Advanced Drawing and Design

8438/36 weeks

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Acknowledgments

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- Leanne Forbes Tipton, Writer/Editor
- Kevin P. Reilly, Administrative Coordinator
Course Description

Suggested Grade Level: 11 or 12

Students use graphic language for product design and technical illustration. They increase their understanding of drawing techniques learned in the Technical Drawing and Design (8435/8434), Engineering Drawing and Design (8159) and Architectural Drawing and Design (8437/8492). Students research design-related fields while identifying the role of advanced drawing and design in manufacturing and construction industry processes. They apply the design process, analyze design solutions, reverse engineer products, create 3D solid models using computer-aided design (CAD), construct physical models, and create multimedia presentations of finished designs. Students will complete a work portfolio based on a chosen graphic project.

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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**Focusing on Drawing**

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<th>Create 3D model parts using CAD.</th>
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<td>Generate multi-view orthographic projections from a 3D design model.</td>
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<td>Generate schedules.</td>
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<td>Generate sectional views.</td>
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<td>Draw a thread detail.</td>
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<td>10</td>
<td>Design parts and assembly drawings using coordinate systems.</td>
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<td>11</td>
<td>Dimension drawings, according to the standards of ANSI (American National Standards Institute), ISO (International Standards Organization), U.S. military standard (MIL), U.S. Department of Defense (DOD) and NCS (National CAD Standards).</td>
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<td>Demonstrate the use and manipulation of styles.</td>
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**Focusing on Documentation**

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<td>Investigate inventive methods of documentation.</td>
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**Maintaining Professionalism**

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<th>Describe ethical issues in the design industry.</th>
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<td>Identify the role of advanced drawing and design in manufacturing and construction industry processes.</td>
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<td>Present a complete electronic work portfolio.</td>
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Legend: ✭Essential ✩Non-essential ☛Omitted

**Curriculum Framework**
Focusing on Design

Task Number 39
Research design-related fields.

Definition

Research should include

- comparison of careers within fields
- colleges that offer design-related programs of study
- employment requirements (education, licenses, certifications, credentials)
- career prospects (on national, state, and local levels)
- professional expectations (compensation, work environment, personal issues, advancement)
- state, national, and global community interaction.

Many websites offer career exploration resources.

Process/Skill Questions

- What is included in a typical compensation package?
- How might a professional demonstrate his or her credentials and achievements in a business meeting?
- What are the credentials, certifications, licenses, and/or educational requirements for a specific job opening?
- How is the safety of others a professional concern in the field of drawing and design?

ITEEA National Standards

- STEL 3

TSA Competitive Events

- STEM Careers (Virginia only event)

Task Number 40
Identify advanced drawing and design terminology.

Definition

Identification should include terms in the following areas:

- Design
- Drawing
- Design process
- Drawing tools
- Computer-aided design (CAD)
- Construction
- Manufacturing (e.g., additive and subtractive)
- Engineering
- Architecture (e.g., commercial and residential)
- Reverse engineering
- Building information modeling (BIM)
• Parametric modeling
• Generative design

Process/Skill Questions
• What are examples of ethical dilemmas one might face in engineering and architectural design?
• What impact does architectural drawing have on construction?
• What are flowcharts?
• How do standards influence engineering?
• What are the different types of engineering?
• What are working drawings?
• How do working drawings differ in various types of engineering?
• What is the advantage of BIM?
• What is the difference between the two-dimensional 2D and three-dimensional (3D) workflow?

ITEEA National Standards
• STEL 8

TSA Competitive Events
• Architecture Design
• CAD Engineering
• CAD Architecture
• Technology Bowl

Task Number 41
Explain the engineering design process.

Definition
Explanation may include the following iterative steps:

• Identify the need or opportunity for an engineering solution by listing the criteria and constraints.
• Establish a system for documentation of workflow.
• Research potential solutions to the design problem.
• Generate (brainstorm) multiple solutions to the design problem.
• Justify an optimal solution to the design problem.
• Create a model or prototype for the chosen solution to the design problem, using appropriate materials and processes.
• Test the solution to the design problem, using mathematical, conceptual, and/or physical modeling, simulating, and optimizing.
• Redesign the solution.
• Test the alternate solution.
• Communicate the solution and results.

Process/Skill Questions
• Why is it important to follow an iterative design process?
• Why is it important to repeat the steps of the design process?
• When is it necessary to refine the design?
• What is concurrent engineering and how does it affect the design process?
Task Number 42

Analyze design solutions.

