Lines and Symbols

Unit: Occupational Skills

Problem Area: Mechanical Drawing

Lesson: Lines and Symbols

Student Learning Objectives.

Instruction in this lesson should result in students achieving the following objectives:

1. **Interpret line types and weights.**
2. **Interpret technical drawing symbols.**

Resources.

The following resources may be useful in teaching this lesson:

E-unit(s) corresponding to this lesson plan. CAERT, Inc. http://www.mycaert.com.

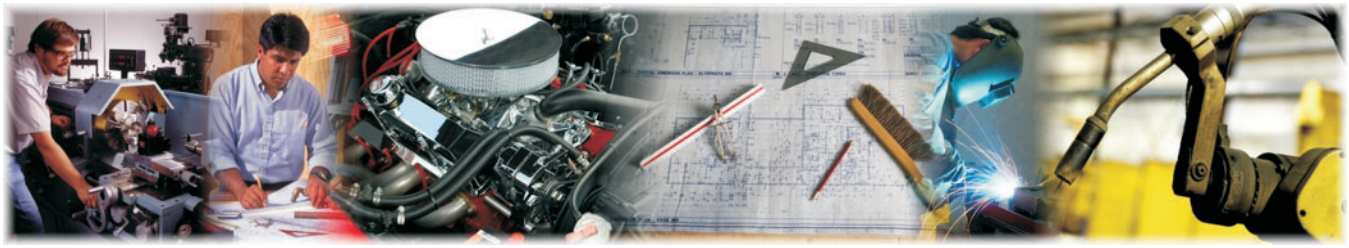
"Design," *ASME*. Accessed Oct. 28, 2014. https://www.asme.org/engineering-topics/design.

Madsen, David P., et al. *Engineering Drawing and Design*, 5th ed. Delmar Cengage® Learning, 2007.

Madsen, David P. *Print Reading for Engineering and Manufacturing Technology*, 3rd ed. Cengage, 2012.

Equipment, Tools, Supplies, and Facilities

- ✓ Overhead or PowerPoint projector
- ✓ Visual(s) from accompanying master(s)
- ✓ Copies of sample test, lab sheet(s), and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials



Key Terms. The following terms are presented in this lesson (shown in bold italics):

- bill of materials
- break lines
- center lines
- dashed lines
- dimension lines
- drawing scale
- extension lines
- hidden lines
- leader lines
- leaders
- line types
- line weights
- mechanical drawings
- section lines
- solid lines
- symbols
- technical drawings

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

> *Display several sets of technical drawings and renderings. Allow students to explore and name as many of the symbols and line types as possible. Answer questions about symbols or lines that students did not recognize. Should no print sets be available, use VM–A as an introduction.*

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Interpret line types and weights.

Anticipated Problem: What are the characteristics of line types and weights used on technical drawings?

I. Line types and weights

A. Technical drawings and model renderings

1. ***Technical drawings*** are graphic representations of objects or concepts that use a universal language of graphic symbols. Technical drawing (drafting) is a form of drawing used by architects, engineers, artists, and designers. Technical drawings have standardized elements, including:
   a. Line types and weights
   b. Symbols
   c. Layout
   d. Text
   e. View projections
   f. Dimensioning
   g. Descriptive geometry
2. ***Mechanical drawings*** are technical drawings that provide information about mechanical systems: HVAC, electrical, plumbing, etc. Other terms for mechanical drawing are "engineering drawings" and "blueprints." Engineering drawings express geometry—the shape of an object from different angles. They also show dimensions, materials, and the finish for the object.
   a. On mechanical drawings, lines, line types, and line weights are used to represent different product parts or forms.
   b. Each line represents a feature or a material within the object. Lines are used to define the outline of a material or to suggest a reference point for locating an object.

B. Line types and weights

1. ***Line types*** are line patterns. Each line type is recognized as a typical symbol or object in the construction and manufacturing industries. Following are the standard types of lines used in technical drawings.
   a. ***Solid lines*** are continuous lines used to represent a visible object that can be seen in plan, elevation, or 3D views. Solid lines can represent the outlines of tools or the edge lines of manufactured parts. Also, they are used as leader lines and dimension lines.

b. ***Hidden lines*** are object edges invisible on 2D drawings and in 3D views. They are composed of short dashed lines; they may represent features (parts or edges) on the opposite side of the product or on the inside of a product or material. Hidden lines are useful to show the extent of a material beyond the line of sight.

c. ***Dashed lines*** are patterns of long dashes compared to those used to indicate hidden lines. Dashed lines are used to show items above or behind an object or the view of the drawing and may indicate shelving or cabinets above a counter.

d. ***Center lines*** are a series of long lines and short dashes used as reference points to designate the center of an object. They can be used as reference points for manufacturing parts or to designate cutouts. Center lines may represent centers of circles and arcs or the center axis of a circular or symmetrical form. In some cases, they may not be shown in isometric projections, depending on the use of the drawing.

