Manufacturing Systems I

8426 18 weeks
8425 36 weeks

Table of Contents

Acknowledgments................................................................................................................................. 1
Course Description.................................................................................................................................. 3
Task Essentials Table............................................................................................................................... 3
Curriculum Framework............................................................................................................................. 5
Introducing Manufacturing Systems......................................................................................................... 5
Understanding the History of Manufacturing .......................................................................................... 15
Practicing Safety ..................................................................................................................................... 18
Exploring Materials and Processes ......................................................................................................... 21
Understanding Production Processes....................................................................................................... 27
Demonstrating Manufacturing Processes.................................................................................................. 34
Exploring Business Concepts ................................................................................................................... 36
Exploring Green Manufacturing................................................................................................................. 41
SOL Correlation by Task........................................................................................................................... 44
Entrepreneurship Infusion Units................................................................................................................ 47
Appendix: Credentials, Course Sequences, and Career Cluster Information ........................................ 48

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Office of Career, Technical, and Adult Education
Virginia Department of Education

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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.

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8425</th>
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<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introducing Manufacturing Systems</td>
<td></td>
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<tr>
<td>39</td>
<td>+</td>
<td>+</td>
<td>Research careers in manufacturing.</td>
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<td>40</td>
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<td>+</td>
<td>Differentiate among types of manufacturing.</td>
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<tr>
<td>41</td>
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<td>+</td>
<td>Demonstrate metrology used in manufacturing.</td>
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<tr>
<td>42</td>
<td>+</td>
<td>+</td>
<td>Explain the importance of manufacturing.</td>
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<tr>
<td>43</td>
<td>+</td>
<td>+</td>
<td>Explain the effect of supply and demand on manufacturing.</td>
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<td>44</td>
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<td>+</td>
<td>Describe societal, economic, and environmental effects of manufacturing.</td>
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<td>Describe societal, economic, and environmental influences on manufacturing.</td>
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<tr>
<td>46</td>
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<td>+</td>
<td>Explain considerations of green, or clean, manufacturing.</td>
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<tr>
<td>47</td>
<td>47</td>
<td>Assess the product life cycle.</td>
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**Understanding the History of Manufacturing**

| 48 | 47 | Outline the history of manufacturing. |
| 49 | 47 | Describe the development of U.S. manufacturing. |
| 50 | 47 | Predict future manufacturing trends. |

**Practicing Safety**

| 51 | 47 | Use required personal protective equipment (PPE). |
| 52 | 47 | Implement a safety plan. |
| 53 | 47 | Maintain safe working practices in the production laboratory. |
| 54 | 47 | Operate lab equipment according to instructor guidelines. |

**Exploring Materials and Processes**

| 55 | 47 | Describe additive processes. |
| 56 | 47 | Describe subtractive processes. |
| 57 | 47 | Distinguish among materials used in the manufacturing process. |
| 58 | 47 | Differentiate among properties of materials. |
| 59 | 47 | Classify methods of altering materials. |
| 60 | 47 | Demonstrate methods of altering materials. |
| 61 | 47 | Demonstrate methods of combining materials. |
| 62 | 47 | Use materials to make a product. |

**Understanding Production Processes**

<p>| 63 | 47 | Explain the product-development process. |
| 64 | 47 | Describe the engineering design process. |
| 65 | 47 | Apply technology to produce a prototype. |
| 66 | 47 | Use the engineering design process to plan production. |</p>
<table>
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<tr>
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<tbody>
<tr>
<td>67</td>
<td>+</td>
<td></td>
<td>Describe the stages/processes of tooling up for production.</td>
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<tr>
<td>68</td>
<td>+</td>
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<td>Describe production planning in manufacturing.</td>
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<td>+</td>
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<td>Describe rapid prototyping/modeling.</td>
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<td>Evaluate the process and the prototype.</td>
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<td>Participate in a production line activity.</td>
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<td>Evaluate the production process.</td>
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<td>73</td>
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<td>Identify the three basic forms of business ownership.</td>
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<td>74</td>
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<td>Explain the effect of corporate citizenship.</td>
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<td>75</td>
<td></td>
<td></td>
<td>Identify levels of management.</td>
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<tr>
<td>76</td>
<td></td>
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<td>Describe the effect of labor and human resources issues on manufacturing.</td>
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<td>77</td>
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<td>Identify the parts of a marketing plan.</td>
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<td>78</td>
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<td>Explain fiscal responsibilities associated with operating a successful enterprise.</td>
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<td>Exercise environmentally conscious manufacturing.</td>
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<td>80</td>
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<td>Explain environmental considerations when designing a product.</td>
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<td>81</td>
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<td>Identify energy efficiency, conservation, and pollution prevention.</td>
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**Curriculum Framework**

