Engineering Studies

8491 36 weeks

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Course Description

Suggested Grade Level: 10 or 11 or 12
Prerequisites: 8450

Designed for students who intend to pursue engineering studies in college, Engineering Studies prepares students by emphasizing integration of mathematics, science, and English concepts and

skills into engineering problems in a curriculum demanding rigorous study habits. Students are encouraged to become routinely inquisitive through brainstorming and prototyping. Students practice engineering skills and communication of technical information while applying the engineering design process to complete engineering projects.

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	8491	Tasks/Competencies
Examining the Engineering Profession		
39	⊕	Describe how engineering and technology have significantly influenced contemporary society and the environment.
40	⊕	Explore career opportunities for the engineering graduate, both within and outside the field of engineering.
41	⊕	Examine the breadth of topics within an engineering plan of study.
42	⊕	Explain application of ethics within the field of engineering.
Practicing Engineering Fundamentals		
43	⊕	Identify the benefits of a case study analysis.
44	⊕	Perform a case study analysis.
45	⊕	Apply measuring skills using instrumentation.
46	⊕	Demonstrate conversion techniques for units of measurement.
47	⊕	Demonstrate the use of engineering design graphics and descriptive geometry.

48	⊕	Demonstrate the techniques and benefits of sketching.	
49	⊕	Sketch orthographic and isometric projections.	
50	⊕	Demonstrate research techniques/strategies used by engineers.	
51	⊕	Define *risk* and *safety*.	
52	⊕	Describe the three types of accidents.	
53	⊕	Identify major precursors of accidents.	
54	⊕	Evaluate the safety of designs.	
55	⊕	Reverse-engineer a product, process, or idea.	
56	⊕	Define *algorithm*.	
57	⊕	Create an algorithm to solve an engineering problem.	
58	⊕	Explain the benefits of modeling and simulation.	
59	⊕	Explain rapid prototyping to develop models.	
60	⊕	Create a model or simulation for an engineering product, process, or idea.	
Communicating Technical Information			
61	⊕	Write a business letter to request information or materials.	
62	⊕	Present an oral technical report on an engineering project.	
63	⊕	Participate in a mock interview.	
64	⊕	Explain applications of mathematics in the engineering design process.	
65	⊕	Explain applications of scientific principles.	
66	⊕	Explain applications of investigative technology.	
Exploring the Physics Concepts of Selected Energy Systems			
67	⊕	Identify the primary concepts and components of mechanical systems.	
68	⊕	Identify the primary concepts and components of fluid energy systems.	
69	⊕	Explore electrical systems.	

70	⊕	Identify the primary concepts and components of thermodynamic systems.	
Applying the Engineering Design Process			
71	⊕	Identify the need for a product or system.	
72	⊕	Explain the validity of designing alternative solutions to an engineering design problem.	
73	⊕	Design an engineering solution to a real-world problem.	
74	⊕	Implement the design.	
75	⊕	Iterate the design.	
76	⊕	Maintain documentation.	
77	⊕	Present a solution.	
Demonstrating College Readiness Skills			
78	⊕	Evaluate study skills needed by an engineering student.	
79	⊕	Demonstrate teamwork skills necessary for success when working in a technological team.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Examining the Engineering Profession

Task Number 39

Describe how engineering and technology have significantly influenced contemporary society and the environment.

Definition

Description should include

- power (e.g., electricity, nuclear technologies)
- transportation (e.g., automobile, airplane, highways)
- water supply (e.g., water purification technologies)
- electronics (e.g., vacuum tubes, transistors)
- communications (e.g., telephone, radio, television, personal computer, Internet)
- mechanization (e.g., agriculture, manufacturing)
- data management (e.g., computer technology)
- construction (e.g., high performance materials)
- healthcare (e.g., drugs, surgical technologies)
- natural resources (e.g., petroleum and natural gas technologies)
- environmental protection (e.g., groundwater, solid-waste processing).

Process/Skill Questions

- How have social, economic, and environmental forces shaped the development and use of new technologies?
- How have new technologies brought new problems as well as improvements to human existence?
- Why must a technological system's influence on the environment always be considered?
- Why do some cultures reject certain technologies? What are some contemporary examples of this phenomenon?