e. ***Dimension lines*** are lines that indicate the measurements (dimensions) of objects, including length, width, height, diameter, etc. They are drawn with thin, solid lines and are parallel to the lines/features they are dimensioning. Typically, arrowheads are affixed to either end of dimension lines. Some dimension lines have an open space in the center in which to place the measurement.

f. ***Extension lines*** are thin solid lines that indicate the two end points of a feature being dimensioned out to the dimension line. They show the exact location of the dimension. Extension lines cross object lines, center lines, and hidden lines. To avoid confusion, however, they do not cross dimension lines. Drafters and designers attempt to extend all dimension lines beyond the object and then locate the dimension statistics outside of the object to keep the drawing clear and less cluttered.

g. ***Leaders*** are lines that connect specific notes, references, or descriptions to objects or lines in drawings. Leaders are sometimes called leader lines. ***Leader lines*** are lines that begin as solid lines and end in arrowheads; they may be drawn at an angle or curved where the text is located. Typically, the end of the leader (near the text) is drawn on the outside of the object.

h. ***Break lines*** are long and short lines with Z breaks for flat objects and S breaks for round objects. Solid, thick freehand lines are used for short break lines. Solid, thin-ruled lines are used for long breaks. Break lines reduce the size of drawings so they can be shown on smaller sheets of paper.

i. ***Section lines*** are lines that show a cutaway view of a floor plan using repeating “dash, dot, dot” patterns. They are used in section drawings to show that a cut has been made through solid material. The portion of the drawing that represents the solid material is filled with section lines. Typically, section lines are thin lines; they are usually shown at a 45-degree

angle. The section line repeats fairly close together, and all are parallel to one another.

2. ***Line weights*** are the lightness or darkness and the thickness (width) of the lines. The number of line weights in a drawing may vary, but most drawings use three line weights. Architects, builders, manufacturers, and others use design drawings to complete tasks. The lines must be crisp and dark to ensure accurate interpretation of the line weights by all professionals.
   a. Light line weights are used to show details within a material and to represent potential object movement (e.g., door swings and hinge direction). In a section cut, the wood grain or material designation pattern would be drawn with light line weights. In general, action lines, information lines (e.g., dimension lines, center lines, and leader lines), and fill patterns are drawn with light lines.
   b. Medium line weights are used to indicate the outline of a material or form within an object, especially secondary objects. Secondary objects include doors, furnishings, counters, and cabinets. In detail sections, medium line weights can be used to designate visible lines between materials.
   c. Heavy line weights are reserved to show the outline of a primary object's entire detail or element. These weights can be used to designate the visible line around the outside of products (e.g., walls in plan view or the outline of the perimeter of an elevation or 3D object). Heavy lines are bold, dark, and thick.
   d. Halftone line weights are any in gray scale. They are used to indicate patterns within materials or to indicate joints or folds on elevation drawings.

Teaching Strategy: *Many techniques can be used to help students master this objective. Use VM–A through VM–C to review. Assign LS–A.*

Objective 2: Interpret technical drawing symbols.

Anticipated Problem: What are common technical drawing symbols?

II. Technical drawing symbols

A. Technical information

1. Title blocks for technical drawings and renderings
   a. The name of the company or organization
   b. The final issue date
   c. Any pertinent information about the drawing/project
   d. The print name and reference number or letter
   e. Many title blocks contain a bill of materials. A ***bill of materials*** is a listing of all parts and/or materials by name, the number of each part required, and the material callout (e.g., plastic or steel) for each part.

2. Reference number
    a. The drawing's reference number identifies each drawing in a set. There are usually multiple drawings (or sheets) in a project set.
    b. Drawings that convey similar information are grouped with a common number or letter code.
3. Cover sheet
    a. A cover sheet lists all the drawings that exist in a set with their reference numbers.
    b. It lists all symbols, terms (and definitions), and abbreviations used on the print set.
4. ***Drawing scale*** is the ratio (a comparison) at which real objects have been reduced or enlarged. Prints drawn to scale allow the objects to be rendered accurately and precisely. Scales may be metric or standard. The scale represents the length in the drawing followed by a colon and the matching length on the real object. The following examples are in standard measure (e.g., inches and feet):
    a. 1 inch = 1 inch or 1:1—This scale is interpreted as 1 inch on the drawing and is equal to 1 inch on the actual object or full size. The measured distance on the drawing is the actual size of the object.
    b. $^1/_2$ inch = 1 foot or 1:24—This scale is interpreted as $^1/_2$ inch on the drawing equals 1 foot on the actual object. It is called half scale. If a part measures $1^3/_4$ inches on the drawing, the actual size of the part is $3^1/_2$ feet.
    c. Other common manufacturing scale ratios are:
        (1) 1:4 is 3 inches = 1 foot 0 inches
        (2) 1:8 is $1^1/_2$ inches = 1 foot 0 inches
        (3) 1:32 is $^3/_8$ inch = 1 foot 0 inches
        (4) 1:48 is $^1/_4$ inch = 1 foot 0 inches

