

Appendix K

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) YOUTH APPRENTICESHIP

ENGINEERING & TECHNOLOGY PATHWAY ENGINEERING DRAFTING (UNIT 3)

Unit 3: Engineering & Technology Pathway Engineering Drafting

Competency

1. Apply engineering principles

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Demonstrate Engineering principles understanding based on ***current training and knowledge***
- Comply with specifications, regulations, and codes during the design process

Learning Objectives

SYSTEMS, PRINCIPLES, CONCEPTS

- Explain physical principles such as forces, friction, and energy
- Apply fundamental laws and principles such as the laws of conservation of energy and momentum relevant to engineering and technology
- Use the relationships between force, motion, energy, work, power to solve a variety of engineering problems
- Apply scalar and vector quantities as applied to physical systems, such as the relationship between position, velocity, and acceleration
- Calculate the mean, mode, median, and range of a data set

DESIGN PROCESS

- Describe what pressures are prevalent in engineering design
- Discuss product specifications and their role in engineering
- Contrast quality and efficiency as significant factors in engineering
- Identify and quantify the impact of potential failures

Comments:

Unit 3: Engineering & Technology Pathway Engineering Drafting

Competency

2. Interpret technical drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Interpret technical drawings accurately as needed for job task
- Use appropriate terminology
- Identify basic elements of technical drawings
- Identify lines, views, symbols, and representations on the drawings as applicable
- Interpret dimensions and scale on the drawings as applicable
- Utilize a metric scale to properly read a drawing

Learning Objectives

- Discuss different types of technical drawings
- Define the basic types of lines
- Define and explain the use of lines, views, symbols, dimensions, and scale on engineering technical drawings
- Interpret auxiliary drawing information
- Identify different lines by name, type, order of usage, & application such as object, hidden, center, section, dimension, extension, cutting plane, short break, long break, phantom
- Demonstrate standard view placement practices
- Compare orthographic projections, pictorial/3D (isometric, diametric, trimetric) view, sectional views, auxiliary (oblique, inclined) views, and dimensional views
- Discuss the ANSI and the National CAD standards for engineering document lines
- Define tolerances
- Identify tolerancing symbols in a technical drawing

Comments:

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Competency

3. Use measuring devices accurately

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Choose appropriate instrument or aid for measuring task
- Verify instrument is accurate for calibration if applicable
- Use and/or measure as required
- Read measuring instrument accurately
- Scale proportions accurately
- Apply appropriate formula and units for measurements
- Record measurements using proper symbols
- Clean and maintain instrument(s) as required
- Store instrument(s) properly

Learning Objectives

- List drafting aids and measuring devices commonly used by engineers
- List common measurements used by engineers
- Add and subtract measurements
- Discuss how to convert standard English measures to metric and vice versa
- Explain engineering scale
- Explain the impact of error in measurement
- Predict the effect of error propagation in calculations
- Explain the link between measurement, calculation and data with the correct number of significant digits

Comments:

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Competency

4. Organize databases, files, & drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Select appropriate documents
- Code documents as required
- Save and store drawings and files to appropriate database
- Sort and retrieve drawings and data from databases
- Enter data and edit fields and documents
- Query to extract information from files and documents
- Create reports from queries
- Use appropriate computer codes, formatting, macros, charts, spreadsheets, etc.
- Verify data prior to entry/storage

Learning Objectives

- Define basic database terms such as database, field, record, query, table, etc.
- Identify the various types of data and documents stored in your companies database management system
- Discuss the access and responsibilities you will have for managing engineering records and documents

Comments:

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Competency

5. Reproduce documents & plans

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain documents or plans
- Remove any staples if hard copy
- Save copies to computer storage devices
- Operate copy machines
- Operate printers, plotters, and scanners
- Number copies as required
- Document copies made

Learning Objectives

- Explain the purpose of copy control and document numbering systems in engineering
- Explain the size of drawings to standards
- Compare ISO to U.S. customary drawing sizes
- Define aspect ratio and how it applies to drawing sizes and copying
- Describe how to operate the computer database storage system, copy machine, printer, scanner, etc. at your facility

Comments:

