Assurance</b>	<b>Occupational Health and Safety Specialist Safety Engineer</b>
<b>Logistics and Inventory Control</b>	<b>Dispatcher Logistician Materials Handler Shipping and Receiving Clerk</b>
<b>Manufacturing Production Process Development</b>	<b>Electro-Mechanical Technician Industrial Engineer Industrial Engineering Technician Manufacturing Systems Engineer Millwright Precision Inspector, Tester, or Grader Production Manager</b>

<b>Career Cluster: Manufacturing</b>	
<b>Pathway</b>	<b>Occupations</b>
	<b>SPC (Statistical Process Control) Coordinator</b>
<b>Production</b>	<b>Assembler Automated Manufacturing Technician Extruding and Drawing Machine Operator Tool and Die Maker</b>
<b>Quality Assurance</b>	<b>Calibration Technician Precision Inspector, Tester, or Grader Quality Control Technician SPC (Statistical Process Control) Coordinator</b>

<b>Career Cluster: Science, Technology, Engineering and Mathematics</b>	
<b>Pathway</b>	<b>Occupations</b>
<b>Engineering and Technology</b>	<b>Computer Programmer Electrical Engineer Electrical Engineering Technician Electro-Mechanical Technician Electronic Drafter Electronics Engineering Technician Human Factors Engineer Industrial Engineer Industrial Engineering Technician Manufacturing Systems Engineer Materials Engineer Mechanical Drafter Mechanical Engineer Mechanical Engineering Technician Power Systems Engineer Project Manager Quality Engineer Quality Technician</b>