ITEEA National Standards

5. The Effects of Technology on the Environment

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

TSA Competitive Events

Essays on Technology

Extemporaneous Speech

Prepared Presentation

Task Number 40

Explore career opportunities for the engineering graduate, both within and outside the field of engineering.

Definition

Exploration should include

- listing relevant job titles within all principal engineering fields of specialization
- listing typical tasks related to each job
- preparing for each job
- researching the opportunities for advancement in each field
- researching the employment trends in each field.

Exploration should also include using job databanks and matching personal interests, abilities, aptitudes, and job expectations with real-world jobs.

Many websites offer career exploration resources, including the Virginia Department of Education's Career Planning Guide, located at http://www.cteresource.org/cpg.

Process/Skill Questions

- Why might it be important for one to survey jobs in all the principal engineering fields of specialization?
- Why should one also investigate career opportunities outside the field of engineering?
- How can one best match personal interests, abilities, aptitudes, and job expectations with real-world jobs?
- How can a career plan help one succeed in preparing for, acquiring, succeeding in, and advancing in a job of one's choice?

TSA Competitive Events

Engineering Design

Structural Design and Engineering

Task Number 41

Examine the breadth of topics within an engineering plan of study.

Definition

Examination should include

- identifying various engineering plans of study
- explaining the reasons an engineer must be able to work across disciplines
- identifying courses that facilitate people skills, particularly communication.

Process/Skill Questions

- Apart from working with colleagues in teams and working for clients, what are some other reasons an engineer must have people skills to succeed?
- Which people skills are the most important to have, and why?
- How might an engineer develop and enhance people skills apart from the classroom?
- What types of planning resources are available?

Task Number 42

Explain application of ethics within the field of engineering.

Definition

Explanation should include

- summarizing the fundamental tenets of the National Society of Professional Engineers Code of Ethics
- describing the reasons for each tenet
- describing patents, including the six legal categories of patents, how patents protect inventors, and how patents are obtained.

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?
- How does culture affect ethics?
- What ethical issues relate to the selection and use of technology?
- How might a use of technology be legal but unethical?
- What criteria might an engineer use to resolve such a conflict?

ITEEA National Standards

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

TSA Competitive Events

Debating Technological Issues

Essays on Technology

Extemporaneous Speech

Prepared Presentation

Practicing Engineering Fundamentals

Task Number 43

Identify the benefits of a case study analysis.

Definition

Identification should include the ways that case studies

- 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

- What are proper research strategies?
- How would one verify the reliability 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?

ITEEA National Standards

13. Assess the Impact of Products and Systems

14. Medical Technologies

15. Agricultural and Related Biotechnologies

17. Information and Communication Technologies

18. Transportation Technologies

19. Manufacturing Technologies

20. Construction Technologies

7. The Influence of Technology on History

8. The Attributes of Design

TSA Competitive Events

Animatronics

Architectural Design

Biotechnology Design

Career Prep

Engineering Design

Structural Design and Engineering

Video Game Design

Task Number 44

Perform a case study analysis.

Definition

Performance 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 the steps to follow when performing a case study analysis?
- How does one choose a case study to analyze?
- How does one improve quality assurance based on one's case study analysis?

ITEEA National Standards

13. Assess the Impact of Products and Systems

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

Structural Design and Engineering

Video Game Design

Task Number 45

Apply measuring skills using instrumentation.

Definition

Application should include

- 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 borrow equipment or ask for guests to demonstrate [e.g., surveying]).

Process/Skill Questions

- How does an engineering scale differ from standard-ruler scales?
- Why must engineering measurements be precise?
- What tools are used for the inspection of parts and products?
- What are uses of laser instruments?

TSA Competitive Events

Architectural Design

Task Number 46

Demonstrate conversion techniques for units of measurement.

Definition

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

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

Process/Skill Questions

Case study use is suggested as motivation to why conversions are important (e.g., international engineering collaboration, consequences of misinterpretation in measurement).