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Competency

6. Use engineering drafting software

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- Access & use appropriate file management to search, create, copy, edit, and save drawing files
- Execute application software
- Demonstrate view use in CAD
- Retrieve or create drawings
 - Access predefined drawing setup
 - Import/export drawings from/to various graphic formats
 - Convert an existing hard copy drawing to an electronic format
- Draw or modify drawings
 - Utilize drawing management standards
 - Set up plot parameter
 - Select appropriate scale
 - Utilize various coordinate systems
 - Apply appropriate naming conventions, line types, and symbol/object management to drawing
 - Apply appropriate notes and/or leaders to drawing
 - Apply appropriate lettering, fonts, line thickness and type
- **Check drawing**
- Maintain drawings in the file management system

Learning Objectives

- Explain the purpose, principle, and advantages of Computer-Aided Drawing (CAD)
- Compare cost, advantages, and disadvantages of CAD versus Manual drawing
- Compare types of CAD
- Identify drafting references, handbooks, vendor's product catalog, and other related appropriate standards and how they are used in engineering drafting
- List appropriate engineering design standards used by your facility
- Identify the hardware and software used at the CAD workstations in your facility
- Discuss common CAD system variables used in engineering
- Describe the feature manager design tree schematic for the CAD software used in your facility
- Compare symbols, text based information, and libraries in the CAD software used in your facility
- Discuss CAD plotting guidelines

Comments:

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Competency

7. Develop one-view drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- **Use engineering drafting software** OR draw manually
- Select proper view
- Draw geometric shapes such as circles, polygons, ellipses, parabola, triangles of various angles, tangent lines, and arcs as needed
- Identify types of lines to be used
- Determine and utilize line precedence
- Construct a one-view drawing
- Show hidden features and centerlines as required
- Complete title block by selecting lettering style and size
- Apply proper thickness to all lines
- **Check drawing**
- Label and save to appropriate project family

Learning Objectives

- Determine the front view for a given object
- Explain how an oblique view of simple geometric solids differs from an isometric view
- Identify common geometric shapes and forms by name
- List formulas used in geometric constructions
- Calculate the area of simple geometric shapes
- Explain how to draw one-views and geometric constructions

Comments:

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Competency

8. Develop 2D (orthographic) view drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- **Use engineering drafting software** OR draw manually
- Select proper views
- Identify types of lines to be used
- Determine and utilize line precedence
- Construct an orthographic drawing
- Show hidden features and centerlines as required
- Complete title block by selecting lettering style and size
- Apply proper thickness to all lines
- **Check drawing**
- Label and save to appropriate project family

Learning Objectives

- Explain the alphabet of lines for drawing
- Explain the three dimensions and how they are represented for width, depth, and height
- Describe projection rules to create 2D sketches of 3D objects
- Define orthographic view and its purpose
- Compare types of orthographic views
- Discuss the line types used in orthographic views
- Explain how orthographic projections are used in engineering drawings
- Explain how to draw orthographic views
- Explain how an oblique view of simple geometric solids differs from an isometric view

Comments:

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Competency

9. Develop 3D view models

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- **Use engineering drafting software** OR draw manually
- Select proper view
- Lay out view corner
- Identify lines to be used
- Determine and utilize line precedence
- Draw 3D view models
- Show hidden features and centerlines as required
- Complete title block by selecting lettering style and size
- Apply proper thickness to lines
- **Check drawing**
- Label and save to appropriate project family

Learning Objectives

- Compare orthographic to pictorial (3D) views
- Describe the types of pictorial (3D) views
- Explain how the viewing direction for a pictorial drawing is chosen
- Explain how to draw pictorial (3D) views
- Compare solid modeling to surface modeling
- Understand and compare 3D features that add and remove geometry including extrude, fillet, shell, revolve, sweep, loft, pattern features

Comments:

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Competency

10. Prepare auxiliary views

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- **Use engineering drafting software** OR draw manually
- Select proper auxiliary plane
 - Inclined
 - Oblique
- Prepare auxiliary drawing
- Complete title block by selecting lettering style and size
- Apply proper thickness to lines
- **Check drawing**
- Label and save to appropriate project family

Learning Objectives

- Define the purpose of auxiliary views
- Compare auxiliary views to one-view, section, orthographic, and pictorial (3D) views
- Explain why auxiliary views are considered special orthographic views
- Compare types of auxiliary views
- Describe how auxiliary views are used in engineering design drawings
- Explain how to draw auxiliary views

Comments:

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Competency

11. Prepare section views

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- **Use engineering drafting software** OR draw manually
- Select proper section view
- Prepare section drawing
- Complete title block by selecting lettering style and size
- Apply proper thickness to lines
- **Check drawing**
- Label and save to appropriate project family

