# Technical Drawing and Design

8434/18 weeks  
8435/36 weeks

## Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgments</td>
<td>1</td>
</tr>
<tr>
<td>Course Description</td>
<td>2</td>
</tr>
<tr>
<td>Task Essentials Table</td>
<td>2</td>
</tr>
<tr>
<td>Curriculum Framework</td>
<td>3</td>
</tr>
<tr>
<td>Introducing the Design Process</td>
<td>3</td>
</tr>
<tr>
<td>Exploring Technical Drawing Foundations</td>
<td>6</td>
</tr>
<tr>
<td>Producing Technical Drawings</td>
<td>13</td>
</tr>
<tr>
<td>Producing Prototypes</td>
<td>17</td>
</tr>
<tr>
<td>Appendix: Credentials, Course Sequences, and Career Cluster Information</td>
<td>20</td>
</tr>
</tbody>
</table>

## Acknowledgments

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Course Description

Suggested Grade Level: 9 or 10 or 11

In this foundational course, students design, sketch, and make technical drawings, models, or prototypes of real design problems while learning the language of technical drawing and design. The course introduces the language of graphic communication to science, technology, engineering, and mathematics (STEM) students and is especially recommended for those planning a future in engineering and architecture.

Task Essentials Table

- Tasks/competencies designated by plus icons (ﲐ) 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.

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8434</th>
<th>8435</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introducing the Design Process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>🔄  🔄</td>
<td></td>
<td>Describe the design process.</td>
</tr>
<tr>
<td>40</td>
<td>🔄  🔄</td>
<td></td>
<td>Apply the design process, including prototyping or modeling.</td>
</tr>
<tr>
<td>41</td>
<td>🔄  🔄</td>
<td></td>
<td>Analyze design solutions.</td>
</tr>
<tr>
<td>42</td>
<td>🔄  🔄</td>
<td></td>
<td>Refine the design solution.</td>
</tr>
<tr>
<td>Exploring Technical Drawing Foundations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>🔄  🔄</td>
<td></td>
<td>Define technical drawing.</td>
</tr>
<tr>
<td>44</td>
<td>🔄  🔄</td>
<td></td>
<td>Compare architectural and engineering drawings.</td>
</tr>
<tr>
<td>45</td>
<td>🍁  🔄</td>
<td></td>
<td>Describe the history of drawing and design.</td>
</tr>
<tr>
<td>46</td>
<td>🔄  🔄</td>
<td></td>
<td>Prepare technical sketches.</td>
</tr>
<tr>
<td>47</td>
<td>🔄  🔄</td>
<td></td>
<td>Maintain a reference library of technical data.</td>
</tr>
<tr>
<td>48</td>
<td>🔄  🔄</td>
<td></td>
<td>Demonstrate care and use of drawing equipment.</td>
</tr>
<tr>
<td>49</td>
<td>☐</td>
<td>✓</td>
<td>Select drawing-related media and materials to communicate a solution for a design problem.</td>
</tr>
<tr>
<td>50</td>
<td>☐</td>
<td>✓</td>
<td>Apply geometric construction principles.</td>
</tr>
<tr>
<td>51</td>
<td>☐</td>
<td>✓</td>
<td>Apply mathematical calculations to technical drawings.</td>
</tr>
<tr>
<td>52</td>
<td>☐</td>
<td>✓</td>
<td>Apply U.S. Customary Systems and metric measuring devices and systems to technical drawings.</td>
</tr>
<tr>
<td>53</td>
<td>☐</td>
<td>✓</td>
<td>Interpret technical documentation.</td>
</tr>
<tr>
<td>54</td>
<td>☐</td>
<td>✓</td>
<td>Perform lettering exercises.</td>
</tr>
<tr>
<td>55</td>
<td>☐</td>
<td>✓</td>
<td>Apply principles of dimensioning, annotation, and lettering.</td>
</tr>
<tr>
<td>56</td>
<td>☐</td>
<td>✓</td>
<td>Utilize a title block.</td>
</tr>
</tbody>
</table>

**Producing Technical Drawings**

| 57 | ☐ | ✓ | Apply technical drawing and design standards. |
| 58 | ☐ | ✓ | Prepare multi-view drawings, using orthographic projections. |
| 59 | ☐ | ✓ | Prepare sectional view drawings. |
| 60 | ☐ | ✓ | Create 2D patterns from 3D objects, using the processing of parallel lines, radial lines, and triangulation developments. |
| 61 | ☐ | ✓ | Prepare pictorial drawings. |
| 62 | ☐ | ✓ | Create solutions, using CAD. |
| 63 | ☐ | ✓ | Revise drawings. |
| 64 | ☐ | ✓ | Prepare a set of architectural drawings. |