TSA Competitive Events

Architectural Design

Task Number 47

Demonstrate the use of engineering design graphics and descriptive geometry.

Definition

Demonstration should include

- defining engineering design graphics and descriptive geometry
- 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).

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

Task Number 48

Demonstrate the techniques and benefits of sketching.

Definition

Demonstration of the techniques should include

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

Demonstration of the benefits should include how sketching

- presents 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 and 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 49

Sketch orthographic and isometric projections.

Definition

Sketching should include

- using sketching techniques to sketch standard projections
- using simple engineering drawings as examples.

Optional approaches may include

- using basic technical drawing instruments
- using basic technical drawing techniques to draw standard projections
- using drawing instruments in accordance with standard procedures.

Process/Skill Questions

- What are the three primary views used in multiview drawings?
- 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 Integrated Manufacturing (CIM)

Computer-Aided Design (CAD), Architecture

Dragster Design

Engineering Design

Task Number 50

Demonstrate research techniques/strategies used by engineers.

Definition

Demonstration should include

- identification of research techniques and strategies commonly used by engineers
- use of at least three of the following resources:
    - University references
    - Industry/corporate references
    - Internet references
    - Patent searches
    - Textbooks
    - Research papers
    - Other engineers
        - documentation of sources of information according to an accepted format
        - verification of information found during research.

Process/Skill Questions

- Why is it important to know and be able to use research techniques and strategies commonly used by engineers?
- Of the various resources used by engineers, which are the most important? Why?
- Why is it important to document sources of information according to an accepted format?
- How can one verify information found during research? Why is verification important?

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 51

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.

Process/Skill Questions

- What are the potential consequences of failure and benefits of success, short-term and long-term?
- What is the expected probability of any potential outcome?
- What are the threshold risk levels?

ITEEA National Standards

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

TSA Competitive Events

Biotechnology Design

Dragster Design

Engineering Design

Task Number 52

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?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Biotechnology Design

Engineering Design

Structural Design and Engineering

Task Number 53

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 would one do if one identified 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?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

2. The Core Concepts of Technology

TSA Competitive Events

Structural Design and Engineering

System Control Technology

Task Number 54

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?

ITEEA National Standards

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Dragster Design

Engineering Design

Transportation Modeling

Task Number 55

Reverse-engineer a product, process, or idea.

Definition

Reverse engineering should include

- analyzing the product (e.g., determining its intended application)
- working backward from a finished item (function)
- disassembling the product, process, or idea
- measuring parts and assembly, if applicable
- finding ways to improve the product, process, or idea.

Process/Skill Questions

- What can be learned from reverse engineering?
- What are the steps to reverse-engineer a product?
- What steps should be taken to improve the product after reverse engineering, while still meeting the goal?

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

9. Engineering Design

TSA Competitive Events

Biotechnology Design

Engineering Design

Task Number 56

Define *algorithm*.

Definition

Definition should state that an algorithm is a procedure or formula for solving a problem.

Process/Skill Questions

- What is the benefit of having an algorithm?
- How can one use algorithms in one's daily life?
- How are algorithms used by Internet platforms?

ITEEA National Standards

13. Assess the Impact of Products and Systems

TSA Competitive Events

System Control Technology

Video Game Design

Task Number 57

Create an algorithm to solve an engineering problem.

Definition

Creation of an algorithm should

- express a logical process for solving an engineering problem or a step-by-step thought process and procedure
- be based on one or more of the following algorithm types:
    - Visual—flow chart
    - Written—pseudo code
    - Mathematical—formula-based

Process/Skill Questions

- What questions should be asked when creating an algorithm?
- How are algorithms used to ensure the quality of a product?
- What procedure can be used to test one's algorithm?

ITEEA National Standards

11. Apply the Design Processes

TSA Competitive Events

System Control Technology

Video Game Design

Task Number 58

Explain the benefits of modeling and simulation.

