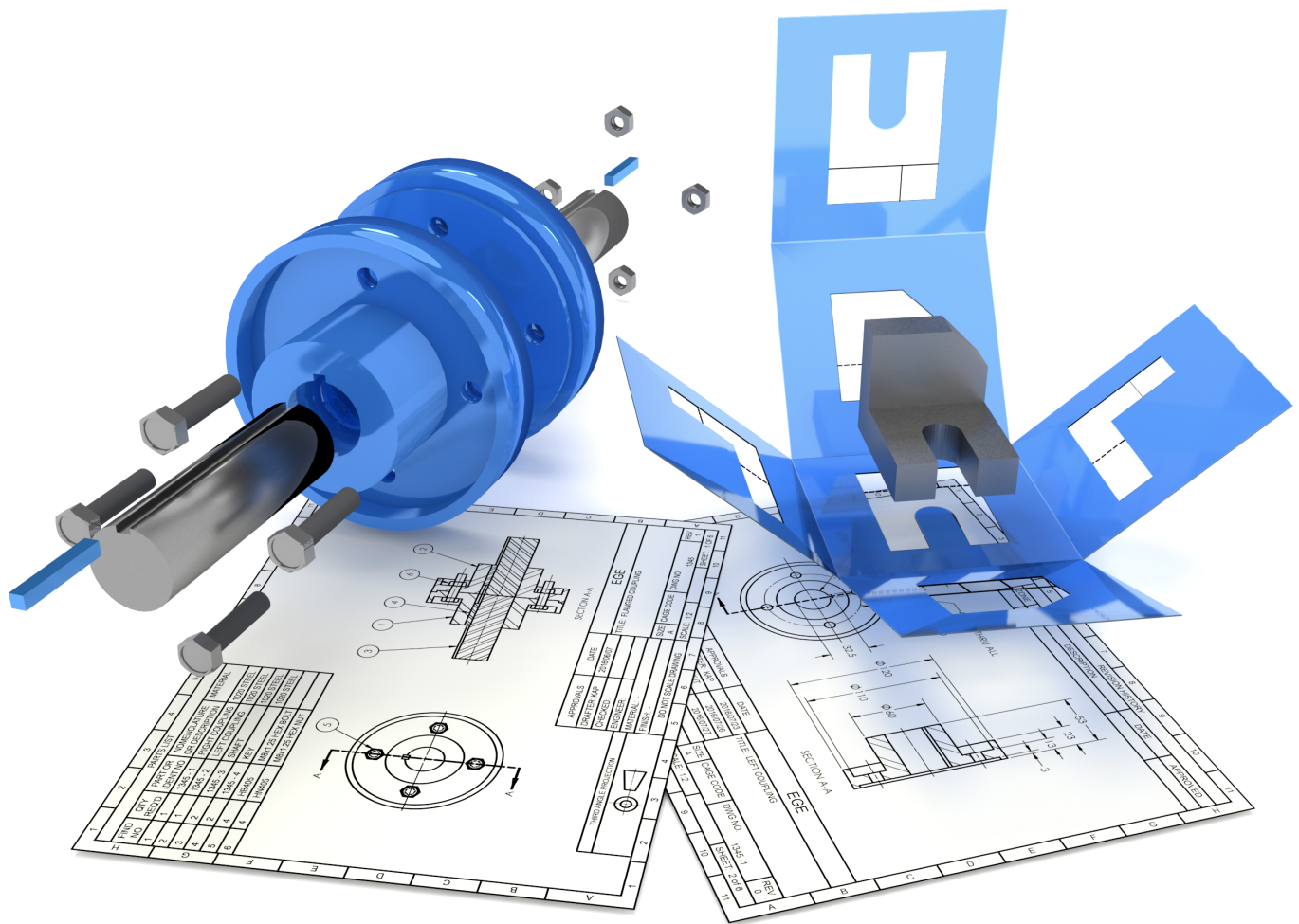


# ENGINEERING GRAPHICS ESSENTIALS

Text and Digital Learning

KIRSTIE PLANTENBERG | FIFTH EDITION



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# CHAPTER 2

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## ORTHOGRAPHIC PROJECTIONS

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## CHAPTER SUMMARY

*In this chapter you will learn how to create orthographic projections. An orthographic projection describes the shape of an object. It is a two-dimensional representation of a three-dimensional object. Different line types are used to indicate visible features, hidden features and symmetry. By the end of this chapter, you will be able to create a technically correct orthographic projection and visualize its three-dimensional form.*

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### 2.1) ORTHOGRAPHIC PROJECTION INTRODUCTION

**An orthographic projection enables us to represent a three-dimensional object in two dimensions** (see Figure 2.1-1). An orthographic projection is a drawing that shows different sides of an object on a sheet of paper (i.e. in two dimensions). The drawing is formed by projecting the edges of the object onto a projection plane from different viewing perspectives. Orthographic projections allow us to represent the shape of an object usually using three views; however, a part may be represented completely with only one or two views. These views together with dimensions and notes are sufficient to manufacture the part.

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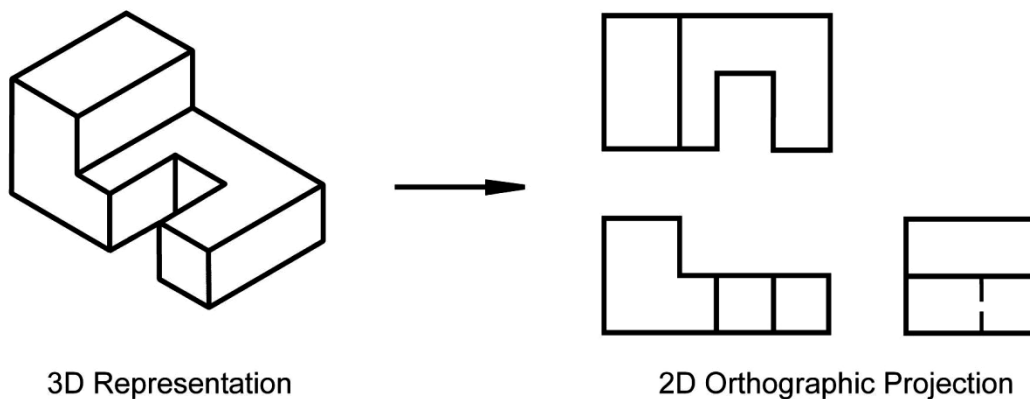


Figure 2.1-1: Orthographic projection.

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#### 2.1.1) The Six Principle Views

The six principle viewing directions of an orthographic projection and their associated view names are shown in Figure 2.1-2. These viewing directions are used to create the six principle views. Each principle view is created by looking at the object in the directions indicated in Figure 2.1-2 and drawing what is seen, as well as, what is hidden from view.