Learning Objectives

- Define the purpose of section views
- Compare section views to orthographic and pictorial views
- Compare types of section views
- Define the “cut line”
- Describe how section views are used in engineering design drawings
- Explain how to draw section views

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Competency

12. Dimension drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- **Use engineering drafting software** OR draw manually
- Select views to be dimensioned
- Dimension views to standard
 - Draw dimension lines
 - Dimension views using appropriate style of dimensioning (coordinated, linear)
- Continue until all features have been dimensioned
- Dimension complex shapes when appropriate (e.g., spheres, cylinders, tapers, pyramids)
- Apply appropriate line thickness and type to dimension, extension, and center lines
- **Check drawing**

Learning Objectives

- Define proportion
- Explain engineering scale
- Describe how scales are indicated on technical drawings
- Define dimensioning in engineering
- Discuss the common rules for engineering dimensioning
- Explain the relationship between design intent and dimensioning
- Define driven and driving dimensions
- Define ordinate dimension
- List common standards for dimensioning at your worksite
- Discuss the basic parts of a dimension
- List common symbols used in dimensioning
- Identify and dimension fillets, rounds, diameters, chamfers, holes, slots, and screw threads in orthographic projection drawings
- Explain the rules that are associated with the application of dimensions to multiview drawings
- Identify and explain the difference between general tolerances, limit dimensions, unilateral, and bilateral tolerances
- Differentiate between clearance and interference fits

Comments:

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Competency

13. Apply lettering & basic annotation to drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- **Use engineering drafting software** OR draw manually
- Add lettering
- **Draw dimension** and extension lines
- Apply adequate drawing notations
- Use appropriate abbreviations
- Apply finish marks
- **Check drawing**

Learning Objectives

- Explain the importance of standardized lettering on engineering design documents
- Discuss common standards to use in lettering
- Discuss when to use dashed lines
- Describe general rules of the use of line weights
- Define annotation
- Explain the purpose of engineering annotations on technical drawings
- List common abbreviations used in annotations in engineering

Comments:

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Competency

14. Check, revise, & record drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

CHECK

- Obtain all material (catalogs, calculations, references) pertaining to drawn item
- Check dimensioning, tolerances and references to other drawings
- Check for complete calculations and dimensioning on all required documents
- Check material specifications are given in detail
- Check that all necessary drawing views are included
- Check clearances and interference between moving and adjacent parts
- Check the parts list on assembly drawings for sizes, catalog information, material, etc.
- Check appropriate unit of scale is indicated

REVISIONS

- Review drawing revision (change) procedures
- Identify drawing to be modified
- **Use engineering drafting software** OR draw manually
- Make modifications to drawing
- Construct a revision table on drawing
- Record changes properly on revision table
- Apply appropriate line thickness and type
- Check revised drawing
- Label and save to appropriate project family

RECORD

- Number all view drawings and supporting documents as required
- Document all checks and revisions as required by facility

Learning Objectives

- List criteria and conditions to evaluate when reviewing technical drawings at your facility
- Compare how drawing changes are made and tracked on CAD and/or manual drawings
- Explain how drawing revisions are tracked to other connected technical documents and materials specifications documents
- Discuss the impact on resources of revisions to completed plans

Comments:

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Competency

15. Participate on an engineering project

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the scope and phases of the design project with worksite professional
- Participate in the following project team activities to develop and implement the engineering project plan as able
 - Identify customer requirements
 - Identify design specifications
 - Research design constraints and criteria
 - Identify possible design solutions with team
 - Finalize design criteria and parameters
 - Plan development process
 - Evaluate project requirements
 - Estimate required resources and budget
 - Estimate time requirements
 - Identify interdependencies
 - Identify critical milestones
 - Create model/prototype
 - Test prototype
 - Refine prototype
 - Coordinate project steps with other project/departments
 - Track critical milestones
 - Track changes to engineering plans and costs
 - Track progress of project
- Periodically review plan activities completed and their results

Learning Objectives

- Define the term engineering design
- Explain the elements and steps of the engineering design process
- Describe design constraints, criteria, and trade-offs in regard to variety of conditions (e.g. technology, cost, safety, society, the environment, time, human resources, manufacturability)
- Identify the steps of a product's lifecycle
- Explain why teams of people are used to develop solutions to design problems
- Describe the use of Gantt and flow charts to manage the various phases of a design project
- Discuss product specifications and their role in engineering
- Contrast quality and efficiency as significant factors in engineering
- Identify and describe estimation techniques
- Classify costs (e.g., direct and indirect, fixed and variable, methods and standards)

Comments: