Engineering Explorations I

8450 36 weeks

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Course Description

Suggested Grade Level: 9 or 10 or 11

In Engineering Explorations I, students examine technology and engineering fundamentals in relation to solving real-world problems. Students investigate engineering history, including major engineering achievements, and they examine the principle engineering specialty fields and their related careers. Students practice engineering fundamentals, using mathematical and scientific concepts, and they apply the engineering design process through participation in hands-

on engineering projects. Students communicate project-related information through team-based presentations, proposals, and technical reports.

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	8450	Tasks/Competencies
Examining How Technology Affects Our World		
39	⊕	Explain the influence of technological systems.
40	⊕	Describe the characteristics and scope of technology.
41	⊕	Identify the core concepts of technology.
42	⊕	Identify historical technology milestones and advancements.
43	⊕	Examine technological systems.
Investigating How Engineering Affects Our World		
44	⊕	Define *engineering*.
45	⊕	Summarize the history of engineering.
46	⊕	Research an engineering achievement.
47	⊕	Present information pertaining to an engineering achievement.
Examining the Engineering Practice		
48	⊕	Describe the principal fields for specialization in engineering.
49	⊕	Summarize the traits of successful professional engineers.
50	⊕	Describe the education needed for specialty fields in engineering and technology.
51	⊕	Explain the importance of communication between engineers and their clients.

52	⊕	Explain the relevance of the National Society of Professional Engineers Code of Ethics.	
53	⊕	Comply with safety rules in laboratory activities.	
Practicing Engineering Fundamentals			
54	⊕	Identify the benefits of case study analysis.	
55	⊕	Analyze a case study analysis.	
56	⊕	Apply measuring skills using instrumentation.	
57	⊕	Demonstrate conversion techniques for units of measurement.	
58	⊕	Demonstrate the use of engineering design graphics and descriptive geometry.	
59	⊕	Apply the techniques and benefits of sketching.	
60	⊕	Draw orthographic and isometric projections, using basic technical drawing instruments.	
61	⊕	Explain rapid prototyping to develop models.	
62	⊕	Demonstrate research techniques/strategies used by engineers.	
63	⊕	Define *risk* and *safety*.	
64	⊕	Describe the three types of accidents.	
65	⊕	Identify major precursors of accidents.	
66	⊕	Evaluate the safety of designs.	
67	⊕	Demonstrate knowledge of appropriate personal safety procedures.	
Examining the Engineering Design Process			
68	⊕	Define an engineering design process.	
69	⊕	Define an engineering design problem.	
70	⊕	Identify the requirements and constraints of the design problem.	
71	⊕	Research potential solutions to the design problem.	
72	⊕	Generate multiple solutions to the design problem.	

73	⊕	Sketch the solutions to a design problem.	
74	⊕	Evaluate the requirements and constraints of each potential solution to the design problem.	
75	⊕	Justify an optimal solution to the design problem.	
76	⊕	Create a model or prototype for the chosen solution.	
77	⊕	Test the solution to the design problem.	
78	⊕	Evaluate the test results.	
79	⊕	Modify the solution to the design problem, if needed.	
80	⊕	Test the modification/alternate solution, if needed.	
81	⊕	Document the final project report.	
82	⊕	Present the final project report.	
Identifying Real-world Problems			
83	⊕	Research local problems that could benefit from engineering solutions.	
84	⊕	Design an engineering solution to a local problem, using the engineering design process.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Examining How Technology Affects Our World

Task Number 39

Explain the influence of technological systems.

Definition

Explanation should include the influence on

- individuals
- resources
- society
- the environment.

Process/Skill Questions

- How do technological systems affect each of the following: individuals, resources, society, the environment?
- What negative and positive affects do technological systems have?

ITEEA National Standards

13. Assess the Impact of Products and Systems

8. The Attributes of Design

TSA Competitive Events

System Control Technology

Technology Problem Solving

Task Number 40

Describe the characteristics and scope of technology.

Definition

Description should include the following:

- Technology is the use of resources and systems to solve problems and to extend human potential.
- Technology is dynamic.
- Technology solves human problems and meets needs (goal-directed research).
- Technology creates change.
- Technology is comprised of artifacts and human inventions.
- The scope of technology is the extent to which technology affects the natural world.

- The rate of technological development and diffusion is increasing.

Process/Skill Questions

- What are some new technologies that have emerged in the past decade?
- What are some technologies that one uses daily?
- What are some technologies that will emerge in the future?
- Why is the rate of technological development and diffusion increasing?
- How does technology impact individuals/the environment/society?
- How does a given technology evolve over time?

ITEEA National Standards

1. The Characteristics and Scope of Technology

TSA Competitive Events

Essays on Technology

Technology Bowl

Technology Problem Solving

Task Number 41

Identify the core concepts of technology.

Definition

Identification should include

- systems model
- resources (people, information, energy, capital, time, materials, tools)
- design processes
- areas of the designed world (e.g., medical technologies, agricultural and related biotechnologies, energy and power technologies, information and communication technologies, transportation technologies, manufacturing technologies, construction technologies).