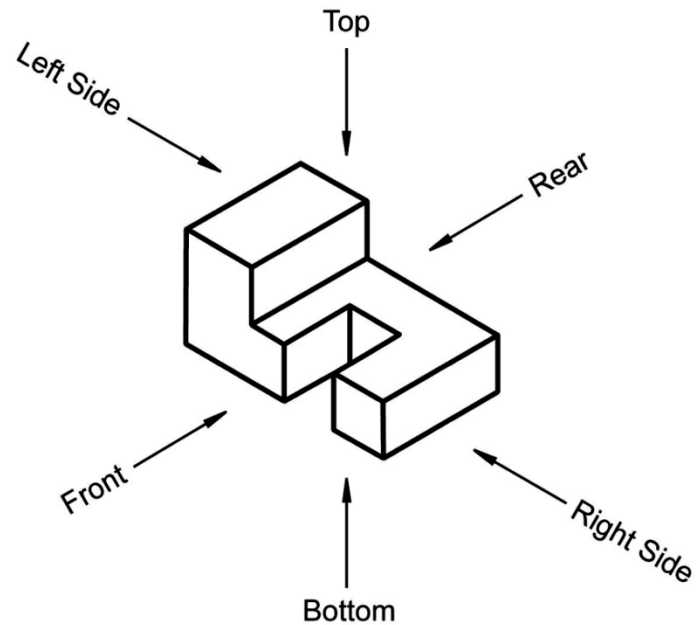


Figure 2.1-2: The six principle viewing directions

## 2.2) THE GLASS BOX METHOD

The glass box method is a very convenient way of visualizing how an orthographic projection is created. To obtain an orthographic projection, an object is placed in an imaginary glass box as shown in Figure 2.2-1. The sides of the glass box represent the six principle planes. Images of the object are projected onto the sides of the box to create the six principle views. The box is then unfolded to lie flat, showing all views in a two-dimensional plane. Figure 2.2-2 shows the glass box being unfolded to create the orthographic projection of the object.