B. Symbols and notes
1. ***Symbols*** are graphic elements that convey information about features on technical drawings or renderings. Drafters and engineers use standard symbols and terminology to communicate design specifications. Symbols help create clear and organized prints. Generally, standard symbols and notes are used in conjunction with a plan, elevation, section, or detail drawings.
2. Notes (text) are used with symbols to clarify drawing features and to call out specifications. Notes include terminology to describe or explain design features or parts. Notes are brief and concise. In addition, notes often have leaders that extend straight from the notes to the locations where they apply. For example, a brief note used for a part specification would be "CUT OUT."
3. Symbol types
    a. Material and graphic symbols may look different in elevations versus plans and section drawings.

b. Material symbols are located in a "material legend." The legend includes all materials used in the drawing, and the symbols for the materials are located in a small rectangle with the names next to them. Material symbols "fill in" the outline of a shape or object on the drawing and represent the object's real material (e.g., brick or stone).
   (1) Most material symbols in elevation plans look like the actual material or object.
   (2) Material symbols in a section plan show the object as if it were sliced in half to show its composition.

c. Graphic symbols are used to reference other drawings or schedules. These symbols have a coded letter and/or number to direct a person to the correct drawing. These reference symbols are typically the same in all types of drawings. The numbers and/or letters are enclosed in a circle, rectangle, triangle, or other basic geometry.

Teaching Strategy: *Many techniques can be used to help students master this objective. Use VM–D through VM–E to illustrate representations. Supply a set of drawings, and have students apply appropriate symbols and notes to the drawings. Assign LS–B.*

Review/Summary.

Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may be used in the Review/Summary.

Application.

Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

Evaluation.

Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

Answers to Sample Test:

Part One: Completion

1. technical drawings
2. line type
3. weight
4. arrowheads
5. leader or leader line
6. section lines
7. extension lines

8. hidden lines
9. mechanical drawings

Part Two: True/False

1. T
2. F
3. T
4. T
5. F
6. T

Part Three: Short Answer

1. Answers may vary slightly but should be similar to the following: Break lines are long and short lines with Z breaks for flat objects and S breaks for round objects. Solid, thick freehand lines are used for short break lines. Solid, thin-ruled lines are used for long breaks. Break lines reduce the size of the drawing so it can be shown on a smaller sheet of paper.
2. Answers will vary but should include five of the common material symbols found on VM–D (e.g., cast iron, electric insulation, rubber, steel, sound & heat insulation, magnesium alloy, fabric or screen, wood, porcelain glass, electrical wingdings, and liquids).

Sample Test

Name _____

Lines and Symbols

Part One: Completion

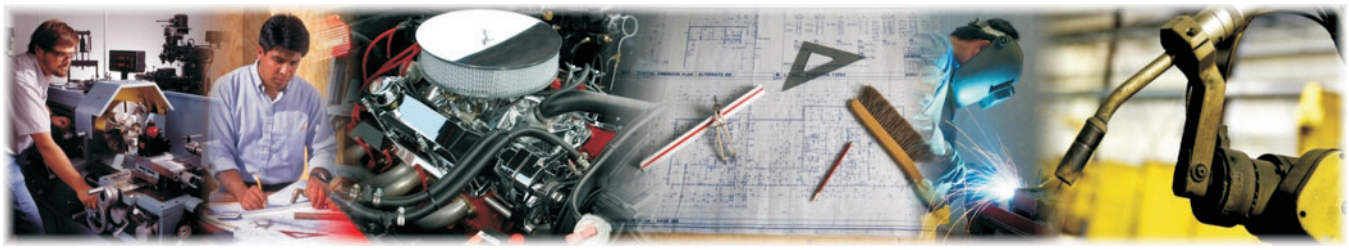
Instructions: **Provide the word or words to complete the following statements.**

1. Graphic representations of objects or concepts that use a universal language of graphic symbols is/are called _____.
2. The pattern of the line is the _____.
3. The lightness or darkness and the thickness (width) of the line are called its _____.
4. Typically, _____ are affixed to either end of a dimension line.
5. A line that connects a specific note, reference, or description to objects or lines in a drawing is a/an _____.
6. Lines that show a cutaway view of a floor plan using a repeating "dash, dot, dot" pattern are called _____.
7. Thin, solid lines that indicate the two endpoints of a feature being dimensioned out to the dimension line are called _____.
8. Lines that indicate object edges invisible on 2D drawings and in 3D views and composed of short dashed lines are called _____.
9. Technical drawings that provide information about systems (e.g., HVAC, electrical, and plumbing) are called _____.