**Producing Prototypes**

| 65 | ☐ | ✓ | Construct a prototype. |
| 66 | ☐ | ✓ | Produce a prototype, using a 3D printer. |

Legend: ✓Essential ☐Non-essential ☐Omitted

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**Curriculum Framework**

**Introducing the Design Process**

**Task Number 39**

**Describe the design process.**

**Definition**

Description should include that the design process is an iterative, creative process for turning ideas into real objects, products, systems, and environments.
Process/Skill Questions

- What are the criteria and constraints of a design?
- Why is it important to identify criteria and constraints, such as deadlines and budget?
- What techniques are used to refine a design?
- How can a design be evaluated?
- What is quality control?
- Why should solutions be reevaluated? How is this done?
- Why is it important to document every step of the design process?
- What is iteration, and how is it related to the design process?

ITEEA National Standards

- STEL 7

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Task Number 40

Apply the design process, including prototyping or modeling.

Definition

Application should include

- outlining the basic steps of progression in any design loop
- establishing a system of documentation for monitoring workflow
- identifying a design problem
- identifying criteria and constraints
- brainstorming to identify potential solutions
- identifying selecting a solution while considering tradeoffs and optimization
- creating a plan/outline for achieving the design
- developing sketches
- evaluating the initial design solution
- developing a prototype or model of a product or system
- re-evaluating solutions and refining the design, as needed.

Process/Skill Questions

- Why is it important to follow an iterative design process?
- Why is sketching of possible solutions done?
- Why is it important to repeat the steps of the design process?
- When is it necessary to refine the design?
- What are some products and designs that have been refined over the last five years?
- How can documentation of previous problems aid in the development of new technologies?

ITEEA National Standards

- STEL 7, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering
Task Number 41
Analyze design solutions.

Definition
Analysis should include
- evaluation of design platforms
- identification of criteria and constraints
- evaluation of ideas through sketching function(s)
- use of quality control(s)
- consideration of critiques (made by client, self, jury, community, superior, or instructor)
- consideration of aesthetic quality
- evaluation of spatial plan, sketches, and parametric models in three-dimensional (3D) improvements for future revisions.

Process/Skill Questions
- What are the criteria used to evaluate successful design?
- What guidelines should be followed to evaluate the design success?
- How is the design solution accepted or disapproved?
- How are solutions evaluated for further study?
- What are the principles of design?
- What are the elements of design?

ITEEA National Standards
- STEL 8

TSA Competitive Events
- CAD Architecture
- CAD Engineering

Task Number 42
Refine the design solution.

Definition
Refinement should include
- analyzing the initial design in terms of given criteria and constraints for the design
- improving functionality
- improving quality control
- improving aesthetic quality
- providing recommendations/ revisions for additional design improvements
- providing technical drawings of the proposed design revisions.

Process/Skill Questions
- What are the principles of design?
- What are the elements of design?
- What are the benefits and drawbacks to refining a design?
- Why is it important to document design decisions and steps?
- Why is it important to document and rate each of the refinement areas discussed in this competency?
ITEEA National Standards

- STEL 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Exploring Technical Drawing Foundations

Task Number 43

Define **technical drawing**.

**Definition**

Definition should include the concept of technical drawing as the graphic representation of an object or a concept, using a universal language consisting of graphic symbols.

**Process/Skill Questions**

- What is graphic communication?
- What is technical drawing?
- Why is it important to be able to define technical drawing?
- What are common uses of technical drawing?
- What is the role of technical drawing in society today?

ITEEA National Standards

- STEL 2

TSA Competitive Events

- Technology Bowl

Task Number 44

Compare architectural and engineering drawings.

**Definition**

Comparison should include the following ideas:

- Architects use a more creative approach to designing buildings and other structures. The aesthetics and function of the building are a priority.
- Engineers use a more scientific, practical, and iterative approach to design. Often, an architect’s working drawings are the foundation of the engineer's work, and their job is to realize the architect’s vision, using sound scientific and mathematical principles.
- Architects and engineers work collaboratively to create aesthetically pleasing and safe structures.

**Process/Skill Questions**

- How do architects and engineers work together on solutions?
- What is unique about an architect’s perspective in designing structures?
- How can an architect’s work be seen as a sculpture?
ITEEA National Standards
- STEL 2

TSA Competitive Events
- CAD Architecture
- CAD Engineering

Task Number 45
Describe the history of drawing and design.