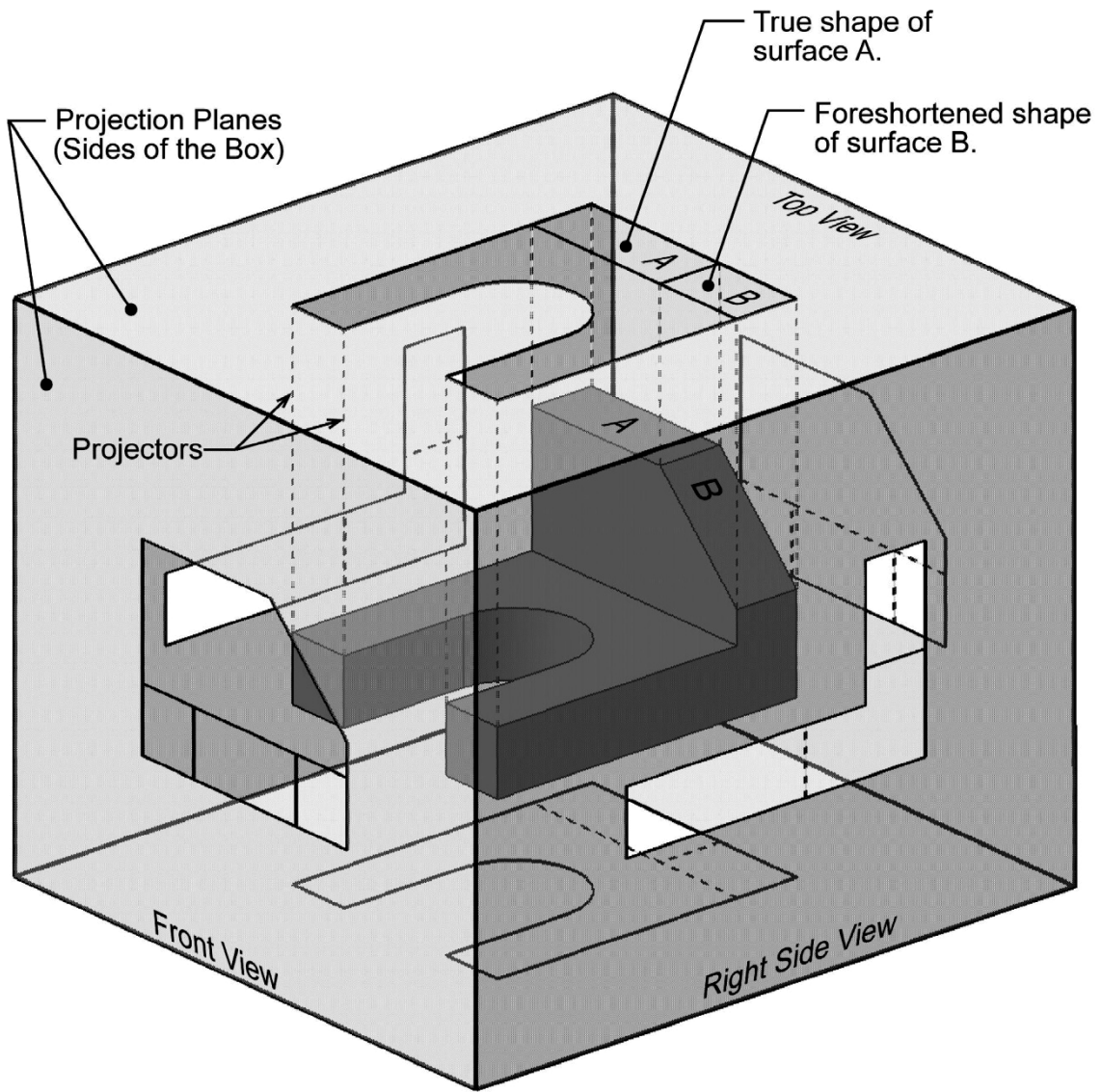


Figure 2.2-1: Object in a glass box

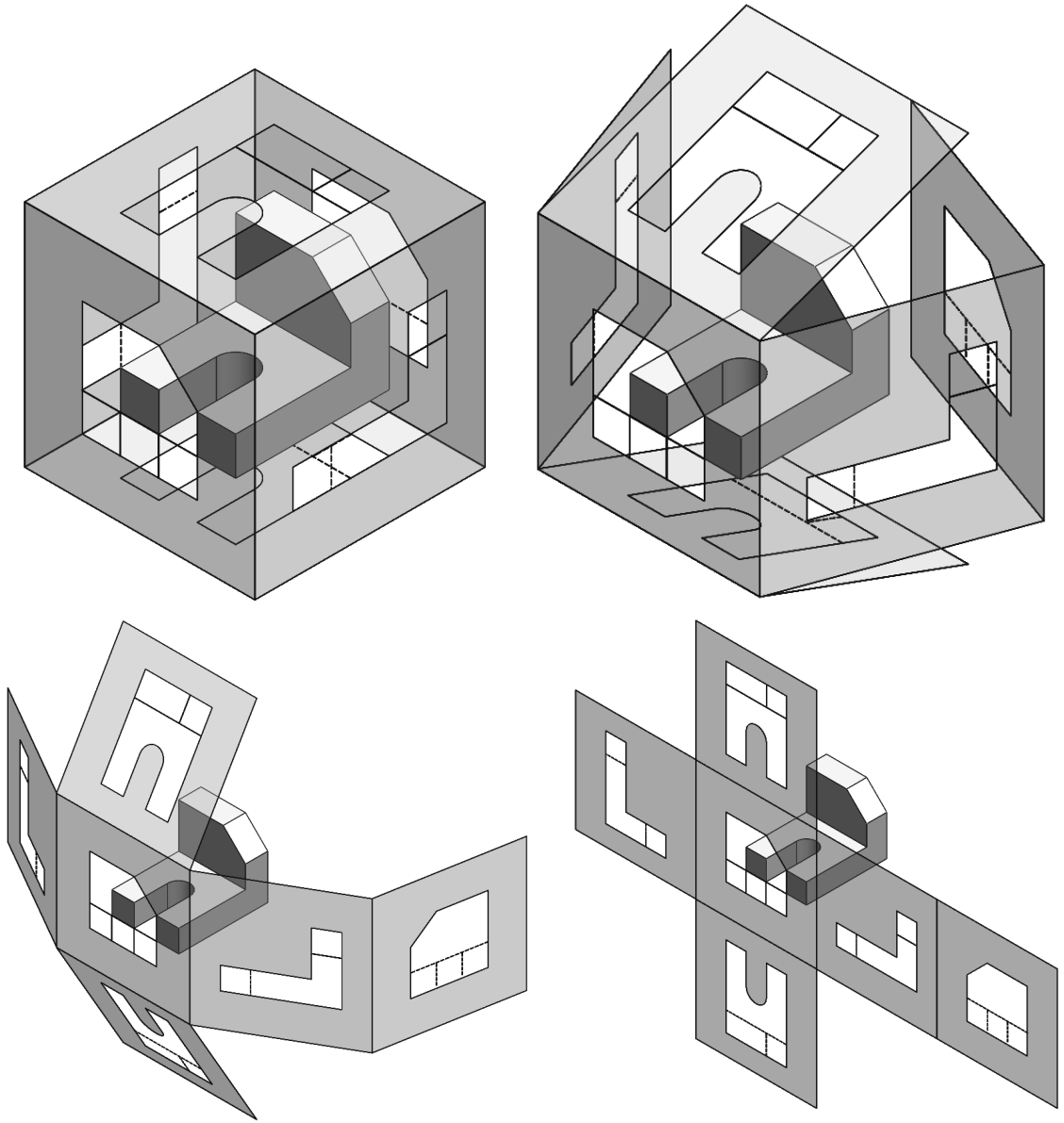
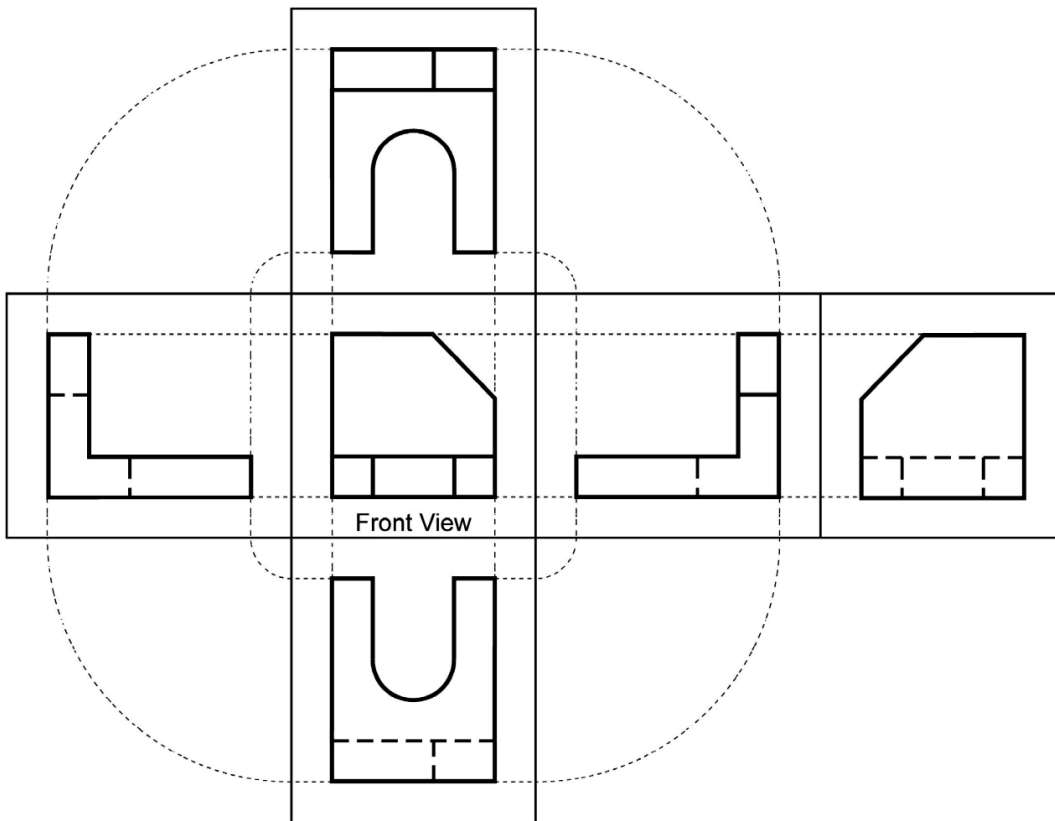


Figure 2.2-2: Glass box being unfolded

**Exercise 2.2-1: Principle views**

Label the five remaining principle views with the appropriate view name. Figure 2.1-1 indicates the six principle viewing directions as well as their associated view names.



What are the differences between the *Right Side* and *Left Side* views?

What are the differences between the *Top* and *Bottom*, and *Front* and *Rear* views?

Which view(s) have the least number of hidden or dashed lines?



## 2.3) THE STANDARD VIEWS

When constructing an orthographic projection, we need to include enough views to completely describe the true shape of the part. The more complex a part, the more views are needed to completely describe its shape. Most objects require three views to be completely described. **The standard views used in an orthographic projection are the front, top, and right side views.** The other views (bottom, rear, left side) are omitted since they usually do not add any new information. The top, front, and bottom views are all aligned vertically and share the same width dimension. The left side, front, right side, and rear views are all aligned horizontally and share the same height dimension.

It is not always necessary to use the three standard views. Some objects can be completely described in one or two views. For example, a sphere only requires one view, and a block only requires two views. No matter how many views are used, the viewing directions should be chosen to minimize the use of hidden lines and convey maximum clarity.

### 2.3.1) The Front View

**The front view shows the most features or characteristics of the object.** It usually contains the least number of hidden lines. The exception to this rule is when the object has a predefined or generally accepted front view. All other views are based on the orientation chosen for the front view.

