Engineering Drawing and Design

8436/36 weeks
8493/18 weeks

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Acknowledgments

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- Leanne Forbes Tipton, Writer/Editor
Course Description

Suggested Grade Level: 10 or 11 or 12

Students use graphic language for product design, technical illustration, evaluation of designs, and engineering drawings. They increase their understanding of drawing techniques learned in Technical Drawing and Design (8435/8434) and Architectural Drawing and Design (8437/8492). Students use computers, calculators, and descriptive geometry and adhere to established standards to solve design problems. They work in teams to design solutions for an identified need and to produce parts on a 3D printer.

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.

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<thead>
<tr>
<th>Task Number</th>
<th>8436 36 wks</th>
<th>8493 18 wks</th>
<th>Tasks/Competencies</th>
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<tr>
<td>39</td>
<td>☂</td>
<td>☂</td>
<td>Define engineering drawing.</td>
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<tr>
<td>40</td>
<td>☂</td>
<td>☂</td>
<td>Describe the engineering design process.</td>
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<tr>
<td>41</td>
<td>☂</td>
<td>☂</td>
<td>Apply the engineering design process.</td>
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<td>42</td>
<td>☂</td>
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<td>Investigate engineering-related careers.</td>
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<td>43</td>
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<td>Describe ethical practices regarding drawing and information acquisition.</td>
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<td>44</td>
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<td>☂</td>
<td>Acquire specification information, using a reference library of technical data.</td>
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<td>45</td>
<td>☂</td>
<td>☂</td>
<td>Apply English and metric measuring devices and systems.</td>
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<td>46</td>
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<td>Create objects, using solid modeling.</td>
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<td>Task Number</td>
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<tr>
<td>47</td>
<td></td>
<td>🔗 Apply mathematical formulas to engineering drawings.</td>
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<td><strong>Producing Illustrations</strong></td>
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<tr>
<td>48</td>
<td></td>
<td>🔗 Prepare freehand technical sketches.</td>
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<td>🔗 Create auxiliary views and revolutions.</td>
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<td>🔗 Create development drawings.</td>
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<td>🔗 Construct models from combined geometric shapes created from development drawings.</td>
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<tr>
<td>52</td>
<td></td>
<td>🔗 Apply advanced principles of dimensioning and annotation.</td>
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<td>🔗 Prepare drawings of parts that transfer energy or motion in mechanical systems.</td>
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<td>🔗 Create examples of mechanical, fluid, and/or electrical/electronic schematic drawings.</td>
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Legend: 🔗Essential 🔓Non-essential 🔎Omitted

**Curriculum Framework**

**Introducing the Design Process**

**Task Number 39**

**Define engineering drawing.**

**Definition**

Definition should include the fact that engineering drawing is the primary method of communication relating to the design and understanding of ideas. It is used to fully and clearly define requirements for engineered items created in engineering disciplines.

**Process/Skill Questions**

- What is engineering drawing and design?
- How has engineering drawing and design affected our society in the areas of transportation and manufacturing?
- What is the role of engineering drawing and design in our society today?
- How are engineering drawings part of legal contractual agreements?
Describe the engineering design process.

Definition
Description should include the concept that the engineering design process is an iterative, creative process for solving problems concerning real objects, products, systems, and environments. The steps of the process include

- identification of a design problem
- identification of criteria and constraints
- creation of multiple designs
- evaluation of the designs
- refinement of designs
- development of a product or system using criteria and constraints for quality control
- reevaluation of final solutions.
- establishing a system of documentation for monitoring workflow.

Teacher resource:
Engineering Design Process, University of Colorado at Boulder

Process/Skill Questions
- How can design problems be identified?
- Why should you research a problem?
- What are the types of problems that concern engineers?
- Why is it important to identify criteria and constraints?
- What techniques are used to refine a design?
- How can a design be evaluated?
- What is quality control?
- Why should final solutions be reevaluated? How is this done?

ITEEA National Standards
- STEL 2, 6, 7

TSA Competitive Events
- CAD Engineering

Task Number 41
Apply the engineering design process.

Definition
Application should include

- identifying a design problem
- identifying criteria and constraints
- creating and refining designs
- considering optimization and trade-offs
• evaluating designs
• developing a product or system using criteria and constraints and quality control
• reevaluating solution(s).