Definition

Analysis should include

- annotations
- criteria and constraints
- form and function
- quality control
- critiques (made by self, jury, community, superior, or instructor)
- aesthetic quality
- spatial plan.

Process/Skill Questions

- What are the criteria used to evaluate successful design?
- What guidelines should be followed to evaluate the design?
- Who passes final judgment on the success of the design implementation?

Task Number 43

Implement a design process.

Definition

Design process should include

- general understanding of the problem, including criteria and constraints
- brainstorming ideas
- sketching ideas and solutions
- producing necessary technical drawings and documentation
- producing working drawings
- evaluating and analyzing final design
- maintaining a design portfolio.
Process/Skill Questions

- What are different forms of documentation used in the design process?

ITEEA National Standards

- STEL 7

TSA Competitive Events

- CAD Architecture
- CAD Engineering
- Computer Integrated Manufacturing (CIM)

Task Number 44

Justify calculations and assumptions made during the design process.

Definition

Justification should include

- examples of research of similar design problems and solutions to obtain supporting data
- software simulation of material/structural testing
- use of the design process model
- mathematical calculations of specific materials used.

Process/Skill Questions

- Why is it important to provide information to justify production decisions?
- What are the steps in the design process model?
- What external forces or conditions might affect a design?
- What has made similar designs succeed or fail, and how does this design compare?

ITEEA National Standards

- STEL 3, 7

Task Number 45

Prepare freehand and electronic preliminary sketches.

Definition

Preparation should include

- pictorial views
- evolution of design iterations
- thumbnails
- selection of necessary views
- proportions
- design notes (explaining justification, philosophy, reasoning).
Process/Skill Questions

- What are some everyday products that are produced from designs?
- What are transition pieces?
- How does geometry play a role in developing designs?
- What pictorial drawings would be produced by an engineer? An architect?

ITEEA National Standards

- STEL 2, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Task Number 46

Develop skills related to using scale.

Definition

Development should include skills in

- overall drawing scale
- individual scale of views.
- How can the scale of a drawing affect its readability?

Process/Skill Questions

- Why are architectural drawings typically set to desired scale?
- Why are detailed drawings set at a larger scale?

ITEEA National Standards

- STEL 3, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Task Number 47

Use measuring skills.

Definition

Use of measuring skills should include

- proper implementation of tolerances
- conversion between units
- conversion between systems of measurement
- use of different types of scale (e.g., metric, SAE International, architecture)
- electronic measuring tools.
Process/Skill Questions

- How does the implementation of tolerances affect interchangeable parts in manufacturing?
- What are examples of catastrophes that could happen when two systems of measurement are used in a project?
- Which scales are used predominantly in which professions?

ITEEA National Standards

- STEL 3, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering
- Computer Integrated Manufacturing (CIM)

Task Number 48
Create a 3D design model of an object.

Definition

Creation should include

- dimensions
- specifications
- proportions
- spatial relationships
- interferences
- physical properties
- structural strength.

Creation should also include the order and number of steps used to build the model using computer-aided design (CAD).

Process/Skill Questions

- What is parametric modeling?
- What measurements are needed to create a proportional drawing (enlargement or reduction) of an object?
- How do the geometric components of a model manifest design concerns?
- What are some of the results of spatial relationships?
- How can analyzing interference in a 3D assembly save money?

ITEEA National Standards

- STEL 8

TSA Competitive Events

- CAD Engineering
Task Number 49

Analyze multi-drawing sets.

Definition

Analysis should include

- interferences
- fit and function
- compatibility of systems
- drawing coordination
- drawing interpretation.

Process/Skill Questions

- Why is scale (scaling) important in multi-drawing sets?
- What types of products/designs might necessitate multi-drawing sets?
- Why are standards important when collaborating on a set of drawings?
- What drawings are typically included in a set of construction documents for a house?
- How is the basic hole system used to control fits and function?

ITEEA National Standards

- STEL 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering
- Computer Integrated Manufacturing (CIM)

Task Number 50

Present design ideas.

Definition

Presentation should include

- visual aids
- clear description of solution
- use of multimedia
- proper documentation and selection of drawings.

Process/Skill Questions

- How can a new design be presented?
- What media can be used for 3D presentations?

