Materials and Processes Technology

8478 18 weeks

8433 36 weeks

Table of Contents

Acknowledgments

The components of this instructional framework were developed by the following curriculum development panelists:

Nasir Ayoub, Instructor, Colgan High School, Prince William County Public Schools and Associate Professor, Northern Virginia Community College, Alexandria/Annandale
William Best, Training Manager, The Apprenticeship Program, Newport News Shipbuilding, Newport News
Byron Clemsen, Instructor, John Handley High School, Winchester Public Schools
Kathleen Ferguson, Instructor, Old Dominion University, Norfolk
Steve Gidaro, Business Unit Manager, Battery and Blower Products, STIHL USA, Virginia Beach
Timothy Pline, Metallurgist, Huntington Ingalls Industries, Newport News

Correlations to the Virginia Standards of Learning were reviewed and updated by:

Leslie R. Bowers, English Teacher (ret.), Newport News Public Schools
Vickie L. Inge, Mathematics Committee Member, Virginia Mathematics and Science Coalition
Anne F. Markwith, New Teacher Mentor (Science), Gloucester County Public Schools
Michael Nagy, Social Studies Department Chair, Rustburg High School, Campbell County Public Schools

The framework was edited and produced by the CTE Resource Center:

Leanne F. Tipton, Writer/Editor
Kevin P. Reilly, Administrative Coordinator

Virginia Department of Education Staff

Dr. Lynn Basham, Specialist, Technology Education and Related Clusters
Dr. Tricia S. Jacobs, CTE Coordinator of Curriculum and Instruction
Dr. David S. Eshelman, Director, Workforce Development and Initiatives
George R. Willcox, Director, Operations and Accountability

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

Course Description

Suggested Grade Level: 9 or 10 or 11

Students focus on physical materials and processes as they fabricate usable products and conduct experiments. Learning experiences include career analysis as well as the use of tools and equipment related to analysis, testing, and processing of metals, plastics, woods, ceramics, and

composite materials. This single-period lab course is recommended for students interested in technical careers and others wishing to improve their technological literacy.

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	8433	8478	Tasks/Competencies
Examining Careers and Professional Practices			
39	⊕	⊕	Implement a safety plan that includes safety rules and emergency procedures for lab work.
40	⊕	⊕	Research careers related to materials and processes.
41	⊕	⊕	Investigate local industry and technical resources related to materials and processes technology.
42	⊕	⊕	Identify organizations that develop product and testing standards.
43	⊕	⊕	Research the responsibilities of the members of a project team.
44	⊕	⊕	Participate in a project team.
Understanding Materials and Processes Technology Concepts			
45	⊕	⊕	Use measuring and layout tools.
46	⊕	⊕	List technological and societal developments related to materials and processes technology.
47	⊕	⊕	Explain the origin of various natural and synthetic materials.
48	⊕	⊕	Explain the life cycle of a given product and the materials and processes associated with it.

49	⊕	⊕	Explain the basic structure of atoms and ions.
50	⊕	⊕	Compare the structure of amorphous and crystalline materials.
51	⊕	⊕	Distinguish between materials.
52	⊕	⊕	Describe mechanical properties.
53	⊕	⊕	Perform material analysis using testing devices.
54	⊕	⊕	Compare chemical and physical properties of selected materials.
55	⊕	⊕	Research emerging technologies.
Working with Polymers			
56	⊕	⊕	Describe the characteristics and uses of thermoplastics and thermosetting plastics.
57	⊕	⊕	Select a polymer for a product, based on the properties of the material.
58	⊕	⊕	Produce polymer items through the use of selected combining techniques.
59	⊕	⊕	Use separating techniques on polymers.
60	⊕	⊕	Use forming techniques on polymers.
61	⊕	⊕	Produce finished surfaces on polymers.
62	⊕	⊕	Apply polymeric materials and processes to a problem, product design, or prototype.
Working with Metals			
63	⊕	⊕	Describe the basic structure of metals.
64	⊕	⊕	Compare typical properties of selected metals and alloys.
65	⊕	⊕	Perform basic metal-forming techniques.
66	⊕	⊕	Perform metal separation processes.
67	⊕	⊕	Perform metal combining techniques.
68	⊕	⊕	Perform metal finishing techniques.

69	⊕	⊕	Apply metal materials and processes to a problem, product design, or prototype.
Working with Wood			
70	⊕	⊕	Describe the nature and structure of wood and forest products.
71	⊕	⊕	Determine the physical, mechanical, and chemical properties of wood.
72	⊕	⊕	Use separating techniques on wood.
73	⊕	⊕	Use wood-combining methods.
74	⊕	⊕	Apply wood-conditioning materials.
75	⊕	⊕	Apply wood materials and processes to a problem, product design, or prototype.
Working with Ceramics			
76	⊕	⊕	Explain the origin, types, and uses of ceramics.
77	⊕	⊕	Classify ceramics, based on their properties.
78	⊕	⊕	Produce a ceramic part or item.
Working with Composites			
79	⊕	⊕	Identify types and applications of composite materials.
80	⊕	⊕	Produce a composite part or item.
Exploring Additive and Subtractive Manufacturing			
81	⊕	⊕	Identify computer-driven additive and subtractive manufacturing processes.
82	⊕	⊕	Generate models to be converted into machine-compatible digital files.
83	⊕	⊕	Create a product using computer-driven additive or subtractive processes.
Exploring Product Standards			

84	⊕	⊕	Identify services that accredit companies and labs to standard quality systems.
85	⊕	⊕	Explain how product standards shape the way raw materials and finished products are manufactured.
86	⊕	⊕	Explain how quality management systems (QMS) shape the way products are manufactured.
87	⊕	⊕	Explain how testing standards help verify product quality.

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework.

Examining Careers and Professional Practices

Task Number 39

Implement a safety plan that includes safety rules and emergency procedures for lab work.

Definition

Implementation should include

- following basic emergency procedures for fire, personal injury, exposure to chemicals, and equipment malfunction
- using personal protective equipment (PPE) when working in the lab
- adhering to safety procedures during each lab activity.

Process/Skill Questions

- What should a visitor wear for protection in the lab?
- What steps should be taken in the event of a chemical spill?
- Why are the emergency shutoff procedures consistent across lab facilities?
- What role does OSHA play in manufacturing?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

Task Number 40

Research careers related to materials and processes.

Definition

Research should include

- gathering information describing materials and processes technology career paths
- exploring education and training requirements for entry and advancement in a chosen occupation
- identifying the advantages of selected occupations
- identifying the projected employment outlook for occupations of interest.

Many websites offer career exploration resources, including the U.S. Bureau of Labor Statistics.

Process/Skill Questions

- What are local industries in which materials and processes might be used?
- What academic courses would support a career in materials and processes technology?
- What technical training opportunities are available for careers in materials and processes technology?

ITEEA National Standards

2. The Core Concepts of Technology

TSA Competitive Events

Career Prep

Prepared Presentation

Task Number 41

Investigate local industry and technical resources related to materials and processes technology.

Definition

Investigation should include

- listing businesses in which materials and processes technology is a main component
- locating specific names of regional or local businesses, using local reference materials
- conducting specific business research.

Process/Skill Questions

- What are some communication skills that could be used to contact local industries?
- What is the main industry in one's area, related to materials and processes technology in the locality?
- What resources are available for investigating local industry and technical resources?

ITEEA National Standards

1. The Characteristics and Scope of Technology

TSA Competitive Events

Essays on Technology

Task Number 42

Identify organizations that develop product and testing standards.

Definition

Identification may include national and international organizations.

Process/Skill Questions

- What United States-based organizations develop standards?
- What organizations in other countries develop standards?

Task Number 43

Research the responsibilities of the members of a project team.

Definition

Research should include

- describing the responsibilities of the members of a project team
- analyzing potential team outcomes.

Process/Skill Questions

- Why does each member of a team have specific responsibilities?
- How is the effectiveness of each group member evaluated?
- Why should the group be stronger than the individual?

ITEEA National Standards

8. The Attributes of Design

Task Number 44

Participate in a project team.

Definition

Participation in a project team should include fulfilling responsibilities to ensure positive team outcomes.

Process/Skill Questions

- What are the advantages of an organized personnel system?
- What are the disadvantages of an organized personnel system?
- How can existing personnel systems be improved?
- How do project teams influence industrial settings?
- What software is available for team management?

ITEEA National Standards

2. The Core Concepts of Technology

TSA Competitive Events

Chapter Team

Understanding Materials and Processes Technology Concepts

Task Number 45

Use measuring and layout tools.

Definition

Use should include

- converting between units of U.S. customary and International System (S.I.) metric units
- using calipers
- completing drawings accurately and to scale
- laying out designs on materials.

Process/Skill Questions

- What are types of measuring tools?
- What are layout tools?
- What are S.I. metric units?
- How are measurements taken from a dial caliper?
- How does one use a caliper and measure a 3-2-1 block?