Process/Skill Questions

- How does one solve a problem?

- How were technology resources used to get students to school today?
- What technological systems does one use in a week?
- Why is it important to understand the areas in which technology plays a key part?
- How can one be sure one understands all areas of the designed world?

ITEEA National Standards

2. The Core Concepts of Technology

TSA Competitive Events

Biotechnology Design

Technology Bowl

Technology Problem Solving

Task Number 42

Identify historical technology milestones and advancements.

Definition

Identification should include

- advancements along a timeline from prehistoric times to the present
- benefits of historical perspective and evolution of technology
- solutions that combine technologies to create improved products/processes
- detail of engineering failures, how they failed, and how design has improved today due to past failures.

Process/Skill Questions

- Who is your favorite inventor, and why?
- What is an important technological advancement? Why?
- How has the cellular telephone evolved since its inception? Will there be further evolutions? If so, how?

ITEEA National Standards

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

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

7. The Influence of Technology on History

TSA Competitive Events

Technology Bowl

Task Number 43

Examine technological systems.

Definition

Examination of each system should include

- definition
- input
- process
- output
- feedback.

Process/Skill Questions

- What is a flowchart and how does it benefit the analytical process?
- What is an example of how unexpected outputs have been beneficial?
- What is the importance of a feedback loop?

ITEEA National Standards

13. Assess the Impact of Products and Systems

7. The Influence of Technology on History

TSA Competitive Events

Biotechnology Design

Engineering Design

Investigating How Engineering Affects Our World

Task Number 44

Define *engineering*.

Definition

Definition should include the idea that engineering is the discipline of acquiring and applying scientific and technical knowledge to the design, analysis, and/or construction of products and/or works for practical purposes benefiting humankind.

Process/Skill Questions

- How does engineering benefit humankind? What are some local examples?
- What are some academic and scientific disciplines related to engineering?
- How does one use technology in engineering?
- What disciplines does engineering utilize?

ITEEA National Standards

9. Engineering Design

TSA Competitive Events

Engineering Design

Structural Design and Engineering

Task Number 45

Summarize the history of engineering.

Definition

Summary should include

- identifying major engineering feats along a timeline from prehistoric time to the present
- describing the benefits of historical perspective and evolution of technology and engineering
- explaining solutions that combine technologies to create improved products/processes.

Process/Skill Questions

- What is the earliest engineered product?
- What is an important, recently engineered product? Why is it important?
- Why is it important to study history and the history of engineering?
- How does one develop a timeline?
- Who are some well-known inventors?

ITEEA National Standards

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

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

7. The Influence of Technology on History

Task Number 46

Research an engineering achievement.

Definition

Research should

- answer who, what, where, and when
- justify the achievement, answering why
- document sources (e.g., trade journals, newspapers, periodicals, books, Internet).

Process/Skill Questions

- How does one conduct an electronic search for information?
- Why is it important to cite/document one's resources?

ITEEA National Standards

11. Apply the Design Processes

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

7. The Influence of Technology on History

TSA Competitive Events

Essays on Technology

Task Number 47

Present information pertaining to an engineering achievement.

Definition

Presentation should include

- providing a timeline detailing the achievement
- answering the questions to who, what, where, and when
- explaining the reason (why) the achievement was important or significant.

Process/Skill Questions

- Why is it important to maintain a professional appearance?
- What goes into a quality presentation?
- What are the rules of courteous audience behavior?

ITEEA National Standards

11. Apply the Design Processes

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

7. The Influence of Technology on History

TSA Competitive Events

Extemporaneous Speech

Prepared Presentation

Examining the Engineering Practice

Task Number 48

Describe the principal fields for specialization in engineering.

Definition

Description should include

- aerospace
- biomedical
- bioengineering
- civil
- environmental
- computer engineering
- chemical
- materials engineering
- mechanical
- electrical
- systems
- fire protection and safety.

Process/Skill Questions

- What skills are required for a specific type of engineering?
- What skills are common across all specializations?
- What specializations overlap?
- How do engineers work in teams?

ITEEA National Standards

14. Medical Technologies

15. Agricultural and Related Biotechnologies

16. Energy and Power Technologies

17. Information and Communication Technologies

18. Transportation Technologies

19. Manufacturing Technologies

20. Construction Technologies

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Flight Endurance

Scientific Visualization (SciVis)

Structural Design and Engineering

Video Game Design

Task Number 49

Summarize the traits of successful professional engineers.

Definition

Summary should describe professionals who are

- analytical
- problem-solving
- curious
- innovative
- creative
- pragmatic
- logical
- empirical
- flexible.

Process/Skill Questions

- What are the characteristics of successful, professional engineers?
- Why do engineers need to be creative?
- How do failures often benefit the solution?
- What do engineers do when they don't get the solution right the first time?
- What does it mean to be a lifelong learner?

ITEEA National Standards

8. The Attributes of Design

Task Number 50

Describe the education needed for specialty fields in engineering and technology.