Definition
Description should include
- the evolution of technical drawing and design from the Renaissance through the Information Age
- the effects of technical drawing and design on the development of technology
- the use of perspective drawing in the development of technical drawing and design
- the application of math through descriptive geometry to create accurate drawings
- earlier uses of orthographic projection in great inventions (e.g., the Wright Flyer)
- the development of tools in technical drawing and design (e.g., from manual drafting equipment through computer software)
- the adoption of American National Standards Institute (ANSI) and International Organization for Standardization (ISO) standards.

Process/Skill Questions
- What is the impact of computer aided design (CAD) systems on the design process?
- How has technical drawing evolved?
- How has the computer improved the drafting process?
- What are the contributions of Leonardo da Vinci, Filippo Brunelleschi, Thomas Jefferson, George Washington, Gaspar Monge, and Michael Graves?

ITEEA National Standards
- STEL 6

TSA Competitive Events
- CAD Architecture
- CAD Engineering

Task Number 46
Prepare technical sketches.

Definition
Preparation should enable quick documentation of preliminary ideas for a given design problem and may include single views, multiviews, and isometrics.

Process/Skill Questions
- For what types of drawings are sketches frequently prepared?
- At what stage(s) of the design process are technical sketches typically used?
- What is the purpose of sketching multiview drawings?
- What are the types of pictorial drawings?
- How is the pattern for a rectangular prism developed?
- What are non-isometric lines?
ITEEA National Standards

- STEL 2, 8

TSA Competitive Events

- CAD Architecture
- CAD Engineering

Task Number 47

Maintain a reference library of technical data.

Definition

Maintenance should include the practical organization of relevant drawing files, symbols, spreadsheets, and other technical data and the following:

- Compilation of a personal portfolio
- Compilation of design evolutions during the design process exercises

Process/Skill Questions

- What may be included in a reference library?
- What is technical data?
- How are drawing files copied, moved, and deleted?
- How are folders created and deleted?

Process/Skill Questions

- STEL 3

Task Number 48

Demonstrate care and use of drawing equipment.

Definition

Demonstration should include examining, cleaning, properly using, and storing equipment, including

- manual tools (e.g., triangles, scales, compasses, T-squares)
- computer hardware, including printers
- computer software.

Designers who use and rely on computer software should pay special attention to product updates, glitches/bugs, and troubleshooting and adhere to standard online operating procedures.

Process/Skill Questions

- What are the angles that can be drawn with a set of drafting triangles?
- What is the purpose of dividers?
- What hardware makes up a CAD system?
- How are scales used to create and read technical drawings?

ITEEA National Standards

- STEL 8
Task Number 49
Select drawing-related media and materials to communicate a solution for a design problem.

Definition
Selection should include the appropriate drawing media. The design problem should be clearly communicated through the appropriate use of electronic media, paper sizes, scales, drafting tools, and presentation tools.

Process/Skill Questions
- What are the sizes of paper that ANSI standards refer to as A, B, C, and D?
- What are different drawing media?
- What electronic media are available to help create technical drawings?
- How is tracing paper used to analyze a design?

ITEEA National Standards
- STEL 8

Task Number 50
Apply geometric construction principles.

Definition
Application may include
- bisecting geometry
- drawing an arc or circle (radius) through three points
- drawing a line parallel to a straight or curved line at a given distance
- drawing a line perpendicular to another line or from a point not on the line
- dividing a line into equal parts or into proportional parts
- transferring an angle, an odd shape, or a complex shape
- proportionally enlarging or reducing a shape
- drawing polygons (e.g., triangle, square, pentagon, hexagon) inscribed and circumscribed in a circle
- locating the center of a circle
- constructing an arc tangent to a right angle, acute angle, obtuse angle, straight line, curve, or two arcs or diameters of unequal radii, an arc concave and convex to a line and another arc or circle
- constructing tangencies to various geometry.
Process/Skill Questions
- Why is it important to learn how to complete these processes by hand as well as with tools such as CAD?
- How are geometric construction principles used in drawing plans for structures?

ITEEA National Standards
- STEL 3

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

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Task Number 51
Apply mathematical calculations to technical drawings.

Definition
Application of mathematical calculations involving practical geometry may include
- scaling drawings
- converting unit systems
- using proportions and ratios
- solving for area
- solving for circumference
- calculating even-centering spacing for multi-view drawings.