ITEEA National Standards

13. Assess the Impact of Products and Systems

TSA Competitive Events

Task Number 46

List technological and societal developments related to materials and processes technology.

Definition

List should include

- the major ages of human civilization, identified by the processing of materials
- technological advances in materials
- the major types of materials and examples of each.

Process/Skill Questions

- What did the discovery of fire contribute to materials technology?
- What were the four earliest metals used by humans?
- What materials were developed as a result of significant historical events, such as the space program or World War II?
- How does society influence the development of products?

ITEEA National Standards

7. The Influence of Technology on History

Task Number 47

Explain the origin of various natural and synthetic materials.

Definition

Explanation should include the methods of obtaining materials through

- mining
- refining
- harvesting

- chemical synthesis.

Process/Skill Questions

- What is the difference between natural and synthetic materials?
- How can natural and synthetic materials be combined in a product?
- Why should one know the origin of the materials with which one is working?
- What is the origin of acrylic plastic?

ITEEA National Standards

1. The Characteristics and Scope of Technology

Task Number 48

Explain the life cycle of a given product and the materials and processes associated with it.

Definition

Explanation may include

- macroscopic to microscopic materials development
- environmental concerns related to the manufacturing of various materials
- primary and secondary processing (i.e., from the raw materials to final disposition of the used product)
- responsibilities of the manufacturer and the consumer
- government infrastructure to support life-cycle options.

Process/Skill Questions

- How does the type of material relate to the quality of a given product?
- How does the type of material relate to the price of a given product?
- What factors are considered in the selection of materials?

ITEEA National Standards

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

---

Task Number 49

Explain the basic structure of atoms and ions.

Definition

Explanation should include

- using the periodic table of elements
- diagraming atoms to identify energy levels and valence electrons
- analyzing ionic, covalent, metallic, and secondary bonds.

Process/Skill Questions

- How do valence electrons influence the bonding of elements?
- What is the difference between an atom and an ion?
- What are the differences among elements, compounds, homogeneous mixtures, and heterogeneous mixtures? How is each related to various materials and their properties?
- What are covalent bonds?

ITEEA National Standards

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

---

Task Number 50

Compare the structure of amorphous and crystalline materials.

Definition

Comparison should include

- face-centered cubic, body-centered cubic, and hexagonal close-packed as, commonly found molecular structures
- unit cells combining to form crystal lattices
- amorphous materials
- unit cells and crystal lattices.

Process/Skill Questions

- What basic molecular structures are found in common materials?
- What common materials are amorphous and crystalline?
- What is the relationship between structure and physical properties?
- How can a material contain both crystalline and amorphous regions?
- How does a crystalline structure influence microscopic and macroscopic properties?
- How can molecular structure be manipulated in nanotechnology?

ITEEA National Standards

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

---

Task Number 51

Distinguish between materials.

Definition

Distinction should be made by identifying and dividing materials into four classifications, based on the following definitions:

- *Metal*—-any of a category of electropositive elements that usually have a shiny surface, are generally good conductors of heat and electricity, and can be melted or fused, hammered into thin sheets, or drawn into wires. Typical metals form salts with nonmetals, basic oxides with oxygen, and alloys with one another.
- *Ceramic*—any of various hard, brittle, heat-resistant, and corrosion-resistant materials made by shaping and then firing a nonmetallic mineral, such as clay, at a high temperature
- *Polymer*—any of numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively light and simple molecule
- *Composite*—a complex material, such as wood or fiberglass, in which two or more distinct, structurally complementary substances, especially metals, ceramics, glasses, and polymers, combine to produce structural or functional properties not present in any individual component

Process/Skill Questions

- What characteristics that make a material easily identifiable as a metal, ceramic, or plastic?
- What properties are unique to each material classification?
- Where are metals and nonmetals found on the periodic table?
- Why can wood be considered a composite or polymer material?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 52

Describe mechanical properties.

Definition

Description may include, but is not limited to

- stiffness in tension (i.e., Young's modulus)
- tensile strength and tensile stress
- compressive strength
- shearing stresses and strains
- torsional strength
- ductility
- brittleness
- elasticity
- durability.

Process/Skill Questions

- How is compressive strength measured?
- When might elasticity be a desirable mechanical property?
- How does the orientation of a material affect its strength?

ITEEA National Standards

13. Assess the Impact of Products and Systems

Task Number 53

Perform material analysis using testing devices.

Definition

Performance should follow standard test methods to better understand mechanical properties and may include testing devices used to conduct

- destructive tests (i.e., compression, common tension, shear torsion, hardness, fatigue)
- nondestructive tests (i.e., penetration, radiography, magnetic particle, ultrasound, and eddy current)
- testing for environmental exposure (i.e., heat, cold, visible and UV light, moisture) and influence on physical properties
- testing for chemical exposure and influence on performance.