Application may also include
• using analysis features of computer-aided design (CAD) software to improve a digital prototype (simulation, stress analysis)
• designing parts using mathematical parameters
• modifying parameters to update designs of parts or systems
• creating physical models or prototypes from digital designs.

Process/Skill Questions
• What are the steps in the engineering design process?
• Why should a design be tested throughout the engineering process?
• What problems did you find with the model while reevaluating it?

ITEEA National Standards
• STEL 7

TSA Competitive Events
• CAD Engineering

Exploring Engineering Design Foundations

Task Number 42
Investigate engineering-related careers.

Definition
Investigation should include a variety of methods, which may include interviews, Internet searches, mentorships, internships, and documentation research.

Process/Skill Questions
• What are the major areas of engineering?
• How is civil engineering drawing different from mechanical engineering drawing?
• What are the educational requirements to become a marine engineer?
• What are the educational requirements to become a mechanical engineer?

ITEEA National Standards
• STEL 3

TSA Competitive Events
• STEM Careers

Task Number 43
Describe ethical practices regarding drawing and information acquisition.

Definition
Description should include issues such as
• copyright
• property rights
• honesty
• theft
• plagiarism.

Process/Skill Questions
• Why is copyright an issue in the drawing and design industry?
• What is plagiarism?
• What is intellectual property?

ITEEA National Standards
• STEL 3, 8

TSA Competitive Events
• Technology Bowl

Task Number 44
Acquire specification information, using a reference library of technical data.

Definition
Acquisition should use various sources, which may include
• instructor handouts
• machinist handbook
• reference tables from text(s)
• online databases and libraries.

Students will organize data through the use of drawing files, spreadsheets, and other technical data. They may use notebooks, electronic storage devices, and manuals.

Process/Skill Questions
• What may be included in a reference library?
• What is technical data?
• What are the steps for copying, moving, and deleting drawing files?
• How are files merged?

ITEEA National Standards
• STEL 3

TSA Competitive Events
• Technology Bowl

Task Number 45
Apply English and metric measuring devices and systems.
Definition
Application should include engineer’s scale, metric scale, decimal measurement, and fractional measurement.

Process/Skill Questions
- What measurement system is used in Europe?
- What is the purpose of scale?
- What are some of the common scales used in engineering and why are they used?
- What are some of the common scales used in architecture?
- What is the scale of some example drawings, and what units are being used?

ITEEA National Standards
- STEL 2, 3

TSA Competitive Events
- CAD Engineering

Task Number 46
Create objects, using solid modeling.

Definition
Creation should include a review of solid modeling concepts. Solid modeling may include
- extruding a model
- revolving a model
- intersecting a model
- subtracting a model
- slicing a model
- sweeping a model
- constructing three dimensional (3D) faces
- arraying a 3D feature
- mirroring a 3D feature.

Process/Skill Questions
- What is solid modeling?
- What is an advantage of parametric software?
- What is the difference between a surface model and a solid model?
- How is an orthographic projection created from a solid model?
- What are the types of tests we can perform on solid models?
- What information is available from a solid model?
- How are patterns and arrays used in engineering design?
- What is the difference between a sketch and a feature?
- What is the difference between surfaces and solids?

ITEEA National Standards
- STEL 8

TSA Competitive Events
- CAD Engineering

Task Number 47
Apply mathematical formulas to engineering drawings.

**Definition**

Application of formulas may be used to

- determine dimensions by parametric constraints
- determine the scale of a drawing
- convert unit systems
- determine the depth of threads of a fastener and the pitch of a threaded fastener
- calculate true length and width of an inclined or oblique plane
- calculate gear ratios and the number of teeth on a gear.

**Process/Skill Questions**

- What is the definition of parameter?
- How might a spreadsheet be used to link parameters to an engineered part drawing?
- What are the factors to consider when choosing a scale of a drawing?
- How are auxiliary views and revolutions used to show the true length and width of inclined and oblique planes?
- How is the number of teeth on a gear related to the gear ratio?
- How can you solve to find a missing angle?
- How can you find the hypotenuse of a triangle?

**ITEEA National Standards**

- STEL 3

**TSA Competitive Events**

- CAD Engineering

Producing Illustrations

**Task Number 48**

Prepare freehand technical sketches.