## 2.4) LINE TYPES USED IN AN ORTHOGRAPHIC PROJECTION

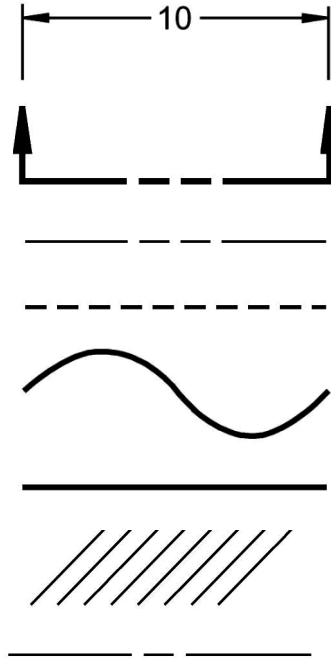
**Line type and line weight provide valuable information to the print reader.** For example, the type and weight of a line can answer the following questions: Is the feature visible or hidden from view? Is the line part of the object or part of a dimension? Is the line indicating symmetry? There are four commonly used line types: continuous, hidden, center and phantom. Important lines are thicker than less important thin lines. The following is a list of common line types and widths used in a basic orthographic projection that has no section views or dimensions.

1. Visible lines: Visible lines represent visible edges and boundaries. The line type is **continuous** and the line weight is **thick**.
2. Hidden lines: Hidden lines represent edges and boundaries that cannot be seen. The line type is **dashed** and the line weight is **medium thick**.
3. Center lines: Center lines represent axes, center points, planes of symmetry, circle of centers, and paths of motion. A *circle of centers* is usually a hole pattern that exists on the circumference of a circle. A *path of motion* indicates the path a feature takes when moving from one position to the next. The line type is **long dash – short dash** and the line weight is **thin**.
4. Phantom lines: Phantom lines are used to indicate imaginary features. For example, they are used to indicate the alternate positions of moving parts, adjacent positions of related parts, repeated detail, reference planes between adjacent views, and filleted and rounded corners. The line type is **long dash – short dash – short dash** and the line weight is usually **thin**.
5. Break lines: Break lines are used to show imaginary breaks in objects. A break line is usually made up of a series of connecting arcs. The line type is **continuous** and the line weight is usually **thick**.

**Exercise 2.4-1: Line types**

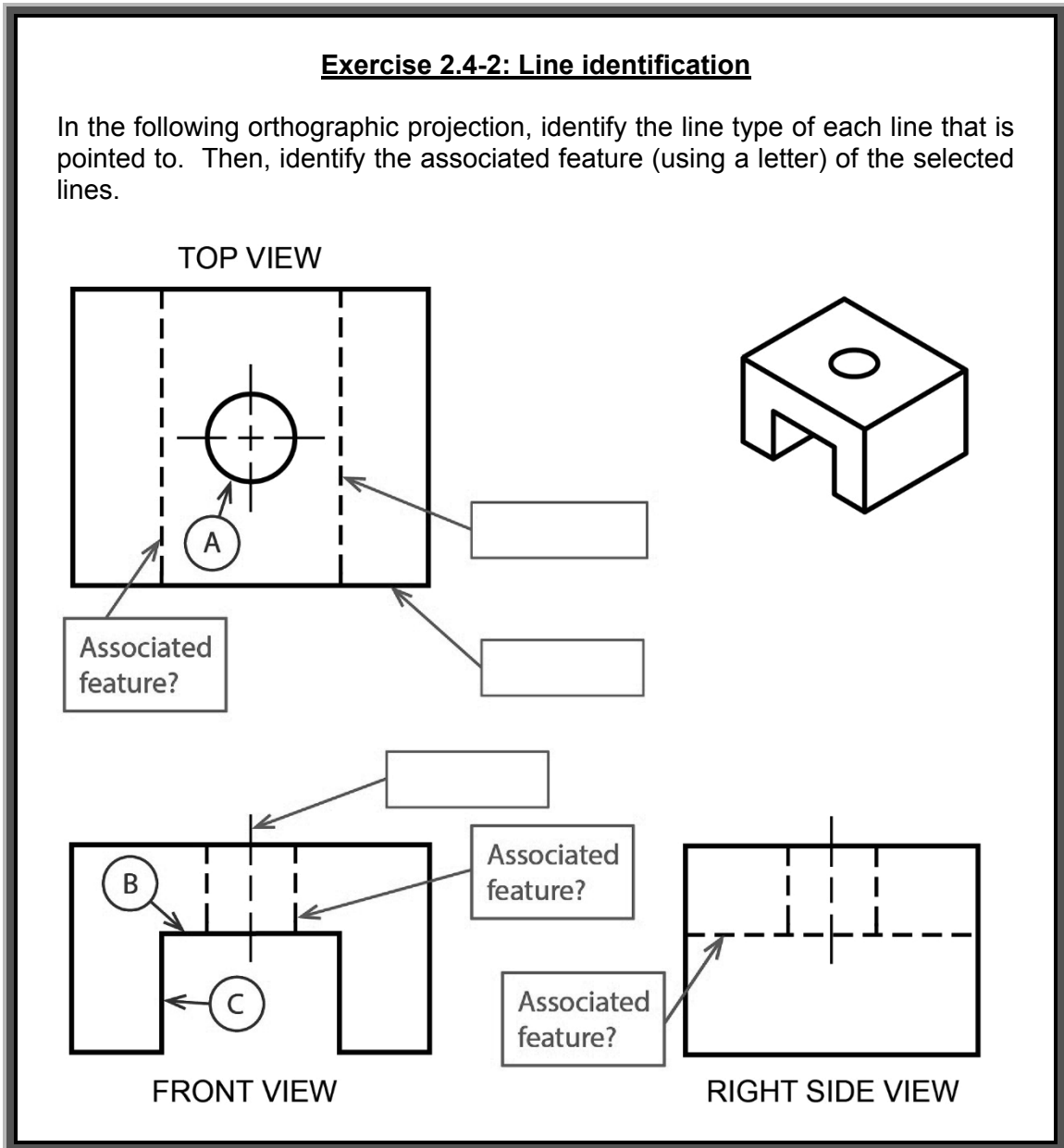
Using the line type definitions, match each line type name with the appropriate line type.

- Visible Line
- Hidden Line
- Center Line
- Phantom Line
- Dimension and Extension Lines
- Cutting Plane Line
- Section Lines
- Break Line



**Exercise 2.4-2: Line identification**

In the following orthographic projection, identify the line type of each line that is pointed to. Then, identify the associated feature (using a letter) of the selected lines.



Line width and type are controlled by the ASME Y14.2 standard. The standard recommends using, no less than, two line widths. Important lines should be twice as thick as the less important thin lines. Thick lines should be at least 0.6 mm in width and thin lines should be at least 0.3 mm in width. However, to further distinguish line importance, it is recommended to use four different thicknesses or weights: thin, medium, thick, and very thick. The actual line thickness should be chosen such that there is a visible difference between the line weights; however, they should not be too thick or thin making it difficult to read the print. The thickness of the lines should be adjusted according to the size and complexity of the part. Table 2.4-1 contains a list of common line types and widths used in an orthographic projection.






Line type name	Line type	Use	Thickness
Visible		visible edges	0.5 - 0.6 mm
Hidden		hidden edges	0.35 - 0.45 mm
Center		symmetry, circle of centers, paths of motion	0.3 mm
Phantom		imaginary features	0.3 mm
Break		imaginary brakes in the part	0.5 – 0.6 mm

Table 2.4-1: Common line types and their thicknesses

## 2.5) RULES FOR LINE CREATION AND USE

The rules and guide lines for line creation should be followed in order to create lines that are effective in communicating the drawing information. However, due to computer automation, some of the rules may be hard to follow. The rules of line creation and use are in accordance with the ASME Y14.2 and ASME Y14.3 standards.

### 2.5.1) Hidden Lines

Hidden lines represent edges and boundaries that cannot be seen.

- Rule 1. The length of the hidden line dashes may vary slightly as the size of the drawing changes. For example, a very small part may require smaller dashes in order for the hidden line to be recognized.
- Rule 2. Hidden lines should always begin and end with a dash, except when the hidden line begins or ends at a parallel visible line (see Figure 2.5-1).
- Rule 3. Hidden line dashes should join at corners (see Figure 2.5-2).

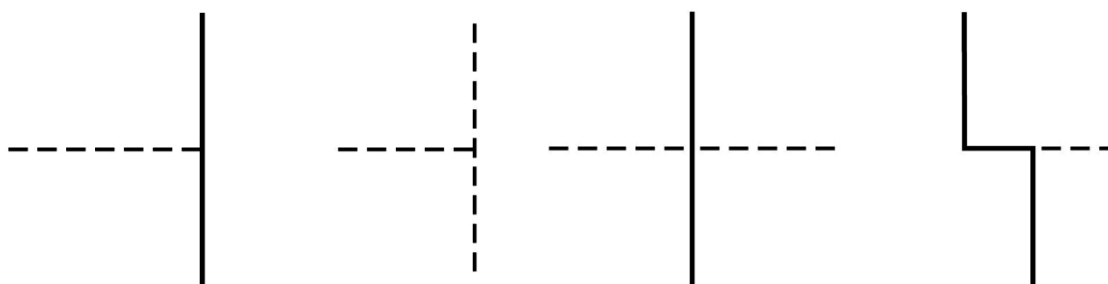


Figure 2.5-1: Drawing hidden lines

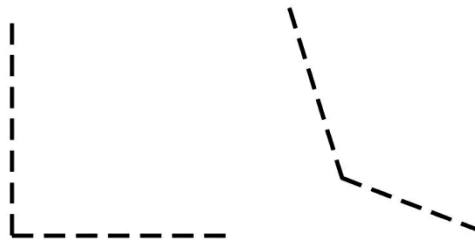


Figure 2.5-2: Hidden lines at corner

### 2.5.2) Center Lines

Center lines are used to identify planes and axes of symmetry and are important for interpreting cylindrical shapes as shown in Figure 2.5-3. If a center line is used to indicate part symmetry, two short thick parallel lines are placed on the center line, outside the part, and perpendicular to the center line (see Figure 2.5-4). Center lines are also used to indicate circle of centers and paths of motion as shown in Figure 2.5-5. Short center lines may be left unbroken if it is certain that they won't be confused with another line type. However, every measure should be taken to produce a break.

- Rule 1. Center lines should start and end with long dashes (see Figure 2.5-3).
- Rule 2. Center lines should intersect by crossing either the long dashes or the short dashes (see Figure 2.5-6).
- Rule 3. Center lines should extend a short distance beyond the object or feature. They should not terminate at other lines of the drawing (see Figure 2.5-7).
- Rule 4. Center lines may be connected within a single view to show that two or more features lie in the same plane as shown in Figure 2.5-8. However, they should not extend through the space between views.

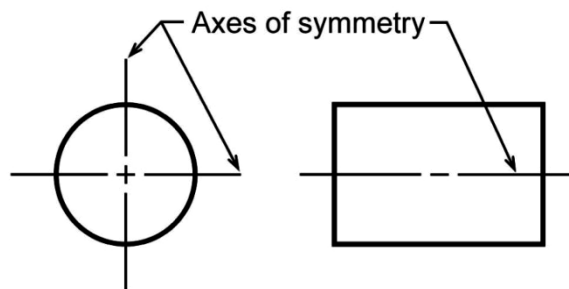
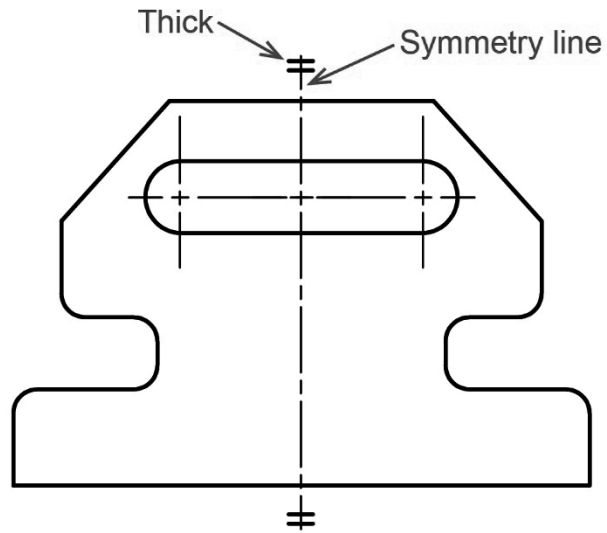


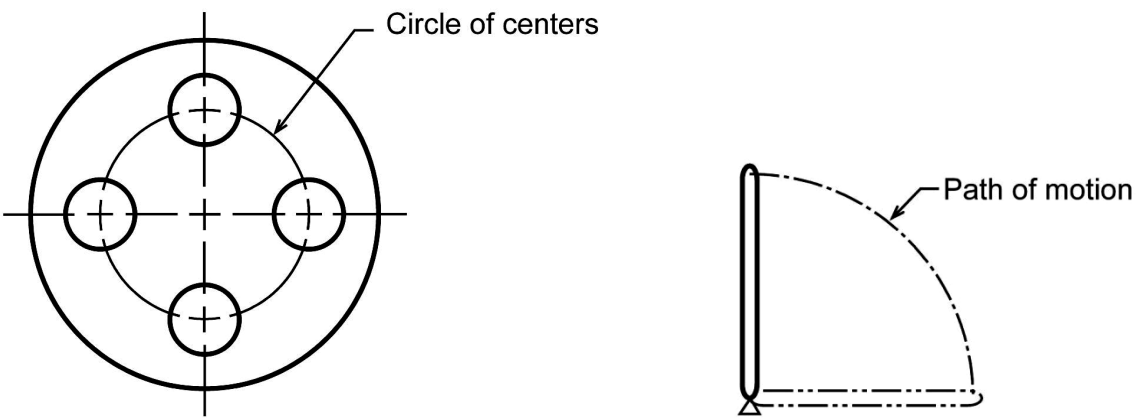
Figure 2.5-3: Axes of symmetry



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Figure 2.5-4: Part symmetry

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Figure 2.5-5: Center line uses

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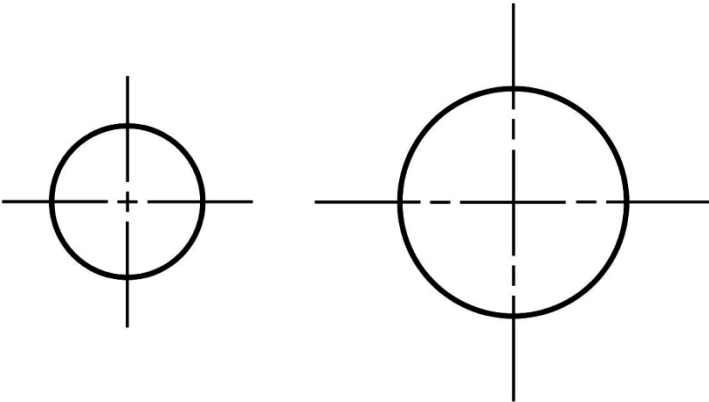


Figure 2.5-6: Crossing center lines.