Process/Skill Questions

- What industry standards are associated with testing?
- How is chemical exposure identified through testing?
- When are destructive tests more useful than nondestructive tests?

ITEEA National Standards

13. Assess the Impact of Products and Systems

19. Manufacturing Technologies

Task Number 54

Compare chemical and physical properties of selected materials.

Definition

Comparison should identify

- chemical properties (i.e., toxicity, chemical resistance, corrosion resistance, combustibility, passivity, biocompatibility)
- physical properties (i.e., density, color, porosity, structure, appearance, conductance)
- factors affecting the corrosion resistance of a material
- the potential for change during a chemical reaction
- any special requirements for working with radioactive materials.

Process/Skill Questions

- How is a material's physical properties altered by its form (e.g., flexibility, strength, tear resistance, surface area)?
- Why are physical properties of selected materials important to modern industry?
- What is the difference between corrosion and oxidation?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 55

Research emerging technologies.

Definition

Research may include topics such as

- nanotechnology
- biotechnology
- green technologies and materials
- sustainable practices
- smart materials.

Process/Skill Questions

- How has the concept of sustainability affected the use of materials and processes?
- What recycling practices exist in one's community?

ITEEA National Standards

1. The Characteristics and Scope of Technology

2. The Core Concepts of Technology

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

---

Working with Polymers

Task Number 56

Describe the characteristics and uses of thermoplastics and thermosetting plastics.

Definition

Description should include

- definitions of *thermoset* and *thermoplastic*
- three forms of polymeric structure (i.e., linear, branched, network)
- the influence of plastic recycling
- the Society of the Plastics Industry (SPI) recycling code
- renewable and nonrenewable resources.

Process/Skill Questions

- What is the SPI recycling code?
- How do thermoplastics and thermosetting plastics compare?
- What are the criteria for choosing between thermoplastic and thermosetting plastics in industrial applications?
- What recycling issues are related to thermosetting plastics and thermoplastics?

ITEEA National Standards

5. The Effects of Technology on the Environment

Task Number 57

Select a polymer for a product, based on the properties of the material.

Definition

Selection should include

- the performance demands of a product
- properties and specifications of polymers
- cost variables of polymers that will match product specifications.

Process/Skill Questions

- What are the properties of common polymers?

- What are common or trade names of some polymers?

ITEEA National Standards

11. Apply the Design Process

Task Number 58

Produce polymer items through the use of selected combining techniques.

Definition

Production should include

- using adhesive, cohesive, and mechanical combining techniques
- listing the costs, limitations, and benefits of using various fastening methods.

Process/Skill Questions

- What are the major methods of fastening?
- What are common uses of various methods of mechanical combining?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 59

Use separating techniques on polymers.

Definition

Uses should include

- shearing and sawing
- choosing a method based on product composition
- adhering to safety standards at all times.

Process/Skill Questions

- What tools can be used to separate polymers?
- What is standard separating equipment?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 60

Use forming techniques on polymers.

Definition

Use should include

- casting, molding, extrusion, drawing, bending, and vacuum forming
- choosing a method based on product composition
- maintaining safety standards at all times.

Process/Skill Questions

- What is an injection molder?
- What other equipment is used in the industry for forming plastics?
- Why is heat an integral part of the forming process?
- What are examples of products made from extrusion?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 61

Produce finished surfaces on polymers.

Definition

Production should include

- choosing abrasive material by grit size
- removing sprues and flash from the castings
- buffing and polishing the product
- using PPE for plastics finishing methods.

Process/Skill Questions

- What procedures can produce a clean edge after a separating process?
- What is the role of a compound in the polishing and buffing process?
- How can sprues and flashing materials be reused?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 62

Apply polymeric materials and processes to a problem, product design, or prototype.

Definition

Application should include

- choosing plastic material based on its properties
- following standard processing techniques, given the material and end design
- testing and evaluating the finished product.

Process/Skill Questions

- How does the prototype relate to the finished product?
- What should be considered when choosing the type of plastic used in the design process?
- What procedures might be followed for the fabrication of a plastic product?

ITEEA National Standards

11. Apply the Design Process

Working with Metals

Task Number 63

Describe the basic structure of metals.

Definition

Description should include

- describing metals as primarily crystalline solids
- describing metallic bonding as it impacts the properties of metals
- enumerating the types of alloys.