Part Two: True/False

Instructions: **Write *T* for true or *F* for false.**

_____1. Most material symbols in an elevation plan look just like the actual material or object.



_____2. A drawing scale is a graphic element that represents a particular item on a technical drawing.

_____3. A drawing's reference number is used to identify a particular drawing within a set.

_____4. Heavy line weights are reserved to show the outline of a primary object's entire detail or element.

_____5. Notes include symbols that describe or explain a design feature or part; they are brief and concise.

_____6. Drawing scale is the ratio at which real objects have been reduced or enlarged.

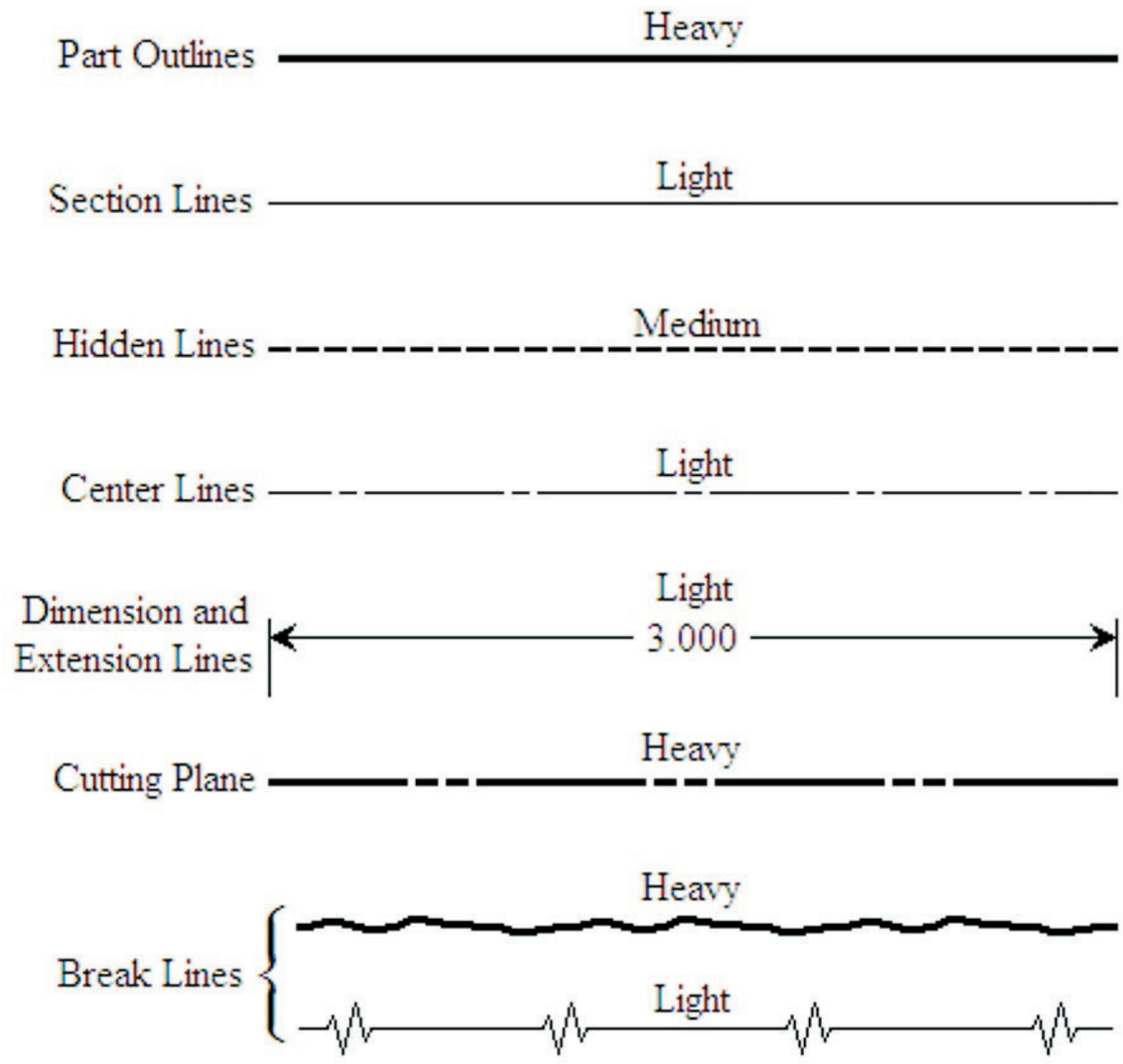
Part Three: Short Answer

Instructions: **Answer the following.**

1. Describe the shape of break lines and their use on technical drawings.

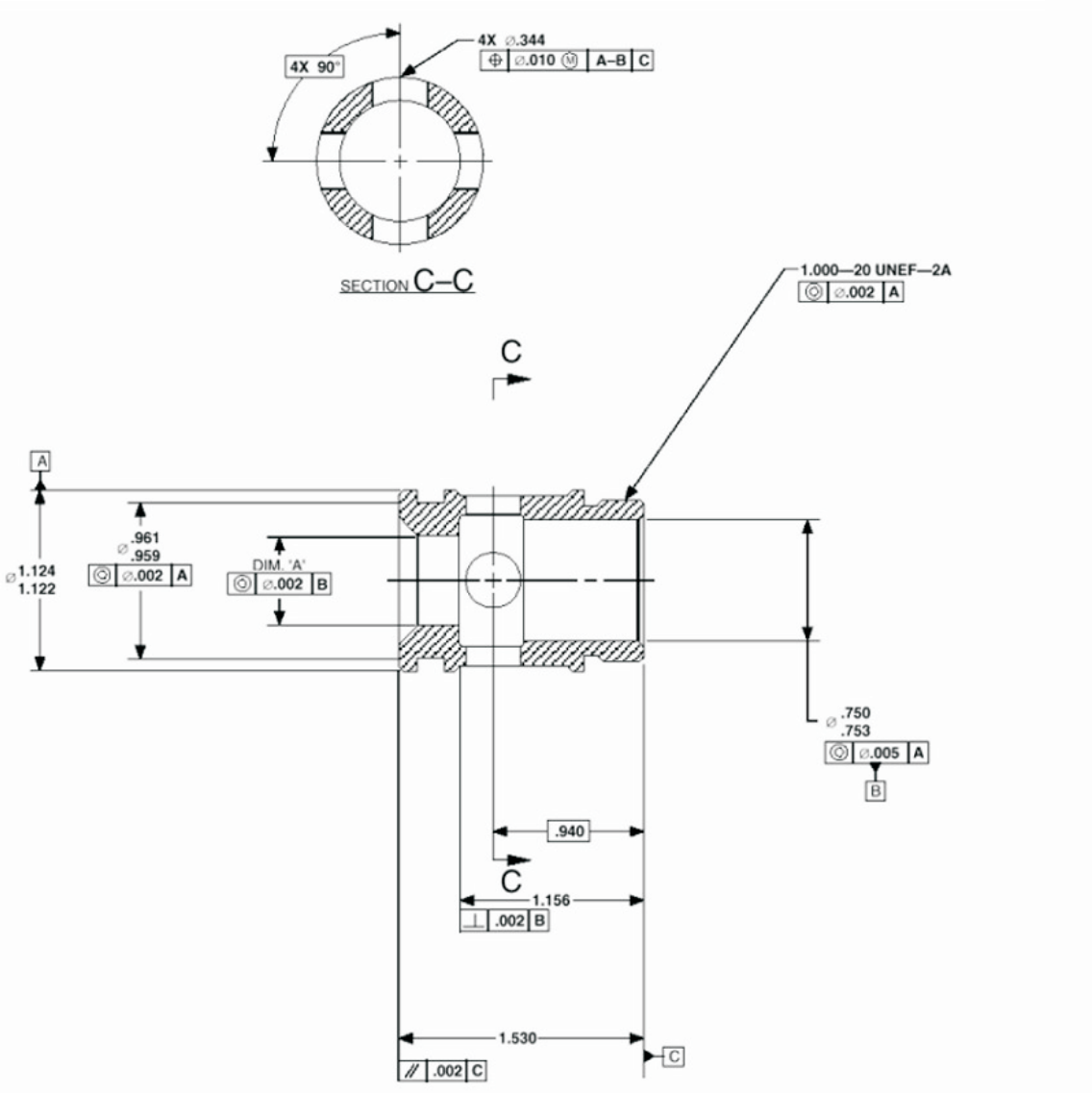
2. Most material symbols in an elevation plan look just like the actual material or object. Draw and label five common material symbols used on technical drawings.