Process/Skill Questions
- How is the radius of a circle different from the diameter?
- How is the true length of an inclined plane in an orthographic projection determined?
- What functions and commands can be used in CAD software to simplify geometric formulas?
- Where can one locate the information needed to perform the calculations?

ITEEA National Standards
- STEL 3

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

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Task Number 52
Apply U.S. Customary Systems and metric measuring devices and systems to technical drawings.

Definition
Application should include selecting and adjusting the following measuring devices to reflect the intended system:
- Engineer’s scale
- Architect’s scale
- Metric scale
- Dual-dimensioning system
- Decimal inch scale
- Surveyor’s scale
- Fractional inch scale

**Process/Skill Questions**
- What measurement system is used in Europe?
- What are some common scales found in an engineer's drawing?
- Why are decimal scales used in engineering drawings?
- What are some common scales found in architectural drawings?
- When should the dual-dimensioning system be used?
- Why are decimal scales used in engineering drawings?

**ITEEA National Standards**
- STEL 2, 3

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**Task Number 53**

**Interpret technical documentation.**

**Definition**
Interpretation should include demonstrating
- knowledge of common symbols, schematics, and standards used in architectural and engineering drawings (e.g., symbol, schematics, and lettering literacy)
- the ability to read a technical drawing and apply the information to a new drawing
- recognition of communicated information with language of line types
- knowledge of and application of alphabet of lines to communicate specific information.

**Process/Skill Questions**
- Why is constructed lettering still important?
- What is the most common lettering style used on drawings?
- What do hidden lines represent in an orthographic projection?
- What is the function of center lines?
- What do object lines show?
- How is lettering manipulated using a CAD program?

**ITEEA National Standards**
- STEL 8

**TSA Competitive Events**
- CAD Architecture
- CAD Engineering

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**Task Number 54**

**Perform lettering exercises.**
Definition
Performance should include Arial or Gothic font for alpha/numeric characters in both upper and lower case.

Process/Skill Questions
- Why is lettering important to practice?
- What is the traditional font of technical drawing?

ITEEA National Standards
- STEL 8

TSA Competitive Events
- CAD Architecture
- CAD Engineering

Task Number 55
Apply principles of dimensioning, annotation, and lettering.

Definition
Application should include following the ANSI general rules of dimensioning and providing information about sizes and locations, including
- overall width, height, and depth of the object
- angles other than 90 degrees
- size and location of drilled holes, chamfers, fillets, and other features
- datums
- relate dimension information to 3D parametric models.

Process/Skill Questions
- What basic information is given by dimensions?
- What is a size dimension?
- What is a location dimension?
- What does datum mean?
- What are the ANSI general rules of placement for dimensioning?

ITEEA National Standards
- STEL 8

TSA Competitive Events
- CAD Architecture
- CAD Engineering

Task Number 56
Utilize a title block.

Definition
Utilization should include the following components:
- Contributor (student) name
- Organization (school) name
• Scale of drawing
• Paper/sheet size
• Sheet number and sheet total
• Title of drawing
• Border line
• Date and/or revision number and date of revision
• Any additional information relevant to the drafting specialization or company

Process/Skill Questions
• Where should the title block be located?
• What key information is included in a title block?
• What additional information might be included in a title block? Why is this information important?
• What is the function of the title block?
• What are field attributes, and how can they be used in title block creation?

ITEEA National Standards
• CAD Architecture
• CAD Engineering

Producing Technical Drawings

Task Number 57
Apply technical drawing and design standards.

Definition
Application may include
• American National Standards Institute (ANSI)
• International Organization for Standardization (ISO)
• SAE International
• ASTM
• company standards
• classroom standards.

Process/Skill Questions
• Why are standards important in technical drawing and design?
• What does ANSI, ISO, SAE, and ASTM stand for?
• Why is it important for an employee to comply with company standards?

ITEEA National Standards
• STEL 5, 7, 8

TSA Competitive Events
• CAD Architecture
• CAD Engineering

Task Number 58
Prepare multi-view drawings, using orthographic projections.

Definition
Preparation should include providing a series of two-dimension (2D) drawings that would allow a person to visualize a 3D object, to include some of the following views of an object:

- Top
- Front
- Bottom
- Left side
- Right side
- Back

Process/Skill Questions
- How do first angle and third angle projections differ?
- Where is each type used?
- What are the three primary views used in multi-view drawings?
- What is orthographic projection?
- Why is it important to identify the front view of an object and what factors are important to its selection?
- How is the front view of an object identified?