Process/Skill Questions

- What is the difference between chemical and physical bonding?
- What are crystalline solids?
- What are alloys?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 64

Compare typical properties of selected metals and alloys.

Definition

Comparison should include

- ferrous, nonferrous, superalloy, and refractory metals
- carbon as the principal hardening agent in steel alloys
- thermal conductivity and electrical conductivity
- heat treatment as used to alter the properties for metals
- the ability to change the properties of an alloy by changing its composition.

Process/Skill Questions

- How is heat conducted by metals?
- What is the fatigue point of various metals?
- How can metal be strengthened?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 65

Perform basic metal-forming techniques.

Definition

Performance may include

- drawing, bending, rolling, forging, extrusion, and casting
- using metal-forming equipment safely
- using a variety of metal-forming methods to create products.

Process/Skill Questions

- Which forming processes require heat?
- What equipment is needed in metal forming?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 66

Perform metal separation processes.

Definition

Performance may include

- sawing, machining, grinding, boring, carbon arching, punching, shearing, and etching
- choosing the best separation technique based on the end-product design.

Process/Skill Questions

- How is etching used in the metal separation process?
- What safety procedures should be followed during the metal separation process?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 67

Perform metal combining techniques.

Definition

Performance may include

- electroplating, galvanizing, welding, and brazing
- using alloys as a combining mixture of materials
- using mechanical fasteners
- using oxidation as a protective coating.

Process/Skill Questions

- What is a pop-rivet tool?
- What are the combining techniques that require heat?
- What combining techniques are used in the assembly of a common household product?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 68

Perform metal finishing techniques.

Definition

Performance may include

- using powder coating, wet spraying, oven baking, anodizing, or chrome, nickel, or zinc-plating
- changing the appearance of a product
- protecting material from a chemical attack.

Process/Skill Questions

- Why must ferrous metals be finished?
- Which finishing process does not involve coating?
- Which metal finish is not cosmetic?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 69

Apply metal materials and processes to a problem, product design, or prototype.

Definition

Application should include

- identifying a problem to solve or product to design that involves the primary use of wood material
- selecting wood materials, based on their properties, to construct the product solution
- generating ideas for solution or product design
- submitting tentative solutions or designs for approval
- sketching the solution or product
- constructing a mockup or prototype for final approval
- engineering plans, using drawings, charts, and material lists
- determining the best method of production
- determining economic feasibility
- producing a finished product or solution
- testing and evaluating the finished product.

Process/Skill Questions

- How does a prototype relate to the finished product?
- What are procedures for the fabrication of a wood product?
- What are some ways that wood can be repurposed?

ITEEA National Standards

11. Apply the Design Process

Working with Wood

Task Number 70

Describe the nature and structure of wood and forest products.

Definition

Description should include the

- ecology and conservation in the industry
- chemical properties of wood
- grains and types of wood
- cuts of lumber and standard stock sizes (e.g., plain-sawing, quarter-sawing lumber)
- grade of lumber
- structural panel products made from composite or reconstituted wood products.

Process/Skill Questions

- What are products from home that are made from different kinds of wood?
- How can wood be categorized as a polymer or a composite?
- How is plywood developed?
- What is *dimension lumber*?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 71

Determine the physical, mechanical, and chemical properties of wood.

Definition

Determination should include

- hardwood and softwood lumber based on grading standards
- the effect of moisture content, density, and specific gravity on the mechanical properties of wood
- the anisotropic characteristics (i.e., strength based on grain direction).

Process/Skill Questions

- What is a model truss?
- What is the difference in the weight of green lumber vs. dry lumber?
- How is the strength of a structure tested, based on the direction of the grain?
- What are the uses of lignum vitae?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 72

Use separating techniques on wood.

Definition

Using separating techniques may include

- sawing, drilling, planing, turning, sanding, or shaping
- using common methods of separating wood
- following safety procedures for using tools and machines designed to separate wood
- manufacturing a product using several wood-separating machines.

Process/Skill Questions

- What determines fabrication time?
- How does grain affect turning or planing?
- How does the design of a product affect the choice of wood?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 73

Use wood-combining methods.

Definition

Use should include

- determining the proper adhesive for bonding selected wood joints, based on their properties
- applying adhesive to bond wood joints
- explaining the systems used to size nails, wood screws, brads, and other mechanical fasteners
- preparing wood joints for mechanical fasteners
- combining wood parts with mechanical fasteners
- explaining the factors that influence the selection of a combining method.

Process/Skill Questions

- What are common wood adhesives?
- What are methods of combining woods without adhesives?
- What is *laminating*?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 74

Apply wood-conditioning materials.