Definition

Explanation should include the ways that modeling and simulation allow for

- ideas to be tested in a virtual environment that

    - is safer (e.g., simulates within a range of conditions and extremes without physical risk)
    - reveals ergonomic issues
    - is easier to control (e.g., confidence in predictability based on known inputs and effect of variables)
    - is easier to modify (e.g., variables of time, conditions, scale, materials, chemistry)
- improvements in cost-effectiveness over real-world testing
- efficiency when creating a prototype
- errors in design/logic to emerge prior to implementation.

Process/Skill Questions

- What is the difference between modeling and simulation?
- How can modeling reveal the cost-effectiveness of a product?
- What are the limitations of modeling and simulation?

ITEEA National Standards

11. Apply the Design Processes

TSA Competitive Events

Computer-Aided Design (CAD), Architecture

Computer-Aided Design (CAD), Engineering

Engineering Design

Scientific Visualization (SciVis)

System Control Technology

Video Game Design

Task Number 59

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.

Process/Skill Questions

- How long has the process of rapid prototyping been used?
- How might rapid prototyping exceed its current boundaries?
- How does design play a critical role in rapid prototyping?

Task Number 60

Create a model or simulation for an engineering product, process, or idea.

Definition

Creation of a model must include a description of a pattern, plan, or representation and be designed to show a main object or workings of an object, system, or concept. The process used for the creation of a model should be based on one of the following model types and procedures:

- Physical model type—design a model, determine the scale, choose and obtain materials, and assemble
- Conceptual model type—present a clearly communicated story or series of images of the phenomenon
- Mathematical model type—determine the relationship between variables or procedural steps and translate them into mathematical symbols

Process/Skill Questions

- How does one determine what software is best suited for one's model or simulation?
- How does one determine the data to input into one's model or simulation?
- How can the results of the model/simulation affect a final product?

ITEEA National Standards

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

11. Apply the Design Processes

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

Video Game Design

Communicating Technical Information

Task Number 61

Write a business letter to request information or materials.

Definition

Writing a business letter should include

- selecting and conforming to an accepted business-letter style (i.e., block form or indented form)
- including all components of a business letter (e.g., heading, inside address, salutation)
- using clear, concise language so that the message cannot be misunderstood
- using correct spelling, grammar, punctuation, and sentence structure
- using a business-like, professional tone adapted for the specific audience.

Process/Skill Questions

- What steps can an engineer take to communicate complex concepts in nontechnical terms to clients?
- What could be the consequences of a client inadvertently miscommunicating or inadequately communicating with an engineer?
- What steps can an engineer take to ensure that communication between the engineer and the client is thorough, accurate, and effective in both directions?
- Why is it important to assess a client's understanding of communications?

ITEEA National Standards

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

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Task Number 62

Present an oral technical report on an engineering project.

Definition

Presentation may include

- statement of the problem
- obstacles and solutions encountered in the process
- graphical representations and other visual aids (e.g., diagrams, sketches, photos, video clips, computer-aided designs)
- solution steps
- results
- evaluation of solution
- final results based on initial expectations and degree of meeting the requirements of the proposal.

Process/Skill Questions

- Why is submitting a proposal important and/or necessary?
- What makes an engineering project proposal persuasive?
- What action could one take if one's proposal is rejected?

ITEEA National Standards

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

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

TSA Competitive Events

Animatronics

Biotechnology Design

Engineering Design

Prepared Presentation

Task Number 63

Participate in a mock interview.

Definition

Participation should include

- deciding on the purpose of the interview
- preparing for the interview (e.g., researching background information, creating specific questions to ask to elicit needed information)
- stating the purpose of the interview
- phrasing questions clearly and succinctly
- listening carefully
- taking notes (key words and phrases needed for recall later)
- recording the interview with permission
- asking for clarification as needed
- keeping on track.

The interview process should also include reviewing written notes and/or recording soon after the interview and following up by writing detailed notes, as needed.

Process/Skill Questions

- Why is it important to prepare properly for interviewing someone?
- Why is listening carefully perhaps the most important aspect of interviewing someone?
- What steps can one take to be assured that one can remember exactly what the interviewee says?
- Why is it necessary to ask the interviewee's permission to make a recording of the interview?
- What are the possible ethical and unethical uses of such a recording?
- Why is it important to review one's written notes and/or the recording soon after the interview?