ITEEA National Standards

- STEL 3, 8
TSA Competitive Events

- CAD Engineering

Task Number 51

Reverse engineer products.

Definition

Reverse engineering should include the following steps:

- Analyze the product (throughout the process).
- Disassemble the product.
- Measure the parts and assembly.
- Create a series of working drawings.
- Improve the product design
- Present the product
- Reevaluate product improvement.

Process/Skill Questions

- What tools are used to acquire accurate measurements to .001in.?
- Why is dimensioning important in reverse engineering?
- Why are multi-view drawings necessary in reverse engineering?
- Why are constant evaluation and updating ultimately beneficial to product refinement?
- Why might a company decide to redesign or improve a product?

ITEEA National Standards

- STEL 8

TSA Competitive Events

- Computer Integrated Manufacturing (CIM)

Task Number 52

Construct physical models of designs.

Definition

Construction should include

- determination of the model scale
- selection of appropriate building materials
- operation of tools.

Process/Skill Questions

- What are some benefits of constructing models of a building or an assembly?
- How does constructing a model help the design process?
- How can an architect or engineer improve quality of life through his or her design?
- How has 3D printing revolutionized fabrication in industry?
ITEEA National Standards

- STEL 7, 8

TSA Competitive Events

- Dragster Design

Task Number 53

Develop proficiency reading working drawings.

Definition

Development should include

- identification of annotations
- graphic representations, such as
  - line weights
  - line types
  - hatches
  - symbols
- reading and interpretation of scales
- inclusion of necessary views and details.

Process/Skill Questions

- What qualities make up an effective working drawing notation?
- How does production rely on working drawings?
- What are some of the standard drawings included in a set of construction documents?
- What is the view plane for a floor-plan drawing?

ITEEA National Standards

- STEL 2, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Focusing on Drawing

Task Number 54

Create 3D model parts using CAD.

Definition

Creation should include

- embedding specifications
- sketching
- applying feature and dimensional constraints
- using modeling features
- generating dimensions and text
- using geometry

**Process/Skill Questions**

- Why is it beneficial to create computer models before creating drawings of designs?
- How is the scale for a model determined?
- How are models exported?
- How is the model for a 3D printer prepared?
- How are feature and dimensional constraints applied?
- How are specifications created?
- How are orthographic views from a solid model generated?

**ITEEA National Standards**

- STEL 8

**TSA Competitive Events**

- CAD Engineering

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**Task Number 55**

**Generate multi-view orthographic projections from a 3D design model.**

**Definition**

Generation should include

- rationale for choices of views
- required number of views to fully describe object
- a reference view
- pencil sketches before digital sketches
- symbols (e.g., centerlines, hidden lines, section lines, cutting-plane lines, materials)
- necessary references
- scale
- dimension conventions.

**Process/Skill Questions**

- What justifies a sectional-view drawing?
- How is the location of the sectional cutting-plane line determined?
- What determines the scale of a sectional view?
- When is a sectional view necessary?
- What is the difference between first- and third-angle projections?
- Where are first- and third-angle projections used?
- How is the front view of an object determined?
- How can the number of views be reduced and still fully describe an object?
- When are more than three views needed?

**ITEEA National Standards**

- STEL 8
Task Number 56
Create working drawings and sheet sets.

Definition
Creation should include

- index of sheet sets
- title blocks
- scale
- assembly view(s) with balloons and a parts list
- construction documents (for architectural drawings and sheet sets)
- all written and visual information necessary to construct the object accurately.

Process/Skill Questions
- What are the basic standards for a finished set of drawings? What must a finished set include?
- Why are sheet sets in a systematic order?
- What is the purpose of design notes?

ITEEA National Standards
- STEL 8

Task Number 57
Generate schedules.

Definition
Generation of schedules should include

- tables
- part numbers
- source
- materials
- codes and references
- building specifications (for architectural schedules)
- properties.

Process/Skill Questions
- What should be included in a specification schedule?
- What is a parts list?
- Why are materials identified for production?
• Why is it important to follow building codes?

ITEEA National Standards
• STEL 3, 8

Task Number 58
Render presentation designs.

Definition
Rendering should include

• lighting
• colors
• shadowing
• finishes
• backgrounds
• materials
• walk-through (architectural).