**Introducing Manufacturing Systems**
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
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

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)

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

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

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

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;

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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

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

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

Understanding the History of Manufacturing
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

Task Number 49

Describe the development of U.S. manufacturing.

Definition

Description should include the factors influencing development, including

- materials
- technologies
- energy sources
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

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

Practicing Safety

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

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

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

Exploring Materials and Processes

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)

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

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

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
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)

Understanding Production Processes

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

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
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

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)

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
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
Exploring Business Concepts

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

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

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

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

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

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

Exploring Green Manufacturing

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

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)

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
| 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  
<p>|    |                                 | 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 |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>49</td>
<td>Describe the development of U.S. manufacturing.</td>
<td>History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14</td>
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<tr>
<td>50</td>
<td>Predict future manufacturing trends.</td>
<td>History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14</td>
</tr>
<tr>
<td>51</td>
<td>Use required personal protective equipment (PPE).</td>
<td>History and Social Science: VUS.8, WHII.8</td>
</tr>
<tr>
<td>52</td>
<td>Implement a safety plan.</td>
<td>History and Social Science: VUS.8, WHII.8</td>
</tr>
<tr>
<td>53</td>
<td>Maintain safe working practices in the production laboratory.</td>
<td>History and Social Science: GOVT.16, VUS.8, VUS.14, WHII.8, WHII.14</td>
</tr>
<tr>
<td>54</td>
<td>Operate lab equipment according to instructor guidelines.</td>
<td>History and Social Science: VUS.8, VUS.14, WHII.8, WHII.14</td>
</tr>
<tr>
<td>55</td>
<td>Describe additive processes.</td>
<td>History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14</td>
</tr>
<tr>
<td>56</td>
<td>Describe subtractive processes.</td>
<td>History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14</td>
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<tr>
<td>57</td>
<td>Distinguish among materials used in the manufacturing process.</td>
<td>History and Social Science: GOVT.16, VUS.8, VUS.14, WHII.8, WHII.14</td>
</tr>
<tr>
<td>58</td>
<td>Differentiate among properties of materials.</td>
<td>Science: PH.1</td>
</tr>
<tr>
<td>59</td>
<td>Classify methods of altering materials.</td>
<td>History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14</td>
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<tr>
<td>60</td>
<td>Demonstrate methods of altering materials.</td>
<td>History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14</td>
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<tr>
<td>61</td>
<td>Demonstrate methods of combining materials.</td>
<td>History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14</td>
</tr>
<tr>
<td>62</td>
<td>Use materials to make a product.</td>
<td>History and Social Science: VUS.8, VUS.13, VUS.14, WG.17, WHII.8, WHII.14</td>
</tr>
<tr>
<td>63</td>
<td>Explain the product-development process.</td>
<td>Mathematics: AFDA.8, PS.8*</td>
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<td>Science: PH.4</td>
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English: 9.5, 10.5, 11.5, 12.5
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<th>Statement</th>
<th>English:</th>
<th>Science:</th>
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<tr>
<td>64</td>
<td>Describe the engineering design process.</td>
<td>10.3, 10.5, 11.3, 11.5, 12.5</td>
<td>PH.1</td>
</tr>
<tr>
<td>65</td>
<td>Apply technology to produce a prototype.</td>
<td>9.5, 9.6, 10.5, 10.6, 11.5, 11.6, 12.5, 12.6</td>
<td>PH.1, PH.2</td>
</tr>
<tr>
<td>66</td>
<td>Use the engineering design process to plan production.</td>
<td></td>
<td>PH.1</td>
</tr>
<tr>
<td>67</td>
<td>Describe the stages/processes of tooling up for production.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>Describe production planning in manufacturing.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Describe rapid prototyping/modeling.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td></td>
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<tr>
<td>70</td>
<td>Evaluate the process and the prototype.</td>
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<tr>
<td>71</td>
<td>Participate in a production line activity.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td>VUS.8, WHII.8</td>
</tr>
<tr>
<td>72</td>
<td>Evaluate the production process.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td>VUS.8, WHII.8</td>
</tr>
<tr>
<td>73</td>
<td>Identify the three basic forms of business ownership.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td>GOVT.14, GOVT.15</td>
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<tr>
<td>74</td>
<td>Explain the effect of corporate citizenship.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td>GOVT.3, GOVT.16</td>
</tr>
<tr>
<td>75</td>
<td>Identify levels of management.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>76</td>
<td>Describe the effect of labor and human resources issues on manufacturing.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td>GOVT.14, GOVT.15, VUS.8, WG.7, WG.14, WG.15, WHII.8</td>
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<tr>
<td>77</td>
<td>Identify the parts of a marketing plan.</td>
<td>9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8</td>
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</tr>
<tr>
<td>78</td>
<td>Explain fiscal responsibilities associated with operating a successful enterprise.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>79</td>
<td>Exercise environmentally conscious manufacturing.</td>
<td>GOVT.14, GOVT.15, VUS.14, WG.16, WG.17, WHII.14</td>
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<tr>
<td>80</td>
<td>Explain environmental considerations when designing a product.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td>VUS.14, WG.16, WG.17, WHII.14</td>
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</table>
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)
- Technical Drawing and Design (8435/36 weeks)
- Technical Drawing and Design (8434/18 weeks)
- Technology Foundations (8403/36 weeks)
- Technology Foundations (8402/18 weeks)
- Technology of Robotic Design (8420/18 weeks)
- Technology of Robotic Design (8421/36 weeks)