ITEEA National Standards

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

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

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Task Number 64

Explain applications of mathematics in the engineering design process.

Definition

Explanation should include

- reasons mathematics is essential in the engineering design process
- summary of types of mathematics commonly used by engineers
- reasons why solving for unknown variables may be necessary before finding a solution
- ways to determine the formulas needed for a solution to an engineering design problem.

Process/Skill Questions

- What is the definition of *algorithm*?
- What are some common examples of algorithms?
- In what kinds of engineering design problems should one establish and use a mathematical algorithm to solve the problem?
- How can one determine whether one's solutions to unknown variables are feasible?
- Why should one not depend exclusively on computer-generated results?

ITEEA National Standards

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

TSA Competitive Events

Engineering Design

Task Number 65

Explain applications of scientific principles.

Definition

Explanation should include

- examples of scientific principles that can be used in the engineering design process
- reasons why application of scientific principles is essential in the process
- a summary of how the application of scientific principles may contribute to a final product.

Process/Skill Questions

- Why must an engineer be very knowledgeable about scientific principles?
- What steps can an engineer take to assure he/she has adequate knowledge of scientific principles?
- What could be the consequences of not considering scientific principles in the engineering design process?

ITEEA National Standards

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

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Task Number 66

Explain applications of investigative technology.

Definition

Explanation should include

- examples of investigative technology that can be used in the engineering design process
- reasons why investigative technology may be used in the process
- ways investigative technology can contribute to a final product.

Process/Skill Questions

- Why must an engineer be knowledgeable about investigative technology?
- What steps can an engineer take to ensure he/she has adequate knowledge of investigative technology?
- What could be the consequences of not using investigative technology in the engineering design process?

ITEEA National Standards

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

TSA Competitive Events

Animatronics

Biotechnology Design

Engineering Design

Exploring the Physics Concepts of Selected Energy Systems

Task Number 67

Identify the primary concepts and components of mechanical systems.

Definition

Identification should include

- explaining force
- using International System of units (SI) and U.S. customary units in formulas
- demonstrating application of force.

Process/Skill Questions

- Why is knowledge of the physics concepts related to force in a mechanical energy system necessary for all engineers, not just mechanical engineers?
- Why are both SI units and U.S. customary units used in engineering?
- What are some innovative ways to demonstrate application of force?
- What resources are available to investigate application of force?

Task Number 68

Identify the primary concepts and components of fluid energy systems.

Definition

Identification should include

- explaining pressure
- using SI units and U.S. customary units in formulas
- demonstrating application of pressure.

Process/Skill Questions

- Why is knowledge of the physics concepts related to pressure in a fluid energy system necessary for all engineers?
- Why are both SI units and U.S. customary units used in engineering?
- What are some innovative ways to demonstrate application of pressure?
- What resources are available to investigate application of pressure?

Task Number 69

Explore electrical systems.

Definition

Exploration should include

- demonstrating the effect of resistance
- applying Ohm's Law, Watt's Law, and Kirchhoff's Law
- identifying series, parallel, and combination circuits
- applying knowledge of AC and DC systems
- identifying the uses and types of inductors and capacitors
- using appropriate electrical units to solve problems
- drawing a circuit diagram and layout the circuit
- identifying the difference between analog and digital signals
- identifying electrical components and their functions.

Process/Skill Questions

- Why is knowledge of the physics concepts related to voltage in an electrical energy system necessary for all engineers, not just electrical engineers?

- Why are both SI units and U.S. customary units used in engineering?
- What are some innovative ways to demonstrate application of voltage?
- What resources are available to investigate application of voltage?
- What is a parallel circuit? What is a series circuit?
- What is Ohm's Law? What is Watt's Law? What is Kirchhoff's Law?

Task Number 70

Identify the primary concepts and components of thermodynamic systems.

Definition

Identification should include

- identifying the three ways heat is transferred
- explaining the difference between Celsius and Fahrenheit scales
- describing heat conductors and insulators
- solving thermal problems using appropriate units
- identifying direction of heat flow given differences in temperature
- understanding the use of insulation to minimize heat flow.