Process/Skill Questions
• What is the difference between line and shade rendering?
• How do color and texture impact drawings? Finishes? Backgrounds?
• What is the difference between a technical drawing and an illustration?
• What determines the type of view in which the rendering is created?
• When are one-, two-, and three-point perspectives used?
• How do colors, finishes, and textures impact presentations?
• What file type is most appropriate for digital presentations?
• How are digital graphic presentation files edited?

ITEEA National Standards
• STEL 3, 8

TSA Competitive Events
• CAD Architecture
• CAD Engineering

Task Number 59
Generate sectional views.

Definition
Generation should include

• a reference view
• symbols (plane lines, phantom lines, section lines, material)
• reference text
• cutting-plane lines
• dimensions and scale
• rationale.
Process/Skill Questions

- What justifies a sectional-view drawing?
- How is the decision made where the sectional cutting-plane line passes?
- What determines the scale of a sectional view?
- What are the types of sections and an example of each?
- When are hidden lines used?
- How are different materials represented by section lines?

ITEEA National Standards

- STEL 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Task Number 60

Draw a thread detail.

Definition

Drawing should include

- calculating thread dimension details
- creating a thread profile
- modeling a thread profile.

Thread representations communicate different graphic forms of thread patterns. This may include simplified, detailed, and schematic.

Process/Skill Questions

- What is a detailed thread representation?
- What are the differences among schematic, detailed, and simplified thread representations?
- How can a symbols library be used to illustrate drawings with threaded fasteners?
- How can 3D software be used to create a solid model of a screw thread?

ITEEA National Standards

- STEL 3, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Task Number 61

Design parts and assembly drawings using coordinate systems.

Definition

Design of parts and drawings should be developed using appropriate coordinate systems.
Process/Skill Questions

- What are the most common coordinate systems?
- What are the benefits and limitations for each of the common coordinate systems?
- Why is it necessary to show the path of the assembly?

ITEEA National Standards

- STEL 3, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Task Number 62


Definition

Dimensioned drawings should include

- location dimensions
- size dimensions
- minimum number of dimensions to construct the object accurately
- architectural or engineering style
- geometric dimensioning and tolerancing information data.

Process/Skill Questions

- What is the purpose of dimensioning a solid model?
- How are architectural or engineering objects dimensioned?
- How might manufacturing errors be managed through dimensioning?
- How does one determine where dimensions are placed?
- How does one determine the most appropriate dimensioning style?

ITEEA National Standards

- STEL 5, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering
Task Number 63

Demonstrate the use and manipulation of styles.

Definition
Demonstration should include using and manipulating

- text characteristics (e.g., size, font, color)
- dimension characteristics (e.g., sizes, scales, features, units)
- table characteristics (e.g., units, colors, formulas)
- materials (e.g., surface textures, transparency, reflectivity)
- scene appearance (e.g., background, hand drawn vs. CAD, line weight and jitter, shadow display, texture display).

Process/Skill Questions

- How are the appearances of dimensions controlled with varying scales?
- What is the advantage of having multiple styles/families?
- What is the effect of changing a style or family?
- How can the use of styles provide control over existing entities?
- How can the use of styles enhance multi-scale drawings?
- How can the use of styles affect renderings?

ITEEA National Standards

- STEL 3, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering
- Computer Integrated Manufacturing (CIM)

Focusing on Documentation

Task Number 64

Develop specification data.

Definition
Development of data should specify

- references
- materials
- parts list
- colors
- codes
- dimensions and tolerances
- quantities.

Process/Skill Questions

- What is the benefit of having a materials list?
Why are parts lists necessary?
What do building codes determine, and how do they affect design choices?
Why is it important to specify dimensions and tolerances on drawings?
How do design constraints affect specifications?
Where is specification data found in a database?

ITEEA National Standards
- STEL 8

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

Task Number 65
Use technical writing style in documentation.

Definition
Use of technical writing style should include attention to
- grammar
- usage
- content
- conciseness
- spelling.

Process/Skill Questions
- What is the difference between expository writing and technical writing?
- What is slang and why should it be avoided?
- Why are spelling, sentence structure, correct grammar, and precise usage crucial in technical writing?

ITEEA National Standards
- STEL 3, 8

TSA Competitive Events
- Technology Bowl

Task Number 66
Create a multimedia presentation of a finished design, incorporating animation files.

Definition
Creation should include
- a storyboard
• various manipulated images
• audio element(s) (e.g., music, narration, sound effects)
• transitions
• CAD solid models
• movie(s) or still clip(s)
• walk-through or fly-about animation(s)
• a title
• support documentation
• credits.