Career Cluster: Manufacturing

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
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</table>
| Health, Safety, and Environmental Assurance | Occupational Health and Safety Specialist  
Safety Engineer |
| Logistics and Inventory Control | Dispatcher  
Logistician  
Materials Handler  
Shipping and Receiving Clerk |
| Manufacturing Production Process Development | Electro-Mechanical Technician  
Industrial Engineer  
Industrial Engineering Technician |
### Career Cluster: Manufacturing

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
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<tbody>
<tr>
<td><strong>Manufacturing</strong></td>
<td>Manufacturing Systems Engineer&lt;br&gt;Millwright&lt;br&gt;Precision Inspector, Tester, or Grader&lt;br&gt;Production Manager&lt;br&gt;SPC (Statistical Process Control) Coordinator</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td>Assembler&lt;br&gt;Automated Manufacturing Technician&lt;br&gt;Extruding and Drawing Machine Operator&lt;br&gt;Tool and Die Maker</td>
</tr>
<tr>
<td><strong>Quality Assurance</strong></td>
<td>Calibration Technician&lt;br&gt;Precision Inspector, Tester, or Grader&lt;br&gt;Quality Control Technician&lt;br&gt;SPC (Statistical Process Control) Coordinator</td>
</tr>
</tbody>
</table>

### Career Cluster: Science, Technology, Engineering and Mathematics

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
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<tbody>
<tr>
<td><strong>Engineering and Technology</strong></td>
<td>Computer Programmer&lt;br&gt;Electrical Engineer&lt;br&gt;Electrical Engineering Technician&lt;br&gt;Electro-Mechanical Technician&lt;br&gt;Electronic Drafter&lt;br&gt;Electronics Engineering Technician&lt;br&gt;Human Factors Engineer&lt;br&gt;Industrial Engineer&lt;br&gt;Industrial Engineering Technician&lt;br&gt;Manufacturing Systems Engineer&lt;br&gt;Materials Engineer&lt;br&gt;Mechanical Drafter&lt;br&gt;Mechanical Engineer&lt;br&gt;Mechanical Engineering Technician&lt;br&gt;Power Systems Engineer&lt;br&gt;Project Manager&lt;br&gt;Quality Engineer&lt;br&gt;Quality Technician</td>
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