Process/Skill Questions

- Why is knowledge of the physics concepts related to temperature difference in a thermal energy system necessary for all engineers?
- Why are both SI units and U.S. customary units used in engineering?
- What are some innovative ways to demonstrate application of temperature difference?
- What resources are available to investigate application of temperature difference?
- What are some common endothermic processes?
- What are some common exothermic processes?

Applying the Engineering Design Process

Task Number 71

Identify the need for a product or system.

Definition

Identification should include

- identifying the need or opportunity for an engineering solution
- defining an engineering design problem
- identifying the requirement and constraints of the design problem.

Process/Skill Questions

- Why are new things invented or innovations made?
- How is the need for a product or system defined as an engineering problem?
- What are constraints?

Task Number 72

Explain the validity of designing alternative solutions to an engineering design problem.

Definition

Explanation should include the

- reason multiple solutions are possible and encouraged
- benefits of exploring alternative solutions (one correct answer/process vs. multiple answers/processes).

Process/Skill Questions

- What is the advantage of generating more than one solution to a problem?
- Is there a right solution to any problem? Explain.
- How are decisions made to narrow down potential solutions?

Task Number 73

Design an engineering solution to a real-world problem.

Definition

Design should include

- researching potential solutions
- generating multiple solutions
- sketching the solutions
- evaluating the design against the requirements and constraints

- justifying an optimal solution.

Process/Skill Questions

- How is a real-world problem defined?
- What role does research play in designing a solution?
- How does one justify an optimal solution?

Task Number 74

Implement the design.

Definition

Implementation should include

- creating a model or prototype for the chosen solution to the design problem, using appropriate materials and processes
- determining the objectives for an engineering test of the solution
- testing the solution, using mathematical, conceptual, and/or physical modeling, simulating, and optimizing
- evaluating the test results.

Process/Skill Questions

- Why should testing be considered before creating a model or prototype?
- How might one use a mathematical model to test a solution?
- What steps need to be taken if the model does not pass the engineering test?

Task Number 75

Iterate the design.

Definition

Iteration should include

- formulating an alternate solution
- iterating on the design
- testing the alternate solution
- documenting the final project report.

Process/Skill Questions

- How should an alternate solution be chosen?
- When iterating a design, why might an alternate solution not be chosen?
- How many times should an alternate decision be tested? Why?

Task Number 76

Maintain documentation.

Definition

Maintenance of documentation (e.g., sketches, notes, reports) should include

- collecting documents, files, and project data that contain information to record performance
- providing a record of progress and self-assessment
- keeping an up-to-date work log or journal
- maintaining a design notebook or portfolio project binder/project file.

Process/Skill Questions

- When should documentation of a project begin?
- Why is it important to keep a record of work on real-world problems?
- How should a work log be maintained?

Task Number 77

Present a solution.

Definition

Presentation should use multimedia elements and include

- an introduction, thorough presentation of points, and a conclusion
- a persuasive tone and strategy
- a realistic/practical approach to the solution and results
- a display of proficient communications skills, professional demeanor, and confidence.

Process/Skill Questions

- How is a presentation of a solution like a sales pitch?
- Should all work on the project be presented? Why or why not?
- What are some examples of professional demeanor?

Demonstrating College Readiness Skills

Task Number 78

Evaluate study skills needed by an engineering student.

Definition

Evaluation should include

- reasons why each skill and habit is important/essential
- ways to enhance each skill and increase each habit.

Process/Skill Questions

- Why is it crucial for an engineering student to have excellent study skills and habits?
- What resources are available to help one evaluate one's study skills and habits and improve those that are weak?
- What steps can one take to increase one's interest in learning necessary material?
- How can one more closely align what one wants to do with what one needs to do?

ITEEA National Standards

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

TSA Competitive Events

Engineering Design

Task Number 79

Demonstrate teamwork skills necessary for success when working in a technological team.

Definition

Demonstration should include

- contributing to the success of the engineering design team (e.g., brainstorming solutions, volunteering, performing in accordance with an assigned role)
- assisting others (e.g., supporting team members and leaders, taking initiative).