Definition

Application should include

- giving reasons for seasoning and preserving lumber
- determining the environment in which the end-product will be used
- preparing wood for finishing (e.g., determining the seasoning and preservation treatments)
- selecting the appropriate finishing method
- using and maintaining finishing tools.

Process/Skill Questions

- What are the methods of applying a wood finish?
- What are kinds of wood that do not require a finish, and in what products are they used?
- What are techniques for finish preparation?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 75

Apply wood materials and processes to a problem, product design, or prototype.

Definition

Application should include

- identifying a problem to solve or product to design that involves the primary use of wood material
- selecting wood materials, based on their properties, to construct the product or solution
- generating ideas for a solution or product design
- submitting tentative solutions or designs for approval
- sketching the solution or product
- constructing a mockup or prototype for final approval
- engineering plans, using drawings, charts, and lists of materials
- determining the best method of production
- determining economic feasibility
- producing the finished product or solution
- testing and evaluating the finished product.

Process/Skill Questions

- How does the prototype relate to the finished product?
- What is the procedure for the fabrication of a wood product?

ITEEA National Standards

19. Manufacturing Technologies

Working with Ceramics

Task Number 76

Explain the origin, types, and uses of ceramics.

Definition

Explanation should include

- describing the process by which raw materials are acquired
- describing the general history of ceramics (e.g., one of the oldest materials used by humans across cultures)
- identifying the types of clays and their characteristics
- classifying materials as crystalline or amorphous
- explaining the function of flux, silica, talc, lime, and gypsum in the creation of ceramics
- explaining how ceramic raw materials are mined and processed.

Process/Skill Questions

- How are ceramics used in the production and transmission of electricity?
- How are ceramic materials used in the construction industry?
- What methods are used to form ceramic products?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 77

Classify ceramics, based on their properties.

Definition

Classification should be made by

- classifying ceramic products (e.g., whitewares, refractories, glass, abrasives, coatings, construction products)
- comparing mechanical properties (e.g., compressive, tensile, influence strength, hardness, plasticity)
- comparing thermal properties (e.g., thermal conductivity, thermal shock resistance)
- comparing color, flow, shrinkage, and porosity
- comparing electrical properties
- comparing the optical properties of types of glass.

Process/Skill Questions

- What are the properties of ceramic materials?
- What role does heat play in changing the properties of ceramic materials?
- What properties would make ceramic flooring preferable to wood flooring in a commercial building?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 78

Produce a ceramic part or item.

Definition

Production may include

- selecting materials, based on their properties, to construct the product or solution
- describing industrial methods of producing and processing ceramics
- demonstrating the forming or casting processes
- selecting tools and techniques
- conditioning a product
- testing and evaluating the finished product.

Process/Skill Questions

- What are common examples of ceramic products?
- How are ceramic products conditioned?
- How can glass be separated?

Working with Composites

Task Number 79

Identify types and applications of composite materials.

Definition

Identification should establish that composites

- are made from two or more materials of different physical or chemical properties
- are combined to create a material with superior properties to those of single-component materials
- have reinforcement material(s) held together by a glue type of matrix.

Some examples of composites include

- concrete
- automobile tires
- fiberglass
- pre-impregnated material in aerospace
- carbon fiber
- Kevlar
- laminated wood structure components.

Process/Skill Questions

- Why would one use a composite material instead of a natural material?
- How is material cost used to determine the use of a composite material?
- How has the space program led to developments in composite materials?
- What are reinforcement materials found in composites?

ITEEA National Standards

19. Manufacturing Technologies

Task Number 80

Produce a composite part or item.

Definition

Production should include

- selecting composite materials, based on their properties, to construct the product solution
- demonstrating the forming or casting processes
- selecting tools and techniques
- conditioning a product
- testing and evaluating the finished product.

Process/Skill Questions

- What are products that make use of composite materials?
- Why is fiberglass considered a composite material?

ITEEA National Standards

19. Manufacturing Technologies

TSA Competitive Events

Engineering Design

Exploring Additive and Subtractive Manufacturing

Task Number 81

Identify computer-driven additive and subtractive manufacturing processes.

Definition

Identification may include

- three-dimensional (3D) printing
- computer numerical controlled (CNC) machining
- laser engraving.

Process/Skill Questions

- What are examples of other processes one might consider additive or subtractive methods?
- What are the advantages of 3D printing?
- Which method is better for producing an object? What are .stl and .obj files?
- What are the advantages of an additive or subtractive process?