**Definition**

Preparation should reflect the concept that technical sketching is the recording of multiple views of preliminary ideas to solve a given design problem. Sketches may include

- pictorial
- multi-view
- sections
- auxiliary
- patterns
- geometric constructions.

**Process/Skill Questions**

- What are four types of sketches?
- What are the steps in sketching circles and arcs?
- How much emphasis should be placed on accuracy/detail when dealing with freehand drawings?

**ITEEA National Standards**

- STEL 2
TSA Competitive Events

- CAD Engineering
- Computer Integrated Manufacturing (CIM)

Task Number 49
Create auxiliary views and revolutions.

Definition
Creation should include the concept that auxiliary views and revolutions are used to describe the true shape of inclined and oblique planes and should include

- choosing the primary orthographic view from which the auxiliary view is projected
- demonstrating that the edge view of the inclined surface is perpendicular to one of the three principal planes
- establishing a projection plane parallel to the inclined surface
- identifying the true length, depth, or height in the primary (orthographic) view
- illustrating the true size and shape of all features in the auxiliary view.

Process/Skill Questions

- What is an auxiliary view, and for what is it used?
- What are the steps in drawing auxiliary views?
- Why should one not dimension an inclined plane when it is displayed on an orthographic projection?
- Why would secondary auxiliary views be needed?

ITEEA National Standards

- STEL 8

TSA Competitive Events

- CAD Engineering

Task Number 50
Create development drawings.

Definition
Creation should show the complete surface or surfaces of an object laid out on a flat plane. These may include

- products made of different materials (e.g., sheet metal, plastic)
- parallel-line development
- cylindrical surfaces
- conical surfaces
- radial-line development
- development of curved surfaces through triangulation
- spheres
- intersecting prisms
- tabs and fold lines.

Process/Skill Questions

- What is the purpose of a surface development?
- What is a line of intersection?
What tools and options in CAD enable us to create the pattern for a cylinder or a rectangular pyramid?

ITEEA National Standards
- STEL 3, 8

TSA Competitive Events
- CAD Engineering

Task Number 51

Construct models from combined geometric shapes created from development drawings.

Definition
Construction should include the intersection of shapes such as
- cylinders
- spheres
- prisms
at varied angles.

Process/Skill Questions
- How do parts with different geometric shapes intersect?
- How does the intersection of shapes affect the development of systems?
- What other manufacturing factors may affect design of parts and systems?

ITEEA National Standards
- STEL 8

TSA Competitive Events
- CAD Engineering

Task Number 52

Apply advanced principles of dimensioning and annotation.

Definition
Applications may include
- fillets and rounds
- datums
- surface texture
- tolerances
- associative geometric dimensions and tolerances
- welding or other field-specific schematics.

Process/Skill Questions
- What basic information is given by dimensions?
- What are the consequences of incorrect dimensioning?
- What is a location dimension?
- When are associative dimensions applied?
• What is a datum?
• What is tolerancing?

ITEEA National Standards
• STEL 8

TSA Competitive Events
• CAD Engineering

Task Number 53

Prepare drawings of parts that transfer energy or motion in mechanical systems.

Definition
Preparation should include calculating formulas. Parts that transfer energy or motion may include

• cams
• gears
• belts
• linkages
• shafts.

Process/Skill Questions
• What is a cam?
• What are the various types of cams?
• What are the types of motions that can be produced by cams?
• What are the various types of gears?
• How do engineers apply gear formulas to solve problems and transfer motion between mechanical parts?
• What are the commands and options in CAD software that help to illustrate the path of a cam or the teeth of a gear?
• What is a cam displacement diagram, and for what is it used?
• How is the curve on a spur gear tooth developed?
• What is an involute curve of a gear tooth?

ITEEA National Standards
• STEL 3, 8

TSA Competitive Events
• CAD Engineering
• Computer Integrated Manufacturing (CIM)

Task Number 54

Create examples of mechanical, fluid, and/or electrical/electronic schematic drawings.

Definition
Creation may include

• welding processes,
• structural drawings,
• fluid drawings (e.g., pipes)
• HVAC layouts
• electrical or electronic schematics.

Process/Skill Questions
• What is the purpose of schematic drawings?
• How are these drawing types interrelated?
• How are symbols portrayed in different types of drawings?
• What consideration is given to scale in these drawings?