Process/Skill Questions

• Why is visualization in multimedia important?
• Why is it important to develop a storyboard before developing a presentation?

ITEEA National Standards

• STEL 3, 8

TSA Competitive Events

• Animatronics
• Digital Video Production
• Music Production
• On Demand Video
• Promotional Design

Task Number 67
Investigate inventive methods of documentation.

Definition
Investigation may include

• examples of real-world product documents
• software
• 3D technology
• virtual reality
• augmented reality.

Process/Skill Questions

• What methods are available to document a product other than the traditional paper method?
• What software is currently used in industry to represent design details?
• How can 3D technology make it easier to understand and visualize how a product is put together?

ITEEA National Standards

• STEL 3, 8

Maintaining Professionalism
Task Number 68

Describe ethical issues in the design industry.

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?
- What information is open resource and how do we know it is legally shareable?

ITEEA National Standards

- STEL 3, 8

TSA Competitive Events

- Technology Bowl

Task Number 69

Identify the role of advanced drawing and design in manufacturing and construction industry processes.

Definition

Identification should include

- increases environmental efficiencies
- influences cultural expression and identity
- affects social issues
- helps the economy
- provides solutions to political issues
- increases efficiency and precision
- includes contractually legal documents.

Process/Skill Questions

- What is green technology?
- What is green architecture?
- How do social issues affect design?
- How does design affect efficiency (i.e., energy use)?
- What are some job titles in the field of drawing and design?
Task Number 70

Characterize what collaboration is necessary among the design trades/fields.

Definition
Characterization should include

- commonly used terms
- understanding of materials
- available fabrication procedures
- general permit and legal responsibilities
- relationship dynamics among trades/fields.

Process/Skill Questions

- What is participatory design?
- What technology is available for real-time design collaboration?
- How does communication affect a project team?
- What values need to be established for collaboration to be successful?
- What is integrated design?

Task Number 71

Present a complete electronic work portfolio.

Definition
Presentation should include

- multimedia (hard copy and digital) elements
- résumé
- 2D and 3D models
- sheet sets
- working drawings
- renderings of solid models
- storyboards
- freehand sketches.

**Process/Skill Questions**

- What constitutes a set of working drawings?
- What portfolio format options are available?
- What is *authorship/ownership*, and how does it affect elements of a design portfolio?

**ITEEA National Standards**

- STEL 3, 8

**TSA Competitive Events**

- CAD Architecture
- CAD Engineering
- Computer Integrated Manufacturing (CIM)