Task Number 82

Generate models to be converted into machine-compatible digital files.

Definition

Generation may include

- designing products
- producing models
- downloading models
- exporting or importing files
- converting files.

Process/Skill Questions

- What software applications are commonly used in additive and subtractive manufacturing?
- What is the purpose of a clean room?
- How can files be converted from design to machine language?

Task Number 83

Create a product using computer-driven additive or subtractive processes.

Definition

Creation should include

- choosing the best material based on the end design
- selecting the best processing method, given the materials used
- testing and evaluating the finished product.

Process/Skill Questions

- What materials are used with 3D printers?
- What advantages might a printed model or part have over a part produced using traditional methods?
- What materials are used with an additive process?
- What advantages might a part made with subtractive processes have over a part made with additive processes?

Exploring Product Standards

Task Number 84

Identify services that accredit companies and labs to standard quality systems.

Definition

Identification may include national and international organizations.

Process/Skill Questions

- What are the major accrediting bodies in the United States?
- How are standard quality systems decided?

Task Number 85

Explain how product standards shape the way raw materials and finished products are manufactured.

Definition

Explanation should include

- defining *product standards*
- identifying how companies use product standards to convey product requirements when ordering goods.

Process/Skill Questions

- What is a product standard?
- How are product standards used?

Task Number 86

Explain how quality management systems (QMS) shape the way products are manufactured.

Definition

Explanation should include

- defining *QMS*
- identifying how companies use QMS to develop internal processes and procedures.

Process/Skill Questions

- How does a QMS affect the manufacturer of goods?
- How is QMS used in a company?

Task Number 87

Explain how testing standards help verify product quality.

Definition

Explanation should include

- defining *product requirements*

- defining *testing methods*.

Process/Skill Questions

- How do testing standards help control the quality of a manufactured product?
- Who determines the product requirements?
- What are some examples of tests?

SOL Correlation by Task

39	Implement a safety plan that includes safety rules and emergency procedures for lab work.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.8, WHII.8 Science: CH.1
40	Research careers related to materials and processes.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8
41	Investigate local industry and technical resources related to materials and processes technology.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8 History and Social Science: GOVT.7, WG.5, WG.6, WG.7, WG.8, WG.9, WG.10, WG.11, WG.12, WG.13 Mathematics: PS.1*, PS.8*
42	Identify organizations that develop product and testing standards.	English: 9.5, 10.5, 11.5
43	Research the responsibilities of the members of a project team.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8 History and Social Science: GOVT.1
44	Participate in a project team.	English: 9.1, 10.1, 11.1 History and Social Science: GOVT.1 Science: BIO.1, CH.1, PH.1
45	Use measuring and layout tools.	Mathematics: G.3, G.14 Science: BIO.1, CH.1, ES.1, PH.1
46	List technological and societal developments related to materials and processes technology.	English: 9.6, 9.7, 10.6, 10.7, 11.6, 11.7 History and Social Science: VUS.8, VUS.13, VUS.14, WHI.1, WHI.2, WHI.3, WHI.4, WHI.5, WHI.6, WHI.8, WHII.13, WHII.14 Science: PH.4

47	Explain the origin of various natural and synthetic materials.	English: 9.5, 10.5, 11.5 History and Social Science: WHI.2
48	Explain the life cycle of a given product and the materials and processes associated with it.	English: 9.5, 10.5, 11.5 History and Social Science: WHI.2, WHI.4
49	Explain the basic structure of atoms and ions.	English: 9.5, 10.5, 11.5 History and Social Science: WHII.8 Science: CH.2, CH.3, CH.4
50	Compare the structure of amorphous and crystalline materials.	English: 9.5, 10.5, 11.5 Science: CH.1, CH.2, CH.3, CH.6, ES.4
51	Distinguish between materials.	English: 9.5, 10.5, 11.5 Science: CH.2
52	Describe mechanical properties.	English: 9.5, 10.5, 11.5 Mathematics: A.8, AFDA.1, AII.3, AII.7, AII.10
53	Perform material analysis using testing devices.	
54	Compare chemical and physical properties of selected materials.	English: 9.5, 10.5, 11.5 Science: CH.2
55	Research emerging technologies.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8 Science: BIO.1, ES.6
56	Describe the characteristics and uses of thermoplastics and thermosetting plastics.	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5
57	Select a polymer for a product, based on the properties of the material.	English: 9.5, 10.5, 11.5 Science: CH.6
58	Produce polymer items through the use of selected combining techniques.	English: 9.6, 9.7, 10.6, 10.7, 11.6, 11.7
59	Use separating techniques on polymers.	English: 9.5, 10.5, 11.5
60	Use forming techniques on polymers.	
61	Produce finished surfaces on polymers.	
62	Apply polymeric materials and processes to a problem, product design, or prototype.	English: 9.5, 10.5, 11.5 Mathematics: AFDA.8, PS.10*
63	Describe the basic structure of metals.	English: 9.5, 10.5, 11.5 Science: CH.2