Definition

Description should include

- three years of science in high school, including physics and chemistry (advanced physics and chemistry preferred)
- four years of mathematics, including calculus
- a Bachelor of Science in Engineering diploma from an Accreditation Board for Engineering and Technology (ABET) engineering school
- possible registration as a professional engineer.

Process/Skill Questions

- Why is it important to take advanced mathematics and science courses in high school in order to later specialize in engineering?
- What colleges in Virginia offer degree programs in engineering? Advanced degrees?
- What are the steps for applying to college?
- What is ABET, and what does it do?
- What is the reason for professional licensing of engineers?
- When or by whom is an engineering license required?

Task Number 51

Explain the importance of communication between engineers and their clients.

Definition

Explanation should include

- difficulties of communicating complex concepts in nontechnical terms
- ways to communicate effectively with clients, including restatement
- ways to assess client understanding of communication
- importance of listening to clients' input
- consequences of not communicating effectively.

Process/Skill Questions

- What steps can an engineer take to communicate complex concepts in nontechnical terms to clients?
- What consequences can occur if an engineer inadvertently miscommunicates or inadequately communicates with a client?
- What consequences can occur if a client inadvertently miscommunicates or inadequately communicates with an engineer?
- What steps can an engineer take to ensure that communication between an engineer and a client is thorough, accurate, and effective?
- Why is it important to assess a client's understanding of communications?

ITEEA National Standards

17. Information and Communication Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 52

Explain the relevance of the National Society of Professional Engineers Code of Ethics.

Definition

Explanation should include the fundamental tenets of the Code:

- Hold paramount the safety, health, and welfare of the public.
- Perform services only in areas of competence.
- Issue public statements only in an objective and truthful manner.
- Act for each employer or client as faithful agents or trustees.
- Avoid deceptive acts.
- Act in an honorable, responsible, ethical, and lawful manner so as to enhance the honor, reputation, and usefulness of the profession.

Process/Skill Questions

- What is the difference between morality and ethics?
- What are personal ethics? What are professional ethics?
- What is the difference between the two?
- How do personal ethics affect professional ethics?
- How can an engineer resolve a conflict between personal and professional ethics?

ITEEA National Standards

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

TSA Competitive Events

Engineering Design

Task Number 53

Comply with safety rules in laboratory activities.

Definition

Compliance must include

- adhering to classroom rules and instructor guidelines
- paying extra attention to procedures dealing with electrical, chemical, and mechanical safety.

Process/Skill Questions

- What are the consequences of noncompliance with safety rules and procedures?
- What should one do if someone is not following safety rules and procedures?
- What should one do if someone gets injured in the classroom/laboratory?

Practicing Engineering Fundamentals

Task Number 54

Identify the benefits of case study analysis.

Definition

Identification should include the ways that case studies

- identify the need for a new product
- support and lead to the creation of new products, processes, and ideas
- allow the design team to avoid previous obstacles, pitfalls, and failures
- provide an awareness of industry trends
- ensure the originality of a design and/or product, process, or idea (to avoid violation of patent laws).

Process/Skill Questions

- How can different models and simulations be used to understand real-world behavior?
- How can one test/justify one's model's predictions?
- What is the definition of *case study*?
- Why would someone need a new client?

Task Number 55

Analyze a case study analysis.

Definition

Analysis should include

- researching the product, process, or idea
- identifying and documenting similar products, processes, or ideas
- analyzing achievements and failures of the product, process, or idea (e.g., similarities, key steps of failure, trends)
- conducting quality assurance
- recommending alternative solutions (improvements) for the product, process, or idea.

Process/Skill Questions

- What are proper research strategies?
- How would one verify the reliability of sources of information?
- What are the best sources to use when researching a case study?
- What is the minimum number of resources needed to confirm the case study?

Task Number 56

Apply measuring skills using instrumentation.

Definition

Application should include

- accurately measuring linear distance, mass, energy, and power with the appropriate measurement devices
- determining significant digits (number of digits beyond the decimal point to determine accuracy of measurement or tolerance)
- encouraging the use of modern electronic measuring equipment and probes (possibly borrowing equipment or asking for guests to demonstrate [i.e., surveying]).

Process/Skill Questions

- Why is it important to make multiple measurements of the same object/item?
- Why should one use significant digits in calculations/measuring?
- How does one measure the volume of the lab?
- What tools does one use to measure length, mass, energy, etc.?

TSA Competitive Events

Architectural Design

Task Number 57

Demonstrate conversion techniques for units of measurement.

Definition

Demonstration should include converting U.S. customary units to Systems International (SI) units, and vice versa. Measures may include

- distances/lengths
- weights
- volumes
- energy (BTUs)
- rates of power.

Use in context will solidify learning.

Process/Skill Questions

- What case studies have shown the importance of proper conversion in engineering?
- What can go wrong if you are inaccurate in converting between systems of measurement?

TSA Competitive Events

Architectural Design

Task Number 58

Demonstrate the use of engineering design graphics and descriptive geometry.