LINE TYPES AND WEIGHTS

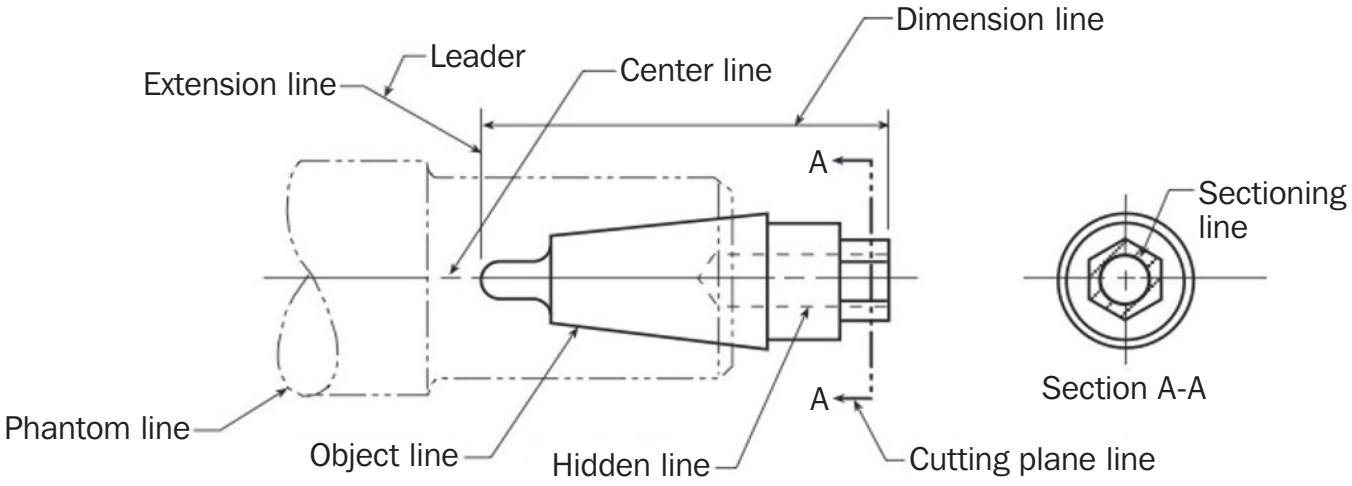


LINE TYPES AND DRAFTING SYMBOLS

This is a technical drawing of a hydraulic valve. Decode the symbols and lines on this drawing. (Courtesy, NIST: U.S. Department of Commerce)

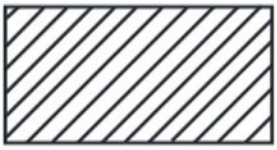


EXAMPLES OF LINE TYPES

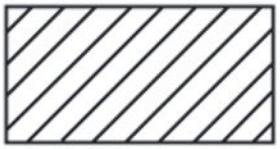


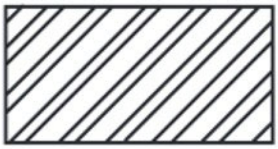
(Courtesy, Alabama Industrial Development Training)