ITEEA National Standards
• STEL 8

TSA Competitive Events
• CAD Architecture
• CAD Engineering
• Computer Integrated Manufacturing (CIM)

Task Number 55
Use descriptive geometry to solve problems.

Definition
Utilization should include the idea that descriptive geometry is primarily used to graphically illustrate mathematical problems and may include
• revolutions,
• multi-auxiliary
• secondary auxiliary views.

Process/Skill Questions
• What is descriptive geometry?
• What is the definition of referenced planes, reference line, and axis of revolution?
• What type of auxiliary view would be needed to show the true shape of an oblique surface?
• What steps lead to a view with the most information?

ITEEA National Standards
• STEL 3, 8

TSA Competitive Events
• CAD Engineering
• Computer Integrated Manufacturing (CIM)

Task Number 56
Design an assembly and prepare working drawings as part of a design team.
Definition
Design should include assembly and working drawings necessary to help visualize the relationship between parts. Assembly and working drawings may include:

- design assembly
- installation assembly
- detail drawings
- item lists (bills of materials)
- notes and specifications
- exploded assemblies
- machining information
- manufacturing processes
- sub-assembly.

Process/Skill Questions

- What are the differences among design assembly drawings, design assembly, and installation assembly?
- What is an identification part number, and what is its function?
- What manufacturing processes will be used to create the product?
- What does the bill of materials display?
- What types of views should be created to fully describe this product or system?

ITEEA National Standards
- STEL 7

TSA Competitive Events
- CAD Engineering
- CIM (Computer Integrated Manufacturing)

Task Number 57

Develop design ideas using freehand multi-view and pictorial sketches.

Definition
Development should include sketching parts of a device the students will assemble from one another's work, or parts of an assembly.

Process/Skill Questions

- Why does a design team work with sketches before starting formal drawings?
- How can components fit together if they are manufactured in different locations?
- What role does tolerance dimensioning have in a successful product design?
- What role does knowledge of material play in design?

ITEEA National Standards
- STEL 2

TSA Competitive Events
- CAD Engineering
- Computer Integrated Manufacturing (CIM)

Task Number 58
Create parts of the assembly using a 3D printer.

Definition
Creation should include individual parts of the assembly prepared by team members. Parts should fit together as a complete assembly.

Process/Skill Questions
- Why is it important to consider manufacturing processes when designing?
- What part of the design process must be revisited if the parts of an assembly do not fit?
- What role does tolerance play in designing?

ITEEA National Standards
- STEL 8

TSA Competitive Events
- CAD Engineering
- Computer Integrated Manufacturing (CIM)

Task Number 59
Present a design solution to explain an engineered system.

Definition
Presentation may include
- graphic representations of the engineered system
- discussion of the system
- problems encountered during the construction of the system
- historical background of the system
- examples of related systems
- details about the parts of the system and how they are interrelated.

Process/Skill Questions
- What are some engineered systems in history that contributed to the system being discussed?
- How does the system work?
- What are the constraints of the system?
- What are some engineered systems that are similar to this one?

ITEEA National Standards
- STEL 3, 8

TSA Competitive Events
- CAD Engineering
- CIM (Computer Integrated Manufacturing)

SOL Correlation by Task

<table>
<thead>
<tr>
<th>Define engineering drawing</th>
<th>English: 10.5, 11.5, 12.5</th>
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<td>English: 10.5, 11.5, 12.5</td>
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<td>Science: BIO.1, CH.1</td>
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<td>Activity</td>
<td>Subjects</td>
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<td>Apply the engineering design process.</td>
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<td>Prepare freehand technical sketches.</td>
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Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials (Only apply to 36-week courses)

- Autodesk Certified Professional Examinations
- Autodesk Certified User Examinations
- Certified SOLIDWORKS Associate (CSWA) Examination
- College and Work Readiness Assessment (CWRA+)
- Mechanical Drafting and Design Assessment
- National Career Readiness Certificate Assessment
- Technical Drafting Examination
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.

- Advanced Drawing and Design (8438/36 weeks)
- Architectural Drawing and Design (8437/36 weeks)
- Architectural Drawing and Design (8492/18 weeks)
- Digital Visualization (8459/36 weeks)
- Technical Drawing and Design (8434/18 weeks)
- Technical Drawing and Design (8435/36 weeks)

Career Cluster: Science, Technology, Engineering and Mathematics

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<td>Commercial and Industrial Designer</td>
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