Definition

Demonstration should include defining engineering design graphics and descriptive geometry and should also include

- finding measurements in 3D spatial problems (e.g., length of a line, distance between lines, distance from a point to a plane, angle between intersecting planes, resultant vector force)
- identify views from 3D objects and vice versa
- use orthographic projections to create 3D views
- use computer-aided drafting and modeling software to create 3D spatial drawings.

Process/Skill Questions

- Why is it important to use standard graphic techniques?
- What is the purpose of verifying a solution to a design problem?
- How can a solution be verified, using engineering design graphics?

ITEEA National Standards

11. Apply the Design Processes

2. The Core Concepts of Technology

TSA Competitive Events

Architectural Design

Computer-Aided Design (CAD), Architecture

Computer-Aided Design (CAD), Engineering

Dragster Design

Structural Design and Engineering

Task Number 59

Apply the techniques and benefits of sketching.

Definition

Application of the techniques should include

- freehand sketching
- isometric sketching
- orthographic/multiview sketching
- computer-aided sketching.

Application of the benefits should include how sketching

- provides a pictorial or graphical presentation of the design solution
- stimulates collaboration
- documents the thinking process.

Process/Skill Questions

- How does sketching help formulate one's ideas?
- What is an isometric drawing? An orthographic drawing?
- How does a sketch differ from a drawing?
- How is a technical drawing/sketch different from an artistic drawing/sketch?

ITEEA National Standards

11. Apply the Design Processes

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Digital Video Production

Dragster Design

Scientific Visualization (SciVis)

Technology Problem Solving

Transportation Modeling

Video Game Design

Task Number 60

Draw orthographic and isometric projections, using basic technical drawing instruments.

Definition

Drawing should include

- using sketching techniques to sketch standard projections
- using basic technical drawing techniques to draw standard projections
- using drawing instruments, in accordance with standard procedures
- using simple engineering drawings as examples.

Process/Skill Questions

- What is orthographic projection?
- Why is it important to identify the front view of an object? How is the front view of an object identified?
- Why are pictorial drawings used?
- What is the isometric axis, and why is it important?
- What are non-isometric lines? What are some examples?
- What are the steps in drawing a pictorial view from a multiview drawing?

ITEEA National Standards

11. Apply the Design Processes

TSA Competitive Events

Computer-Aided Design (CAD), Engineering

Dragster Design

Engineering Design

Task Number 61

Explain rapid prototyping to develop models.

Definition

Explanation should include

- defining *rapid prototyping*
- summarizing current uses and future potential uses of rapid prototyping
- stating the advantages of using rapid prototyping
- summarizing the materials needed
- describing the steps in the process
- describing additive vs. subtractive rapid prototyping
- describing CNC machining.

Process/Skill Questions

- Why has rapid prototyping become such a hot topic in recent years?
- Is rapid prototyping expected to become prevalent in all engineering areas? Why, or why not?
- What are the limitations of rapid prototyping?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

19. Manufacturing Technologies

TSA Competitive Events

Computer Integrated Manufacturing (CIM)

Task Number 62

Demonstrate research techniques/strategies used by engineers.

Definition

Demonstration should include

- identifying research techniques and strategies commonly used by engineers
- using at least three of the following resources:
    - University references
    - Industry/corporate references
    - Internet references
    - Patent searches
    - Textbooks

    - Research papers
    - Other engineers
- documenting sources according to an accepted format
- verifying information found during research.

Process/Skill Questions

- For the chosen engineering problem, rank/order the types of resources to be used for research and justify that ranking.
- Why must engineers research problems?
- What are some aspects of a problem/solution an engineer might need to research?

ITEEA National Standards

13. Assess the Impact of Products and Systems

9. Engineering Design

TSA Competitive Events

Biotechnology Design

Structural Design and Engineering

Task Number 63

Define *risk* and *safety*.

Definition

Definition should include the following:

- Safety is the minimization of risk.
- Risk is the exposure to the chance of injury, loss, or danger.
- Risk management is the technique of weighing risk to make a positive change.
- There is risk with new products and services and the potential for lawsuits.
- Identify *engineering ethics*.
- Safety is an engineering ethic that must never be compromised or overseen.

Process/Skill Questions

- What are the potential consequences of failure and benefits of success, short-term or long-term?
- What is the expected probability of any potential outcome?
- What are the threshold risk levels?
- Why is safety the most important engineering ethic in terms of product function?

Task Number 64

Describe the three types of accidents.

Definition

Description should include accidents that are

- procedural—stemming from not following the prescribed procedure or from following an incorrect procedure
- engineered—stemming from design flaws
- systemic—stemming from flaws or failures in any system component.

Accidents might also be categorized as any combination of the three.

Process/Skill Questions

- How would one prevent a procedural accident?
- What should be in place to prevent a procedural accident?
- What were the problems with some famous engineering failures (e.g., Challenger and Columbia space shuttles, Hubble Space Telescope, Fukushima and Chernobyl nuclear power plants)?
- How could these accidents have been avoided?

Task Number 65

Identify major precursors of accidents.