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## SOL Correlation by Tasks

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<th>Social Studies:</th>
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<tr>
<td>Justify calculations and assumptions made during the design process.</td>
<td>9.5, 9.8, 10.5, 10.8, 11.5, 11.8, 12.5</td>
<td>G.8, G.9, G.11, G.13, G.14</td>
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<tr>
<td>Prepare freehand and electronic preliminary sketches.</td>
<td>9.5, 9.6, 9.7, 10.5, 10.6, 10.7, 11.5, 11.6, 11.7, 12.5, 12.6, 12.7</td>
<td>G.2, G.3, G.8, G.9, G.11, G.13, G.14</td>
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<tr>
<td>Develop skills related to using scale.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Use measuring skills.</td>
<td></td>
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<tr>
<td>Create a 3D design model of an object.</td>
<td>9.2, 9.5, 10.2, 10.5, 11.2, 11.5, 12.2, 12.5</td>
<td>G.3, G.7, G.8, G.9, G.13, G.14</td>
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<tr>
<td>Analyze multi-drawing sets.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Present design ideas.</td>
<td>9.1, 9.5, 10.1, 10.5, 11.1, 11.5, 12.1, 12.5</td>
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<tr>
<td>Reverse engineer products.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Construct physical models of designs.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Develop proficiency reading working drawings.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Create 3D model parts using CAD.</td>
<td>9.2, 10.2, 11.2, 12.2</td>
<td></td>
</tr>
<tr>
<td>Generate multi-view orthographic projections from a 3D design model.</td>
<td>9.2, 10.2, 11.2, 12.2</td>
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<tr>
<td>Create working drawings and sheet sets.</td>
<td>9.5, 9.6, 9.7, 10.5, 10.6, 10.7, 11.5, 11.6, 11.7, 12.5, 12.6, 12.7</td>
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<tr>
<td>Generate schedules.</td>
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<tr>
<td>Task</td>
<td>English:</td>
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<tr>
<td>----------------------------------------------------------------------</td>
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<tr>
<td>Render presentation designs.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Generate sectional views.</td>
<td>9.5, 9.6, 9.7, 10.5, 10.6, 10.7, 11.5, 11.6, 11.7, 12.5, 12.6, 12.7</td>
<td></td>
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<tr>
<td>Draw a thread detail.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Design parts and assembly drawings using coordinate systems.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Dimension drawings, according to the standards of ANSI (American National Standards Institute), ISO (International Standards Organization), U.S. military standard (MIL), U.S. Department of Defense (DOD) and NCS (National CAD Standards).</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Demonstrate the use and manipulation of styles.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Develop specification data.</td>
<td>9.5, 9.6, 10.5, 10.6, 11.5, 11.6, 12.5, 12.6</td>
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<tr>
<td>Use technical writing style in documentation.</td>
<td>9.6, 9.7, 10.6, 10.7, 11.6, 11.7, 12.6, 12.7</td>
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<tr>
<td>Create a multimedia presentation of a finished design, incorporating animation files.</td>
<td>9.2, 9.5, 10.2, 10.5, 11.2, 11.5, 12.2, 12.5</td>
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<tr>
<td>Investigate inventive methods of documentation.</td>
<td>9.5, 9.8, 10.8, 10.5, 11.8, 11.5, 12.8, 12.5</td>
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<tr>
<td>Describe ethical issues in the design industry.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Identify the role of advanced drawing and design in manufacturing and construction industry processes.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
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<tr>
<td>Characterize what collaboration is necessary among the design trades/fields.</td>
<td>9.5, 10.5, 11.5, 12.5</td>
<td></td>
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<tr>
<td>Present a complete electronic work portfolio.</td>
<td>9.5, 9.6, 9.7, 10.5, 10.6, 10.7, 11.5, 11.6, 11.7, 12.5, 12.6, 12.7</td>
<td></td>
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</tbody>
</table>
Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials (Only apply to 36-week courses)

- Architectural Apprentice Drafter Examination
- Architectural Certified Drafter Examination
- Architectural Drafting Assessment
- Architectural Drafting Examination
- Autodesk Certified Professional Examinations
- Autodesk Certified User Examinations
- Certified SOLIDWORKS Associate (CSWA) Examination
- College and Work Readiness Assessment (CWRA+)
- Mechanical Apprentice Drafter Examination
- Mechanical Certified Drafter Examination
- Mechanical Drafting and Design Assessment
- 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.

- Architectural Drawing and Design (8437/36 weeks)
- Architectural Drawing and Design (8492/18 weeks)
- Digital Visualization (8459/36 weeks)
- Engineering Drawing and Design (8436/36 weeks)
- Engineering Drawing and Design (8493/18 weeks)

Career Cluster: Arts, Audio/Video Technology and Communications

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
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<tbody>
<tr>
<td>Audio and Video Technology and Film</td>
<td>Graphic Designer</td>
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<tr>
<td>Performing Arts</td>
<td>Costume Designer</td>
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<td></td>
<td>Lighting Designer</td>
</tr>
<tr>
<td>Visual Arts</td>
<td>Costume Designer</td>
</tr>
<tr>
<td></td>
<td>Fashion Designer</td>
</tr>
<tr>
<td></td>
<td>Graphic Designer</td>
</tr>
<tr>
<td></td>
<td>Illustrator Interior Designer</td>
</tr>
<tr>
<td></td>
<td>Textile Designer</td>
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</table>

Career Cluster: Science, Technology, Engineering and Mathematics

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Occupations</th>
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<tbody>
<tr>
<td>Engineering and Technology</td>
<td>Aeronautical Drafter</td>
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<tr>
<td></td>
<td>Architect</td>
</tr>
<tr>
<td></td>
<td>Commercial and Industrial Designer</td>
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<tr>
<td></td>
<td>Electrical Drafter</td>
</tr>
<tr>
<td></td>
<td>Electronic Drafter</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
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<tr>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>Engineer</td>
<td></td>
</tr>
<tr>
<td>Engineering Technician</td>
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<tr>
<td>Landscape Architect</td>
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<tr>
<td>Mechanical Drafter</td>
<td></td>
</tr>
<tr>
<td>Pipeline Drafter</td>
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</tbody>
</table>