Process/Skill Questions

- What team skills are helpful at school? In the workplace?
- What are typical roles of team members?
- What are the consequences of using the strengths of team members? Of not using the strengths of team members?
- What can one do to integrate a new person into a group or team?
- How can a team move forward if a team member is acting in the competing mode and refuses to compromise?

ITEEA National Standards

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

TSA Competitive Events

Animatronics

Chapter Team

Computer Integrated Manufacturing (CIM)

Engineering Design

Geospatial Technology (Virginia only)

Structural Design and Engineering

System Control Technology

Technology Problem Solving

SOL Correlation by Task

39	Describe how engineering and technology have significantly influenced contemporary society and the environment.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.9, GOVT.15, VUS.13, VUS.14, WHII.13, WHII.14 Science: PH.4
40	Explore career opportunities for the engineering graduate, both within and outside the field of engineering.	English: 10.5, 10.8, 11.5, 11.8, 12.5, 12.8
41	Examine the breadth of topics within an engineering plan of study.	English: 10.5, 11.5, 12.5
42	Explain application of ethics within the field of engineering.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.1, GOVT.16
43	Identify the benefits of a case study analysis.	English: 10.5, 11.5, 12.5
44	Perform a case study analysis.	English: 10.8, 11.5, 11.8, 12.5, 12.8 Science: PH.3
45	Apply measuring skills using instrumentation.	Science: PH.2
46	Demonstrate conversion techniques for units of measurement.	Science: PH.1
47	Demonstrate the use of engineering design graphics and descriptive geometry.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Mathematics: G.14, MA.7 Science: PH.2
48	Demonstrate the techniques and benefits of sketching.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.1, VUS.1, WHII.1 Mathematics: G.3, G.14 Science: PH.2
49	Sketch orthographic and isometric projections.	Mathematics: G.3, G.14
50	Demonstrate research techniques/strategies used by engineers.	English: 9.8, 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 History and Social Science: GOVT.1, VUS.1, WHII.1
51	Define *risk* and *safety*.	English: 10.3, 11.3, 12.3
52	Describe the three types of accidents.	English: 10.5, 11.5, 12.5
53	Identify major precursors of accidents.	English: 10.5, 11.5, 12.5

54	Evaluate the safety of designs.	Mathematics: COM.3 Science: PH.1
55	Reverse-engineer a product, process, or idea.	English: 10.5, 11.5, 12.5
56	Define *algorithm*.	English: 10.3, 11.3, 12.3
57	Create an algorithm to solve an engineering problem.	Mathematics: AFDA.1, AFDA.3, AFDA.4, AII.6, AII.7, AII.9, AII.10, COM.1, COM.4, COM.5, COM.6, COM.8, COM.9, COM.13, COM.14, COM.15, DM.8, DM.10, DM.5*, MA.2, MA.3, MA.7, MA.11, MA.14
58	Explain the benefits of modeling and simulation.	English: 10.5, 11.5, 12.5 Mathematics: COM.1, COM.3, COM.5, COM.8, COM.10, COM.17, COM.18 Science: PH.1
59	Explain rapid prototyping to develop models.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
60	Create a model or simulation for an engineering product, process, or idea.	English: 10.1, 10.5, 11.1, 12.1, 12.5 Mathematics: AFDA.1, AFDA.2, AFDA.3, AFDA.4, AII.3, AII.6, AII.7, AII.8, AII.9, AII.10, COM.1, COM.4, COM.6, COM.8, COM.14, COM.15, MA.2, MA.3, MA.7, MA.10, MA.11
61	Write a business letter to request information or materials.	English: 10.6, 10.7, 11.6, 11.7, 12.6, 12.7
62	Present an oral technical report on an engineering project.	English: 10.1, 11.1, 12.1 History and Social Science: GOVT.1, VUS.1, WHII.1
63	Participate in a mock interview.	English: 10.1, 11.1, 12.1
64	Explain applications of mathematics in the engineering design process.	English: 10.5, 11.5, 12.5 Mathematics: A.1, A.4, A.7, A.9, G.11, G.12, AFDA.1, AFDA.3, AFDA.4, AFDA.5, AII.3, AII.4, AII.5, AII.6, AII.7, AII.10, COM.4, MA.4, MA.7, PS.8*, PS.12* Science: PH.1
65	Explain applications of scientific principles.	English: 10.5, 11.5, 12.5 Science: PH.1
66	Explain applications of investigative technology.	English: 10.5, 11.5, 12.5