COMMON MANUFACTURING MATERIALS SYMBOLS

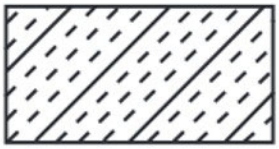

Cast iron

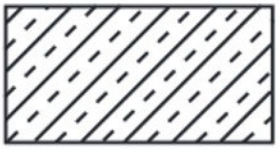

Electric insulation

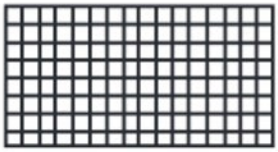

Rubber

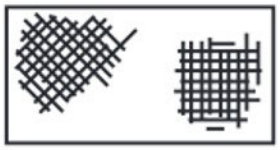

Steel

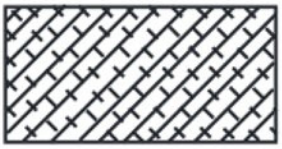

Sound & heat insulation


Magnesium alloy

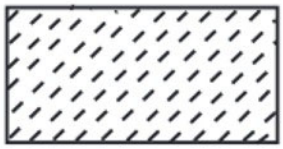

Bronze, brass copper

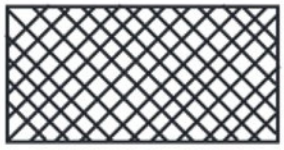

Electrical windings


Fabric or screen


Aluminum & alum. alloy


Transparent material


Porcelain glass

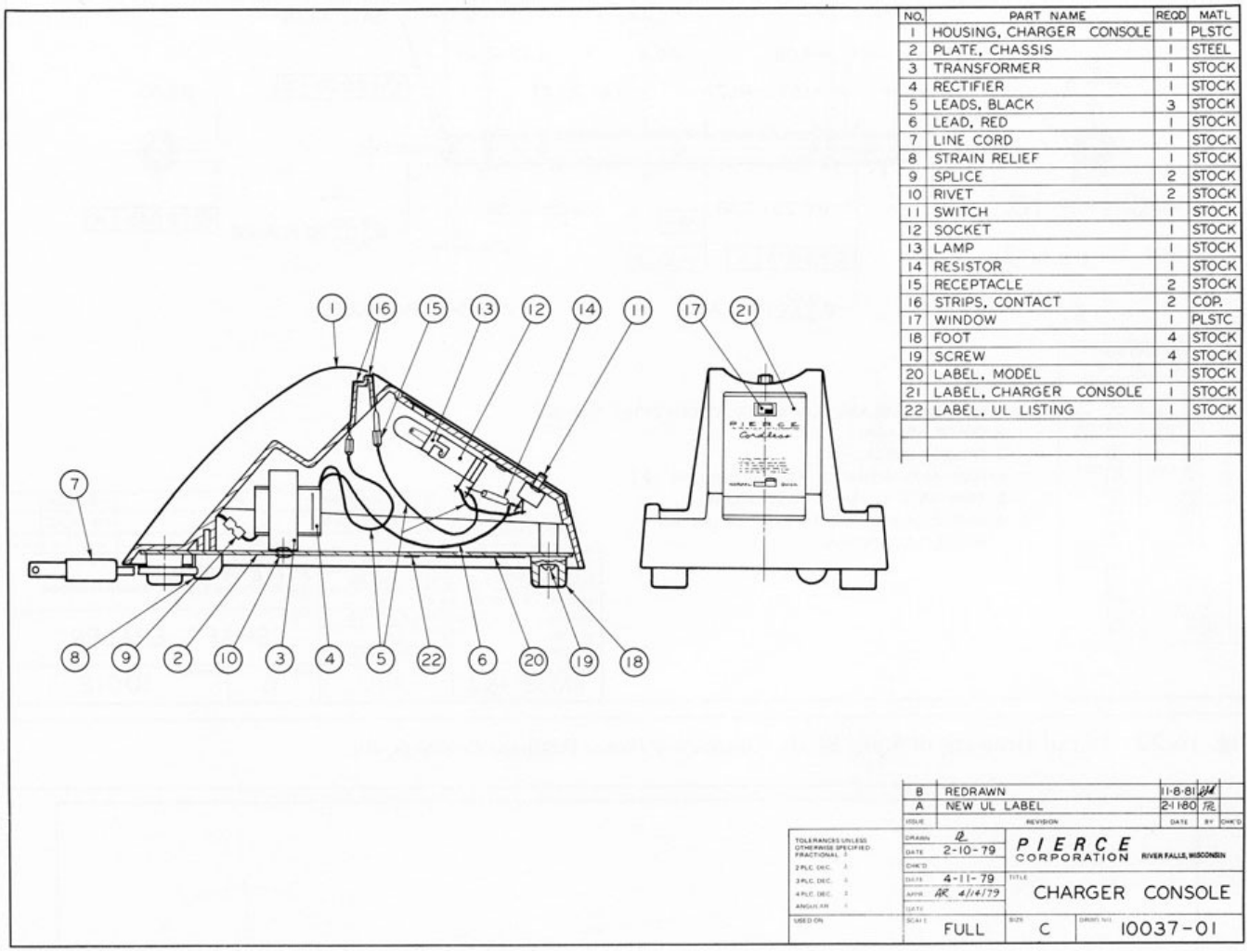

Zinc, lead babbitt


Wood


Liquids

(Courtesy, Alabama Industrial Development Training)

BILL OF MATERIALS



NO.	PART NAME	REQD	MATL
1	HOUSING, CHARGER CONSOLE	1	PLSTC
2	PLATE, CHASSIS	1	STEEL
3	TRANSFORMER	1	STOCK
4	RECTIFIER	1	STOCK
5	LEADS, BLACK	3	STOCK
6	LEAD, RED	1	STOCK
7	LINE CORD	1	STOCK
8	STRAIN RELIEF	1	STOCK
9	SPLICE	2	STOCK
10	RIVET	2	STOCK
11	SWITCH	1	STOCK
12	SOCKET	1	STOCK
13	LAMP	1	STOCK
14	RESISTOR	1	STOCK
15	RECEPTACLE	2	STOCK
16	STRIPS, CONTACT	2	COP.
17	WINDOW	1	PLSTC
18	FOOT	4	STOCK
19	SCREW	4	STOCK
20	LABEL, MODEL	1	STOCK
21	LABEL, CHARGER CONSOLE	1	STOCK
22	LABEL, UL LISTING	1	STOCK

ISSUE	REVISION	DATE	BY	CHK'D
B	REDRAWN	11-8-81	JH	
A	NEW UL LABEL	2-11-80	FR	

DRAWN R. DATE 2-10-79
CHK'D DATE 4-11-79
APPR. AR 4/14/79
DATE
SCALE FULL
PIERCE CORPORATION RIVER FALLS, WISCONSIN
TITLE CHARGER CONSOLE
SIZE C DRWG NO. 10037-01

Many title blocks contain a bill of materials, which is a listing of all parts and/or materials by the name, the number of each part required, and the material callout for each part. (Courtesy, Alabama Industrial Development Training)