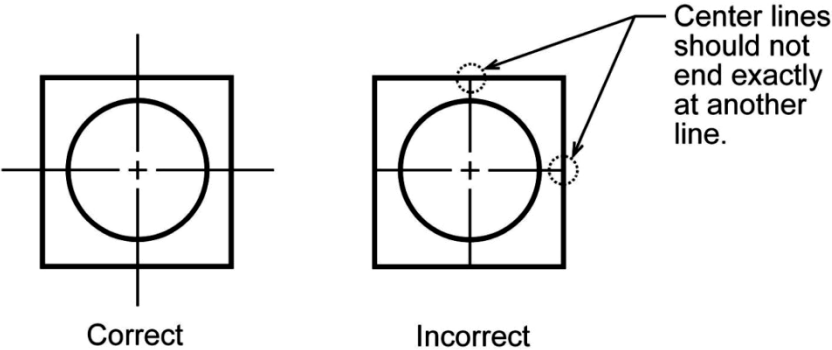


Figure 2.5-7: Terminating center lines.

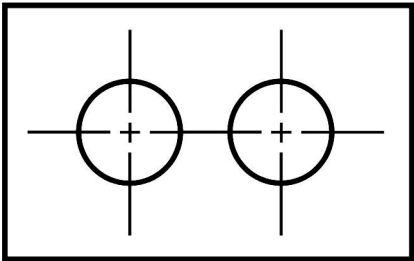


Figure 2.5-8: Connecting center lines.

### 2.5.3) Phantom Lines

Phantom lines are used to indicate alternate positions of moving parts (see Figure 2.5-5). They may also be used to indicate adjacent positions of related parts, repeated detail, reference planes between adjacent views, and filleted and rounded corners as shown in Figures 2.5-9 through 2.5-11. Phantom lines are only used to show fillets and rounds in the view that does not show the radius. In this case, the phantom lines are used to show a change in surface direction (see Figure 2.5-11).

Rule 1. Phantom lines should start and end with a long dash.

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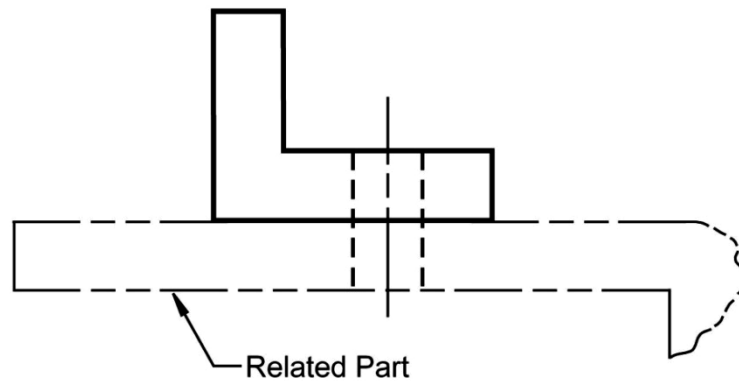


Figure 2.5-9: Related part.

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Figure 2.5-10: Repeated detail.

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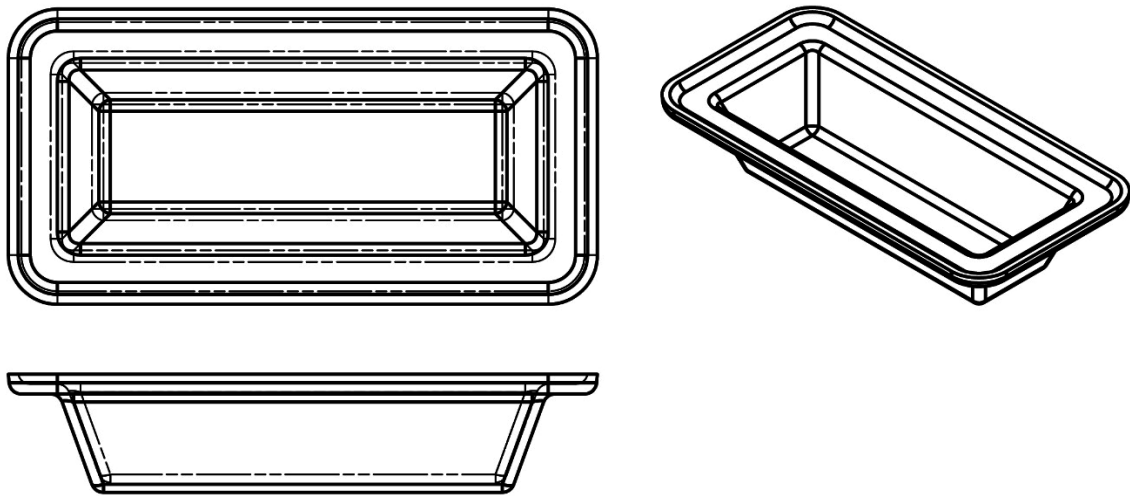


Figure 2.5-11: Phantom lines used to indicate a change in surface direction

#### 2.5.4) Break Lines

Break lines are used to shorten the length of a detail and indicate where the part contains an imaginary break. For example, when drawing a long rod, it may be broken and drawn at a shorter length as shown in Figure 2.5-12. When a break is used, the drawing should indicate the characteristic shape of the cross section.

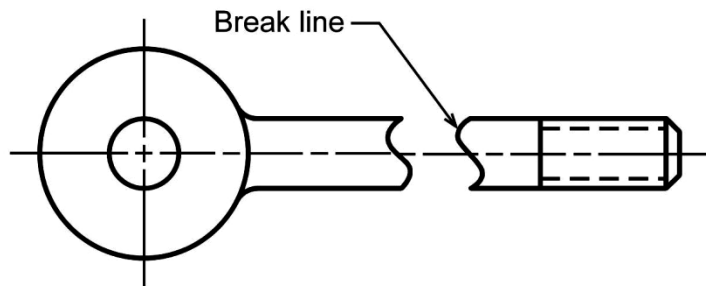


Figure 2.5-12: Using break lines.

There are two types of break lines. A break line may be a series of connecting arcs, as shown in Figure 2.5-12, or a straight line with a jog in the middle as shown in Figure 2.5-13. If the distance to traverse is short, the series of connecting arcs is used. This series of arcs is the same width as the visible lines on the drawing. If the distance is long, the thin straight line with a jog is used.