67	Identify the primary concepts and components of mechanical systems.	English: 10.5, 11.5, 12.1 Science: PH.5, PH.7
68	Identify the primary concepts and components of fluid energy systems.	English: 10.5, 11.5, 12.5 Science: PH.7
69	Explore electrical systems.	English: 10.5, 11.5, 12.5 Science: PH.11
70	Identify the primary concepts and components of thermodynamic systems.	English: 10.5, 11.5, 12.5 Science: PH.7
71	Identify the need for a product or system.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5
72	Explain the validity of designing alternative solutions to an engineering design problem.	English: 10.5, 11.5, 12.5
73	Design an engineering solution to a real-world problem.	English: 10.5, 10.8, 11.5, 11.8, 12.5, 12.8
74	Implement the design.	English: 11.5, 12.5 Mathematics: AFDA.1, AFDA.2, AFDA.3, AFDA.4, AII.3, AII.6, AII.7, AII.8, AII.9, AII.10, COM.1, COM.4, COM.6, COM.8, COM.14, COM.15, COM.17, MA.2, MA.3, MA.7, MA.10, MA.11
75	Iterate the design.	
76	Maintain documentation.	English: 10.6, 10.7, 11.6, 11.7, 12.6, 12.7 Science: PH.1
77	Present a solution.	English: 10.1, 11.1, 12.1
78	Evaluate study skills needed by an engineering student.	English: 10.5, 12.5
79	Demonstrate teamwork skills necessary for success when working in a technological team.	English: 10.1, 11.1, 12.1 History and Social Science: GOVT.1, GOVT.16, VUS.1, WHII.1

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

- Autodesk Certified User Examinations
- Certified SOLIDWORKS Associate (CSWA) Examination
- College and Work Readiness Assessment (CWRA+)
- Engineering Technology Examination
- Manufacturing Technician Level I Certification Examination
- National Career Readiness Certificate Assessment
- Pre-Engineering Certification Examinations
- Pre-Engineering/Engineering Technology 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.*

- Engineering Explorations I (8450/36 weeks)
- Engineering Practicum IV (8453/36 weeks)

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Aerospace Engineer** **Aerospace Engineering Technician** **Agricultural Engineer** **Architect** **Assembler** **Biomedical Engineer** **Chemical Engineer** **Civil Engineer** **Civil Engineering Technician** **Commercial and Industrial Designer** **Computer Hardware Engineer** **Computer Programmer** **Computer Software Engineer** **Electrical Engineer** **Electrical Engineering Technician**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
	Electro-Mechanical Technician **Electronics Engineering Technician** **Engineer** **Engineering Manager** **Engineering Technician** **Environmental Engineer** **Human Factors Engineer** **Industrial Engineer** **Industrial Engineering Technician** **Landscape Architect** **Manufacturing Systems Engineer** **Marine Engineer** **Materials Engineer** **Mechanical Drafter** **Mechanical Engineer** **Mechanical Engineering Technician** **Network and Computer Systems Administrator** **Network Systems and Data Communication Analyst** **Nuclear Engineer** **Petroleum Engineer** **Power Systems Engineer** **Production, Planning, Expediting Clerk** **Project Manager** **Quality Engineer** **Quality Technician** **Statistician** **Systems Analyst** **Technical Writer** **Telecommunications Specialist** **Transportation Manager**
Science and Mathematics	**Atmospheric Scientist** **Ecologist** **Environmental Scientist** **Geoscientist** **Hydrologist** **Materials Scientist** **Oceanographer** **Research Chemist** **Secondary School Teacher** **Technical Writer** **Toxicologist** **Veterinarian** **Veterinary Assistant**