ITEEA National Standards
- STEL 2

TSA Competitive Events
- CAD Architecture
- CAD Engineering

Task Number 59

Prepare sectional view drawings.

Definition
Preparation should show internal details of an object not readily available from a single view, and might include the following views:

- Full
- Half
- Broken-out
- Revolved
- Removed
- Offset
- Assembly

Process/Skill Questions
- When should a sectional view be used?
- Which view should be chosen to show a sectional view? Which type of sectional view should be used to shorten long objects to fit in a drawing?
- At what angle are section linings usually drawn?
- Why would only a half section be chosen?
- What type of drawing is going to include section views?
**Task Number 60**

Create 2D patterns from 3D objects, using the processing of parallel lines, radial lines, and triangulation developments.

**Definition**

Creation should include

- reverse-engineering boxes or packages
- replicating a 2D pattern from a 3D object
- demonstrating 3D object functionality from a 2D pattern
- applying revolution for projections to find true length of elements and assemble patterns
- applying revolution projections to find true length elements used for assembly of layouts/patterns.

**Process/Skill Questions**

- What is a stretch-out pattern?
- What are examples of everyday products created from patterns?
- What are transition pieces?
- How does geometry play a role in developing patterns?

**Task Number 61**

Prepare pictorial drawings.

**Definition**

Preparation should provide visual understanding of an idea and may include

- axonometric projection (isometric)
- oblique projection (cavalier, cabinet)
- perspectives (parallel, two point, three point)
- exploded view
- isometric circles.

**Process/Skill Questions**

- Why are pictorial drawings used?
- What are three types of pictorial drawings?
• What is the pictorial axis, and why is it important?
• What are non-isometric lines?
• What are the steps in drawing a pictorial view from a multiview drawing?

ITEEA National Standards
• STEL 3, 8

TSA Competitive Events
• CAD Architecture
• CAD Engineering

Task Number 62
Create solutions, using CAD.

Definition
Creation should demonstrate CAD literacy, including the ability to
• set drawing limits
• set units
• edit and manipulate layers
• design, edit, and manipulate templates
• use drawing commands
• modify commands
• analyze and manipulate dimensioning
• print or plot a drawing.

Process/Skill Questions
• What are the advantages of using CAD over the hands-on or manual drafting process?
• What are the challenges of using CAD?
• What are some free and proprietary CAD software programs used by professional and
  student designers today?

ITEEA National Standards
• STEL 8

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

Task Number 63
Revise drawings.

Definition
Revision should include documenting the reevaluation and refinement stages of the design
process.

Process/Skill Questions
• What is the logical procedure in making corrections?
• Who is responsible for checking drawings in the design process?
- What is the procedure for modifying drawings?
- How are required changes indicated?
- How are revisions documented?

**ITEEA National Standards**
- STEL 8

**TSA Competitive Events**
- CAD Architecture
- CAD Engineering

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**Task Number 64**

**Prepare a set of architectural drawings.**

**Definition**

Preparation should include a selection of the following:

- Floor Plans
- Sections
- Elevation
- Wall section
- Rendering
- Standard architectural symbols, line types, and lettering
- Two-point and one-point perspective sketch of exterior/interior

**Process/Skill Questions**

- What is architecture?
- How does architectural lettering differ from engineering lettering?
- How are architectural drawings dimensioned?
- What is required in a floor plan?
- What are the standard symbols used in an architectural drawing?
- What drawing methods are used in architecture? When should they be used?
- What are the line types and scales used in architectural drawings?
- What is the importance of a set of house plans?

**ITEEA National Standards**
- STEL 8

**TSA Competitive Events**
- Architectural Design
- CAD Architecture
- CAD Engineering

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**Producing Prototypes**

**Task Number 65**

**Construct a prototype.**
Definition

Construction of scaled replicas or full-sized prototypes may include the following elements:

- Materials with similar properties of those that are proposed for production
- Functional components
- Design standards, including form, function, and quality

Process/Skill Questions

- How are problems with the prototype determined?
- What are the advantages and disadvantages of constructing prototypes?
- What are factors to consider when determining the type of prototype to construct?
- How might improving the prototype also improve the design and final product?
- How does a static model differ from a working model?

ITEEA National Standards

- STEL 7, 8

TSA Competitive Events

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

Task Number 66

Produce a prototype, using a 3D printer.

Definition

Production should include

- scanning 3D objects
- designing new objects and entering their data into a computer application.