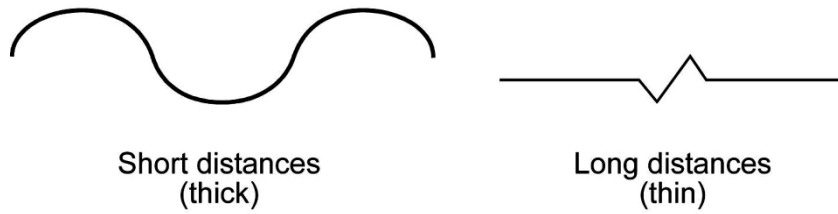


Figure 2.5-13: Types of break lines.

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### 2.5.5) Line Type Precedence

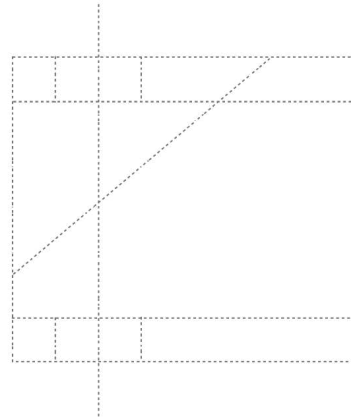
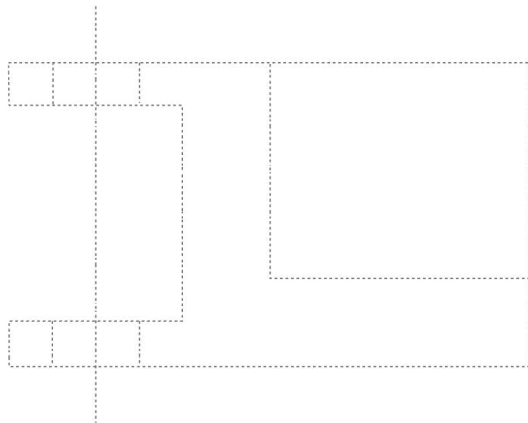
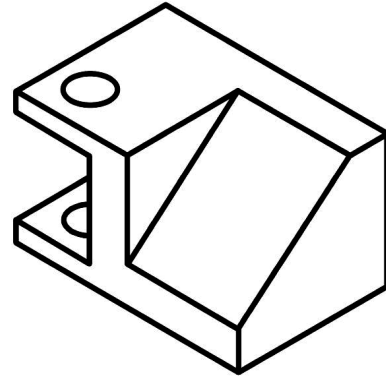
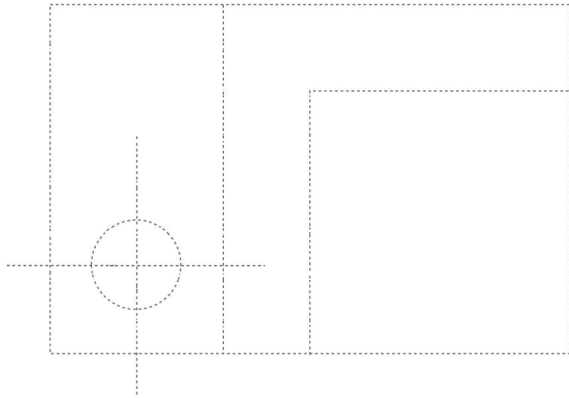
Some lines are considered more important than other lines. **Two lines may occur in the same place, however, only the line that is considered to be the most important is shown.** Lines in order of precedence/importance are as follows:

1. Cutting plane line
2. Visible line
3. Hidden line
4. Center line

*Try Exercise 2.5-1*

**Exercise 2.5-1: Line use in an orthographic projection**

Fill the following dotted orthographic projection with the appropriate line types.



## 2.6) CREATING AN ORTHOGRAPHIC PROJECTION

The steps presented in this section are meant to help you create a technically correct orthographic projection using the third-angle projection standard. Once you become experienced and proficient at creating orthographic projections, you will develop short cuts and may not need to follow the steps exactly as written. These steps are visually illustrated in Figure 2.6-1.

1. **Choose a front view.** This is the view that shows the most about the object.
2. **Decide how many views are needed** to completely describe the object. If you are unable to determine which views will be needed, draw the standard views (front, top and right side).
3. **Draw the visible features of the front view.**
4. **Draw projectors off of the front view** horizontally and vertically in order to create the boundaries for the top and right side views.
5. **Draw the top view.** Use the vertical projectors to fill in the visible and hidden features.
6. **Project from the top view back to the front view.** Use the vertical projectors to fill in any missing visible or hidden features in the front view.
7. **Draw a 45° projector** off of the upper right corner of the box that encloses the front view.
8. **From the top view, draw projectors over to the 45° line and down** in order to create the boundaries of the right side view.
9. **Draw the right side view.**
10. **Project back to the top and front view** from the right side view as needed.
11. **Draw center lines where necessary.**

Following the aforementioned steps will ensure that the orthographic projection is technically correct. That is, it will ensure that:

- √ The front and top views are vertically aligned.
- √ The front and right side views are horizontally aligned.
- √ Every point or feature in one view is aligned on a projector in any adjacent view (front and top, or front and right side).
- √ The distance between any two points of the same feature in the related views (top and right side) are equal.

Figure 2.6-1 identifies the *adjacent* and *related* views. Adjacent views are two adjoining views aligned by projectors. Related views are views that are adjacent to the same view.