Name _____

Create a Technical Drawing

Purpose

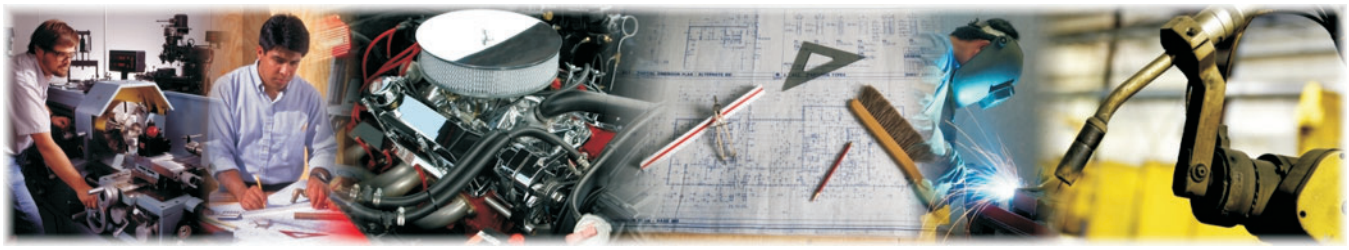
The purpose of this activity is to produce a technical drawing that includes a top view and four elevations.

Objectives

1. Review your class notes about technical drawing symbols and lines.
2. Sketch your desk in top view and four elevations.
3. Measure the exact dimensions of the desk, and record the dimensions on your sketch.
4. Draw your desk using hand or CADD drafting materials and tools.
5. Make any modifications following your instructor's review and input.

Materials

- desk (or other piece of classroom furniture)
- tape measure
- class notes
- hand-drawing materials and tools:
  - drafting pencil and paper
  - drawing board
  - scale ruler
  - triangles
  - T-square
- CADD drawing materials, equipment, and tools:
  - computer with CADD software
  - printer
- stapler
- flash drive



Procedure

1. Work independently.
2. Produce a set of drawings for your desk (or other piece of classroom furniture as specified by your instructor). The drawings are a top view and four elevations.
   a. First, sketch your desk from a top view. Then sketch it from the four elevations.
   b. Next, use the tape measure to take measurements of all the main features of your desk, and place the dimensions on the sketch. Attach your sketch with measurements to this lab sheet, and/or record the dimensions in the space provided, including:

      Legs = _____

      Frame = _____

      Top surface = _____

      Other: _____ = _____
3. Draw your desk using hand or CADD drafting tools.
   a. Determine the scale.
   b. Add line types and weights as needed.
   c. Add symbols and notes (e.g., materials and graphics) as needed.
4. Review the drawing scale, line types and weights, and symbols with your instructor. Make any needed edits or modifications to the drawing. Print your CADD drawing, and attach it to this lab sheet. Do not forget to save it.
5. Turn in your completed drawing to your instructor.

Name _____

Create a Technical Drawing

Purpose

The purpose of this activity is to produce a technical drawing with symbols, graphics, and dimensions.

Objectives

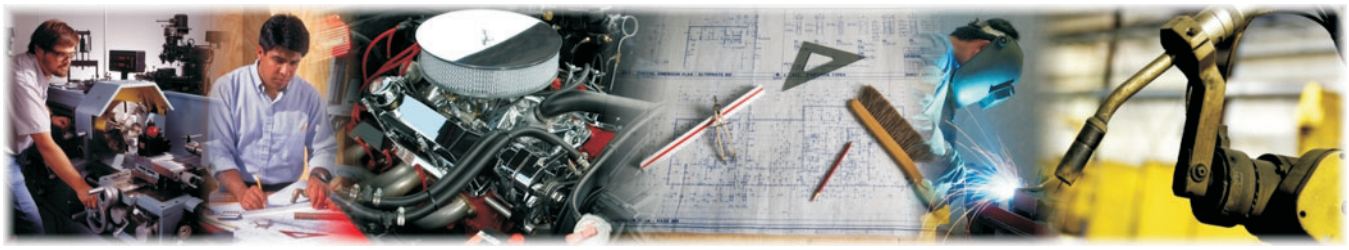
1. Draw leaders with notes.
2. Add appropriate symbols for specifications.
3. Add graphics as required.
4. Add all necessary dimensions.
5. Make any needed modifications following instructor review.

Materials

- drafting pencil
- drafting paper
- drawing board
- scale ruler
- triangles
- T-square
- computer with CADD software
- printer

Procedure

1. Work independently.



2. Complete the drawing set—top view and four elevations—you created in LS–A by adding the appropriate symbols, graphics, and dimensions.

   a. First, draw the appropriate leaders with notes for all the desk features.
   b. Next, add the appropriate symbols for specifications.
   c. Finally, add all the necessary dimensions. Ensure the dimensions are clear and accurate. [All dimension and extension lines should match exactly to your original drawing.]

3. Ask your instructor to review your work. Make any needed modifications.

4. Turn in your completed drawing to your instructor.