Definition

Identification should include

- normalization of deviation
- multiple human errors
- disregard for operating experience.

Process/Skill Questions

- What led to the Challenger explosion, and how did engineers try to warn NASA officials about it (deviations of standards, also known as normalization of deviation)?
- What are the factors leading to the 2018 pedestrian bridge collapse in Miami? How could this disaster have been prevented?
- Refer to the Cannons or Principals of the engineering professions. What should one do if one identifies a precursor?
- How could one use the design process to avoid accidents? What methods could one use to identify deviation? Human error? Operating experience?
- What tools or experiences could one use to detect precursors?

Task Number 66

Evaluate the safety of designs.

Definition

Evaluation should include asking the following questions:

- Does the design create the safest product within constraints?
- Does the design adhere to industry/legal safety standards?
- Has the design been tested?
- Has the design minimized the risk to the end user (consumer) and artisan (manufacturer)?

Process/Skill Questions

- When is a design considered safe? Unsafe?
- When would a company make a decision to order a recall?
- What is the safety/cost trade-off in an engineering design project?
- What do automotive industry companies do to test vehicle safety?

Task Number 67

Demonstrate knowledge of appropriate personal safety procedures.

Definition

Demonstration should include

- describing the role of the Occupational Safety and Health Administration (OSHA) in the technical workplace

- describing and using safety equipment
- describing the function of safety devices.

Note: This is a specific topic covered in the National Occupational Competency Testing Institute (NOCTI) Pre-Engineering exam and should be specifically covered.

Process/Skill Questions

- What is OSHA's role in the workplace?
- How does one use safety equipment?
- What are the functions of safety devices?

Examining the Engineering Design Process

Task Number 68

Define an engineering design process.

Definition

Definition of an engineering design process should include multiple steps covering

- identifying and defining problems
- identifying constraints and criteria for success
- brainstorming potential solutions
- sketching potential solutions
- evaluating potential solutions considering constraints
- identifying an optimal solution
- creating model and prototype
- testing the solution
- evaluating results
- iterating or modifying as needed
- communicating final results.

Process/Skill Questions

- How does the engineering design process differ from the scientific method?
- What is the most crucial step in the engineering design process? Why?
- Why don't the engineering design steps need to be completed in one, and only one, order?

ITEEA National Standards

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

11. Apply the Design Processes

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Dragster Design

Engineering Design

Flight Endurance

Geospatial Technology (Virginia only)

System Control Technology

Technology Problem Solving

Transportation Modeling

Video Game Design

Task Number 69

Define an engineering design problem.

Definition

Definition of an engineering design problem should include the

- reasons it is important to have a clear concept of a problem before attempting to solve it

- essential components of an engineering design problem
- nature and use of an engineering design brief (i.e., a statement that explains what the solution to an engineering design problem must accomplish)
- most important components of an engineering design brief.

Process/Skill Questions

- Why is it important to have a clear definition of the problem before attempting to solve it?
- What might be the consequences of not having a clear concept of an engineering design problem before attempting to solve it?
- How can an engineering design problem be stated succinctly?
- How is an engineering design brief used in an engineering design process?

Task Number 70

Identify the requirements and constraints of the design problem.

Definition

Identification should include the specifications, constraints, and criteria of the problem—i.e., what the design must do to be considered a success, the resources required, and the availability or non-availability of all required resources.

Process/Skill Questions

- How can one locate resources required to solve an engineering design problem?
- If resources are not available, what should one do?
- What are constraints?
- Why is all engineering design performed under constraints?
- What is the difference between a specification and a criterion?

ITEEA National Standards

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

11. Apply the Design Processes

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Technology Problem Solving

Transportation Modeling

Video Game Design

Task Number 71

Research potential solutions to the design problem.

Definition

Research should include

- the use of multiple resources from libraries, the Internet, and other sources of information
- examples of current solutions to the problem, including proper citations or documentation as needed
- the critique and evaluation of current solutions to the problem
- citing research sources.

Process/Skill Questions

- How does one identify quality resources?
- What are the dangers of using the Internet as one's only source of information?
- Why is it important to use multiple resources about the same topic?
- What are the benefits of using multiple media sources of information for research?
- How does one cite one's sources?

ITEEA National Standards

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

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System Control Technology

Transportation Modeling

Video Game Design

Task Number 72

Generate multiple solutions to the design problem.

Definition

Generating should include brainstorming to produce explanations of at least three potential solutions and may include sketches, lists, flowcharts, and/or multimedia elements.

Process/Skill Questions

- What are the benefits of generating multiple solutions?
- What is brainstorming? What are its steps?

- How can sketches and other graphic displays aid the brainstorming process?

ITEEA National Standards

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

11. Apply the Design Processes

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Technology Problem Solving

Transportation Modeling

Video Game Design

Task Number 73

Sketch the solutions to a design problem.

Definition

Sketches of the solutions may

- be performed freehand
- use technical drawing tools
- be computer-aided/generated.

Process/Skill Questions

- What technical skills are necessary for making effective sketches?
- What are the benefits of sketching the design process?
- What are some examples of orthographic multiviews?
- What are some examples of computer-aided sketches?

ITEEA National Standards

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

11. Apply the Design Processes

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Architectural Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Transportation Modeling

Video Game Design

Task Number 74

Evaluate the requirements and constraints of each potential solution to the design problem.

Definition

Evaluation should include requirements and constraints including but not limited to

- environmental effects
- societal effects
- sustainability
- cost and budget
- time requirements and limitations
- resources needed, including availability or non-availability
- use of a decision matrix.

Process/Skill Questions

- Why should one analyze the requirements and constraints of the various solutions?
- What might be the consequences of not analyzing the requirements and constraints?
- Why is time often limited?
- Why is sustainability an important issue?
- What is a decision matrix?

ITEEA National Standards

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

11. Apply the Design Processes

13. Assess the Impact of Products and Systems

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

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Technology Problem Solving

Transportation Modeling

Video Game Design

Task Number 75

Justify an optimal solution to the design problem.

Definition

Justification should include

- comparing all known aspects of the proposed solutions to the criteria
- explaining how the decision matrix is used to choose the optimal solution
- explaining reasons one solution may be the best.

Process/Skill Questions

- What is the definition of optimal solution?
- What are trade-offs?
- What is criteria?
- How do trade-offs affect the decision-making process?
- How can the optimal solution among multiple solutions be determined?
- Why is selecting the optimal solution not a guarantee of success in solving the design problem?

ITEEA National Standards

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

11. Apply the Design Processes

13. Assess the Impact of Products and Systems

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

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Transportation Modeling

Video Game Design

Task Number 76

Create a model or prototype for the chosen solution.

Definition

Creation of a model as a solution to a design problem should include using appropriate materials and processes (e.g., 3D rapid prototyping) and

- explaining the importance of creating a model or prototype and benchmark
- identifying standard methods for creating a model or prototype and benchmark
- listing the materials, tooling, and processes required

- describing why each material and process is needed
- using computer software to model, if applicable
- constructing the model or prototype so that it demonstrates the effectiveness of the solution.

Process/Skill Questions

- What is the purpose of constructing a model or prototype for the chosen solution? What can it show?
- What are the common limitations of modeling or prototyping?
- How can one determine which materials, tools, and processes to use for the construction of the model or prototype?
- Should availability of materials guide this determination?

ITEEA National Standards

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

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Technology Problem Solving

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Video Game Design

Task Number 77

Test the solution to the design problem.

Definition

Testing should include using mathematical, conceptual, and/or physical modeling, simulating, and optimizing. It should also include

- determining the objectives for an engineering test of the solution to the design problem (explain a successful test)
- determining the model type(s) to use, based on the identified goals and constraints
- explaining what each model type will show or accomplish
- creating the model or prototype in accordance with a plan
- applying mathematical formulas, as applicable.

Process/Skill Questions

- What factors contribute to selection of a model type?
- What constraints should one consider when selecting a model type?
- How does one determine which model type will produce the most robust solution?
- How can one create a mathematical model from the techniques available?
- Why is a plan for a model needed before one begins construction?

ITEEA National Standards

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

11. Apply the Design Processes

13. Assess the Impact of Products and Systems

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

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Transportation Modeling

Video Game Design

Task Number 78

Evaluate the test results.

Definition

Evaluation should include

- determining the degree to which the solution meets the objective stated in the design brief
- interpreting data to determine whether the test results demonstrated by the model are repeatable and reliably consistent
- weighing the advantages and disadvantages of the solution, considering its costs, resources required, time required, impacts, plausibility, and ethics involved
- identifying areas that need improvement.

Process/Skill Questions

- Why is it important to know whether the test results demonstrated by the model are repeatable and reliably consistent?

- Why is it important to carefully consider the disadvantages of the solution before attempting to implement it, even when the disadvantages are greatly outweighed by the advantages?
- How does one determine the true cost of one's solution?
- What are the factors affecting cost?
- What is the difference between efficiency and effectiveness?
- How does one validate one's data and results?
- Why is it important to consider how one's solution might affect the environment?
- Why is it crucial to consider the ethics of the potential solution?
- What kind of criteria might one use to determine the degree to which the solution meets the objective stated in the design brief?

ITEEA National Standards

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

11. Apply the Design Processes

13. Assess the Impact of Products and Systems

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Transportation Modeling

Video Game Design

Task Number 79

Modify the solution to the design problem, if needed.

Definition

Modification should include

- revisiting the solutions proposed in the brainstorming step
- proposing alternate optimal solutions, based on the data acquired
- justifying the alternate solution
- adapting/modifying the current design.

Process/Skill Questions

- Why should one revisit the solutions proposed in the brainstorming step when formulating an alternate solution to the problem?
- How might the data one acquired in the test influence the formulation of an alternate solution?
- What factors might help one to justify an alternate solution as optimal?

ITEEA National Standards

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

11. Apply the Design Processes

13. Assess the Impact of Products and Systems

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Dragster Design

Engineering Design

Flight Endurance

System Control Technology

Transportation Modeling

Video Game Design

Task Number 80

Test the modification/alternate solution, if needed.

Definition

Testing the alternate solution should include

- collecting feedback
- reviewing and evaluating the product and/or process(es) already tested.

Process/Skill Questions

- What is high-quality or effective feedback?
- Why might one need to review the process or product more than once?
- What does looping the design process mean?
- Why are engineers seldom entirely satisfied with the final product or process?

ITEEA National Standards

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

9. Engineering Design

TSA Competitive Events

Animatronics

Biotechnology Design

Engineering Design

Flight Endurance

System Control Technology

Task Number 81

Document the final project report.

Definition

Documentation should include

- abstract
- introduction
- research questions and/or hypothesis
- methods and materials
- results
- conclusions
- appendices (e.g., raw data, sketches, notes, surveys)
- citations of references used.

Process/Skill Questions

- What is an abstract? What is its purpose?
- What elements belong in an abstract?
- Why should one include appendices in the report?

ITEEA National Standards

11. Apply the Design Processes

17. Information and Communication Technologies

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

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Computer Integrated Manufacturing (CIM)

Digital Video Production

Engineering Design

Essays on Technology

Fashion Design and Technology

Flight Endurance

Future Technology Teacher

Music Production

Scientific Visualization (SciVis)

System Control Technology

Transportation Modeling

Video Game Design

Task Number 82

Present the final project report.

Definition

Presentation should include

- statement of the engineering-design problem
- obstacles encountered and solutions found in the process
- graphical representations and visual aids (e.g., diagrams, sketches, photos, videos, models, prototypes)
- solution steps
- results

- evaluation of the solution
- final results based on initial expectations and degree of meeting the requirements of the proposal
- demonstration of the final product.

Process/Skill Questions

- What are the benefits of incorporating graphical and/or visual representations of one's solution into one's presentation?
- What makes a presentation effective and persuasive? How can the quality of one's presentation affect the acceptance of one's solution?
- Why is it important to show a demonstration of one's product?

ITEEA National Standards

17. Information and Communication Technologies

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

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Engineering Design

Essays on Technology

Fashion Design and Technology

Flight Endurance

Future Technology Teacher

Music Production

System Control Technology

Video Game Design

Identifying Real-world Problems

Task Number 83

Research local problems that could benefit from engineering solutions.

Definition

Research may include

- identifying regional problems that could benefit from engineering solutions (e.g., in areas such as government, schools, businesses, media, and the medical industry)
- interviewing experts or stakeholders about a selected problem
- assessing the relevance of historical data concerning the selected problem to an engineering solution to the problem.

Process/Skill Questions

- Where do you find historical data about happenings and problems in the community?
- What are the general guidelines for conducting appropriate interviews?
- How can one judge the relevance of historical data about a problem to an engineering solution to the problem? Why is doing this important?

ITEEA National Standards

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

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Architectural Design

Biotechnology Design

Essays on Technology

Task Number 84

Design an engineering solution to a local problem, using the engineering design process.

Definition

Design should

- be based on visualization, conceptualization, imagination, innovation, and creativity
- include the following components in written form:
    - A statement of the problem
    - An explanation of the solution, including its appropriateness
    - An argument for the plausibility of the solution
    - An outline of the engineering design process needed for the solution
    - A cost analysis of the process
    - An assessment of the marketability of the solution
    - Create a product that answers or solves the local problem

Process/Skill Questions

- Who are the local decision makers for a problem solution?
- How does one estimate the costs to implement one's solution?
- What is the most effective presentation format for one's solution?
- Where might one find funding for one's solution?

ITEEA National Standards

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

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

8. The Attributes of Design

9. Engineering Design

SOL Correlation by Task

39	Explain the influence of technological systems.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.13, WG.2, WG.4, WG.5, WG.9, WG.14, WG.17, WHI.14 Science: PH.1
40	Describe the characteristics and scope of technology.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.8, VUS.10, VUS.13, VUS.14, WG.2, WG.4, WG.5, WG.9, WG.14, WG.17, WHII.9, WHII.13, WHII.14
41	Identify the core concepts of technology.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.13, WG.2, WG.4, WG.5, WG.9, WG.14, WG.17
42	Identify historical technology milestones and advancements.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.2, VUS.8, VUS.10, VUS.13, VUS.14, WHII.4, WHII.9, WHII.13, WHII.14
43	Examine technological systems.	English: 9.3, 9.5, 10.3, 10.5, 11.5 History and Social Science: VUS.2, VUS.8, VUS.10, VUS.13, VUS.14, WHII.4, WHII.9, WHII.13, WHII.14 Science: PH.4
44	Define *engineering*.	English: 9.3, 9.5, 10.3, 11.3
45	Summarize the history of engineering.	English: 9.5, 10.5, 11.5

		History and Social Science: VUS.2, VUS.8, VUS.10, VUS.13, VUS.14, WG.2, WHII.4, WHII.9, WHII.13, WHII.14
46	Research an engineering achievement.	English: 9.8, 10.8, 11.8 History and Social Science: GOVT.1, VUS.2, VUS.8, VUS.10, VUS.13, VUS.14, WG.1, WHII.4, WHII.9, WHII.13, WHII.14
47	Present information pertaining to an engineering achievement.	English: 9.5, 10.5, 11.5 History and Social Science: VUS.2, VUS.10, VUS.13, VUS.14, WHII.4, WHII.9, WHII.13, WHII.14
48	Describe the principal fields for specialization in engineering.	English: 9.5, 10.5, 11.5
49	Summarize the traits of successful professional engineers.	English: 9.5, 10.5, 11.5
50	Describe the education needed for specialty fields in engineering and technology.	English: 9.5, 10.5, 11.5
51	Explain the importance of communication between engineers and their clients.	English: 9.5, 10.5, 11.5
52	Explain the relevance of the National Society of Professional Engineers Code of Ethics.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8
53	Comply with safety rules in laboratory activities.	English: 9.5, 10.5, 11.5
54	Identify the benefits of case study analysis.	English: 9.5, 10.5, 11.5
55	Analyze a case study analysis.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8
56	Apply measuring skills using instrumentation.	English: 9.5, 10.5, 11.5
57	Demonstrate conversion techniques for units of measurement.	
58	Demonstrate the use of engineering design graphics and descriptive geometry.	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5 Mathematics: G.14, MA.7, MA.8
59	Apply the techniques and benefits of sketching.	English: 9.5, 10.5, 11.5 Mathematics: G.3, G.4, G.14 Science: PH.2
60	Draw orthographic and isometric projections, using basic technical drawing instruments.	Mathematics: G.3, G.4, G.14

61	Explain rapid prototyping to develop models.	English: 9.3, 9.5, 10.3, 10.5, 11.3, 11.5
62	Demonstrate research techniques/strategies used by engineers.	English: 9.5, 9.8, 10.5, 10.8, 11.5, 11.8
63	Define *risk* and *safety*.	English: 9.3, 10.3, 11.3
64	Describe the three types of accidents.	English: 9.5, 10.5, 11.5
65	Identify major precursors of accidents.	English: 9.5, 10.5, 11.5
66	Evaluate the safety of designs.	
67	Demonstrate knowledge of appropriate personal safety procedures.	English: 9.5, 10.5, 11.5 History and Social Science: GOVT.15
68	Define an engineering design process.	English: 9.3, 10.3, 11.3
69	Define an engineering design problem.	English: 9.3, 10.3, 11.3
70	Identify the requirements and constraints of the design problem.	English: 9.5, 10.5, 11.5 Science: PH.1
71	Research potential solutions to the design problem.	English: 10.8, 11.8 Science: PH.1, PH.4
72	Generate multiple solutions to the design problem.	English: 9.5, 10.5, 11.5
73	Sketch the solutions to a design problem.	English: 9.5, 10.5, 11.5 Mathematics: G.3, G.14
74	Evaluate the requirements and constraints of each potential solution to the design problem.	English: 9.5, 10.5, 11.5 Science: PH.1, PH.4
75	Justify an optimal solution to the design problem.	English: 9.5, 10.5, 11.5 Science: PH.4
76	Create a model or prototype for the chosen solution.	English: 9.5, 10.5, 11.5 Science: PH.1
77	Test the solution to the design problem.	English: 9.5, 10.5, 11.5 Mathematics: A.4, AII.3 Science: PH.1
78	Evaluate the test results.	English: 9.5, 10.5, 11.5 Mathematics: PS.5, PS.1*, PS.17, PS.18, PS.19, PS.2*, PS.20, PS.3*, PS.4*, PS.7*, PS.8* Science: PH.2

79	Modify the solution to the design problem, if needed.	English: 9.5, 10.5, 11.5 Science: PH.1
80	Test the modification/alternate solution, if needed.	Science: PH.2
81	Document the final project report.	English: 9.6, 9.7, 10.6, 10.7, 11.6, 11.7
82	Present the final project report.	English: 9.1, 10.1, 11.1 Mathematics: COM.7, COM.12
83	Research local problems that could benefit from engineering solutions.	English: 9.8, 10.8, 11.8 Science: PH.4
84	Design an engineering solution to a local problem, using the engineering design process.	English: 9.1, 10.1, 11.1 Science: PH.4

Entrepreneurship Infusion Units

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

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- College and Work Readiness Assessment (CWRA+)
- National Career Readiness Certificate Assessment
- 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.*

- Biomedical Engineering (8467/36 weeks)
- Engineering Analysis and Applications II (8451/36 weeks)
- Engineering Concepts and Processes III (8452/36 weeks)
- Engineering Practicum IV (8453/36 weeks)
- Engineering Studies (8491/36 weeks)

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Biomedical Engineer** **Civil Engineer** **Civil Engineering Technician** **Electrical Engineer** **Electrical Engineering Technician** **Industrial Engineer** **Industrial Engineering Technician** **Mechanical Engineer** **Mechanical Engineering Technician**