64	Compare typical properties of selected metals and alloys.	English: 9.5, 10.5, 11.5 Science: CH.2
65	Perform basic metal-forming techniques.	
66	Perform metal separation processes.	
67	Perform metal combining techniques.	
68	Perform metal finishing techniques.	
69	Apply metal materials and processes to a problem, product design, or prototype.	English: 9.5, 10.5, 11.5 Mathematics: AFDA.8, PS.10*
70	Describe the nature and structure of wood and forest products.	English: 9.5, 10.5, 11.5 History and Social Science: WG.2, WG.3
71	Determine the physical, mechanical, and chemical properties of wood.	English: 9.5, 10.5, 11.5 History and Social Science: WG.1, WG.2, WG.3 Mathematics: PS.2*
72	Use separating techniques on wood.	English: 9.5, 10.5, 11.5
73	Use wood-combining methods.	English: 9.5, 10.5, 11.5
74	Apply wood-conditioning materials.	English: 9.5, 10.5, 11.5
75	Apply wood materials and processes to a problem, product design, or prototype.	English: 9.5, 10.5, 11.5 Mathematics: AFDA.8, PS.10*
76	Explain the origin, types, and uses of ceramics.	English: 9.5, 10.5, 11.5 History and Social Science: WHI.4, WHI.5, WHI.6, WHI.8, WHI.11, WHII.5, WHII.6
77	Classify ceramics, based on their properties.	English: 9.5, 10.5, 11.5
78	Produce a ceramic part or item.	English: 9.5, 10.5, 11.5 Mathematics: AFDA.8, PS.10*
79	Identify types and applications of composite materials.	English: 9.5, 10.5, 11.5
80	Produce a composite part or item.	English: 9.5, 10.5, 11.5 Mathematics: AFDA.8, PS.10*
81	Identify computer-driven additive and subtractive manufacturing processes.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.14, WG.17, WHII.14
82	Generate models to be converted into machine-compatible digital files.	English: 9.2, 9.5, 10.2, 10.5, 11.2, 11.5

		History and Social Science: VUS.14, WG.17, WHII.14
83	Create a product using computer-driven additive or subtractive processes.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.14, WG.17, WHII.14 Mathematics: AFDA.8, PS.10*
84	Identify services that accredit companies and labs to standard quality systems.	English: 9.5, 10.5, 11.5
85	Explain how product standards shape the way raw materials and finished products are manufactured.	English: 9.5, 10.5, 11.5
86	Explain how quality management systems (QMS) shape the way products are manufactured.	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5
87	Explain how testing standards help verify product quality.	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5

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."

Reference Material

The following is additional reference material:

For Professors, ASTM International;
For Students, ASTM International;
Standard Development in ASTM, ASTM International;
Standards in the Classroom, ASTM International;
Resources and Teaching Materials, International Organization for Standardization;
A World in Motion, SAE International;
What is the ISO 9000 Standards Series? American Society for Quality;
ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories, International Organization for Standardization
NIST Summer Institute, National Institute of Standards and Technology
SI Education and Training, National Institute of Standards and Technology
Resources: U.S. Accreditation Bodies, American National Standards Institute
UL Schemes and Certification Bodies, UL

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- College and Work Readiness Assessment (CWRA+)
- National Career Readiness Certificate Assessment
- Stratasys Additive Manufacturing Certification – Level 1 Examination
- 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 I (8425/36 weeks)
- Manufacturing Systems I (8426/18 weeks)
- Production Systems (8446/18 weeks)
- Production Systems (8447/36 weeks)
- Sustainability and Renewable Technologies (8414/36 weeks)

Career Cluster: Manufacturing	
Pathway	**Occupations**
Health, Safety, and Environmental Assurance	**Occupational Health and Safety Specialist** **Safety Engineer**
Manufacturing Production Process Development	**Industrial Engineer** **Industrial Engineering Technician** **Manufacturing Systems Engineer** **Precision Inspector, Tester, or Grader**
Production	**Assembler** **Automated Manufacturing Technician**
Quality Assurance	**Precision Inspector, Tester, or Grader** **Quality Control Technician** **SPC (Statistical Process Control) Coordinator**