Process/Skill Questions

- What are the benefits of 3D printing?
- What are some challenges with using 3D printers?
- How are 3D printers used in today’s industries?
- What 3D printers are available?
- From what materials can prototypes be made?
- What sizes of prototypes can be made on 3D printers?
- How can the use of 3D modeling and 3D printing aid in the prototype process?

ITEEA National Standards

- STEL 7, 8

TSA Competitive Events

- CAD Engineering

SOL Correlation by Task

<table>
<thead>
<tr>
<th>Describe the design process.</th>
<th>English: 9.5, 10.5, 11.5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science: PH.3</td>
</tr>
<tr>
<td>Task</td>
<td>English:</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Apply the design process, including prototyping or modeling.</td>
<td>9.5, 9.6, 9.7, 10.5, 10.6, 10.7, 11.5, 11.6, 11.7</td>
</tr>
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<tr>
<td>Define technical drawing.</td>
<td>9.3, 9.5, 10.3, 10.5, 11.3, 11.5</td>
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<tr>
<td>Compare architectural and engineering drawings.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Describe the history of drawing and design.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Prepare technical sketches.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Maintain a reference library of technical data.</td>
<td>9.5, 9.6, 9.7, 10.5, 10.6, 10.7, 11.5, 11.6, 11.7</td>
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<tr>
<td>Demonstrate care and use of drawing equipment.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Select drawing-related media and materials to communicate a solution for a design problem.</td>
<td>9.2, 9.5, 10.2, 10.5, 11.2, 11.5</td>
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<tr>
<td>Apply geometric construction principles.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Apply mathematical calculations to technical drawings.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Apply U.S. Customary Systems and metric measuring devices and systems to technical drawings.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Interpret technical documentation.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Perform lettering exercises.</td>
<td>9.2, 9.5, 10.2, 10.5, 11.2, 11.5</td>
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<tr>
<td>Apply principles of dimensioning, annotation, and lettering.</td>
<td>9.2, 9.5, 10.2, 10.5, 11.2, 11.5</td>
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<tr>
<td>Utilize a title block.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Apply technical drawing and design standards.</td>
<td>9.2, 9.5, 10.2, 10.5, 11.2, 11.5</td>
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<tr>
<td>Prepare multi-view drawings, using orthographic projections.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Prepare sectional view drawings.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Create 2D patterns from 3D objects, using the processing of parallel lines, radial lines, and triangulation developments.</td>
<td>9.2, 9.5, 10.2, 10.5, 11.2, 11.5</td>
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<tr>
<td>Prepare pictorial drawings.</td>
<td>9.5, 10.5, 11.5</td>
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<tr>
<td>Create solutions, using CAD.</td>
<td>9.2, 9.5, 10.2, 10.5, 11.2, 11.5</td>
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<tr>
<td>Revise drawings.</td>
<td>9.5, 9.6, 10.5, 10.6, 11.5, 11.6</td>
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<tr>
<td>Prepare a set of architectural drawings.</td>
<td>9.5, 10.5, 11.5</td>
</tr>
<tr>
<td>Construct a prototype.</td>
<td>9.5, 10.5, 11.5</td>
</tr>
<tr>
<td>Produce a prototype, using a 3D printer.</td>
<td>9.5, 10.5, 11.5</td>
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</table>
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 Apprentice Drafter Examination
- Mechanical Drafting and Design Assessment
- National Career Readiness Certificate 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.

- 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)
- Technology Foundations (8403/36 weeks)
- Introduction to Engineering Design PLTW (8439/36 weeks)

<table>
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<tr>
<th>Pathway</th>
<th>Occupations</th>
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<tr>
<td>Engineering and Technology</td>
<td>Aerospace Engineer</td>
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<td>Aerospace Engineering Technician</td>
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<td>Agricultural Engineer</td>
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<td>Architect</td>
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<td>Assembler</td>
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<td>Biomedical Engineer</td>
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<td>Chemical Engineer</td>
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<td>Civil Engineer</td>
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<td></td>
<td>Civil Engineering Technician</td>
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<td>Commercial and Industrial Designer</td>
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<td>Computer Hardware Engineer</td>
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<td>Electrical Engineering Technician</td>
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<td>Human Factors Engineer</td>
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<td>Industrial Engineer</td>
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<tr>
<td></td>
<td>Machine Setter, Operator</td>
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<td>Manufacturing Systems Engineer</td>
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<td>Marine Engineer</td>
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<td>Materials Engineer</td>
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<tr>
<td>Mechanical Drafter</td>
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<td>Mechanical Engineer</td>
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<td>Mechanical Engineering Technician</td>
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<td>Power Systems Engineer</td>
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