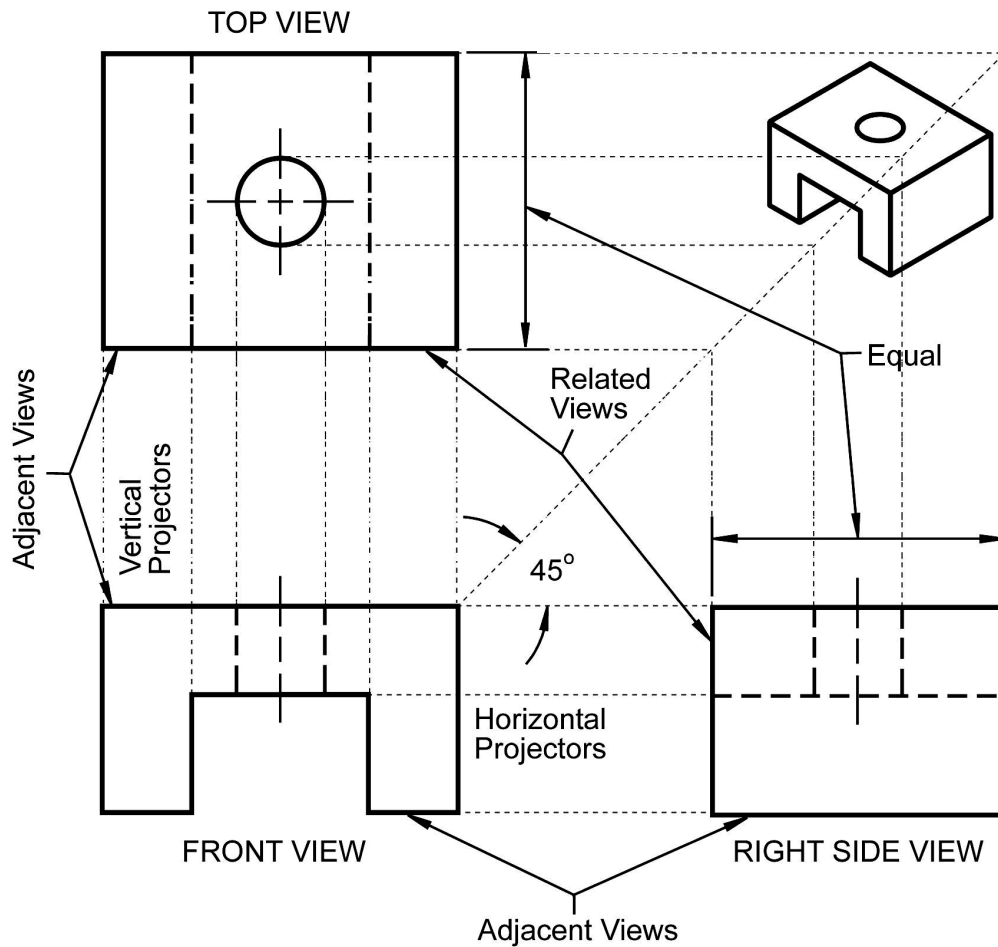


Figure 2.6-1: Features of a technically correct orthographic projection

### 2.6.1) Projection Symbol

Two internationally recognized systems of projection used to create orthographic projections are third-angle projection and first-angle projection. In the United States, we use third-angle projection to create an orthographic projection. This is the method of creating orthographic projections that is described in this chapter. In some parts of Europe, and elsewhere, first-angle projection is used. To inform the print reader what projection method was used to create the drawing, the projection symbol is placed in front of the projection block. If the drawing uses metric units, the text "SI" is placed in front of the projection symbol. The projection symbols are shown in Figure 2.6-2 and 2.6-3.

It is extremely important to let the print reader know which projection method was used to create the orthographic projection. Without knowledge of the projection method, reading a drawing may be confusing and lead to interpretation mistakes. The glass box method described in a previous section will produce a drawing in third-angle projection. Figures 2.6-4a and b show an object represented in both third-angle and first-angle projection.

To understand and visually see how views are created using the third-angle projection standard, put your right hand on a table palm up. You are looking at the front view of your hand. Now rotate your hand so that your thumb points up and your little finger is touching the table. This is the top view of your hand. Put your hand back in the front view position. Now rotate your hand so that your finger tips are pointing down and your wrist is off the table. This is the right side view of your hand. Now let's see how that changes when we are creating a first-angle projection drawing. Put your right hand on the table with your palm down. The back of your hand is the front view. Now, rotate your hand so that your thumb is pointing up and your little finger is on the table. This is the top view of your hand. Put your hand back in the front view position. Rotate your hand so that your fingers are pointing up. This is the right side view of your hand. To be more technical, **third-angle projection** forms the orthographic projection by placing the projection plane between the object and the observer, and **first-angle projection** places the object between the observer and the projection plane. Note that the geometry of the views for both first-angle and third-angle projections are the same, it is just the placement of the views that are different.

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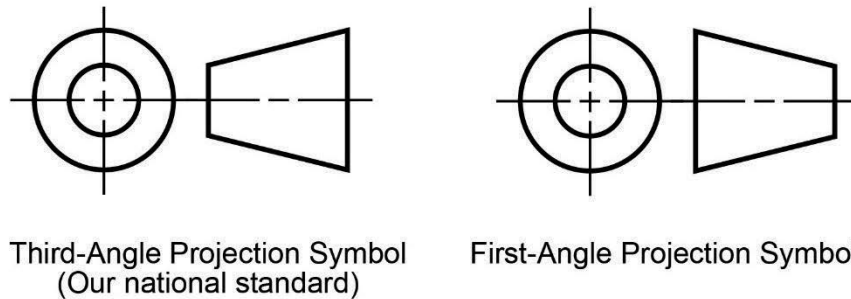


Figure 2.6-2: First and third-angle projection symbols

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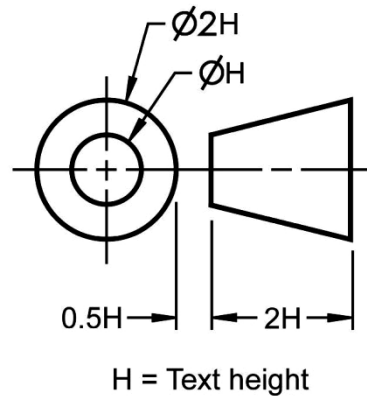


Figure 2.6-3: Projection symbol proportions.

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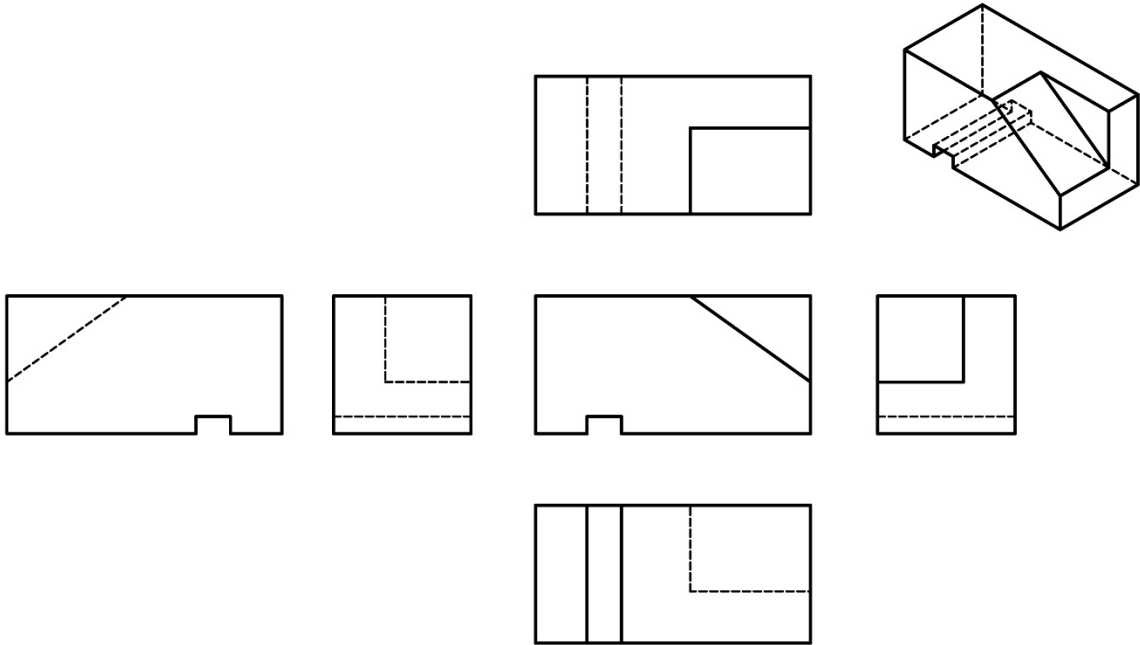


Figure 2.6-4a: Third-angle projection methods

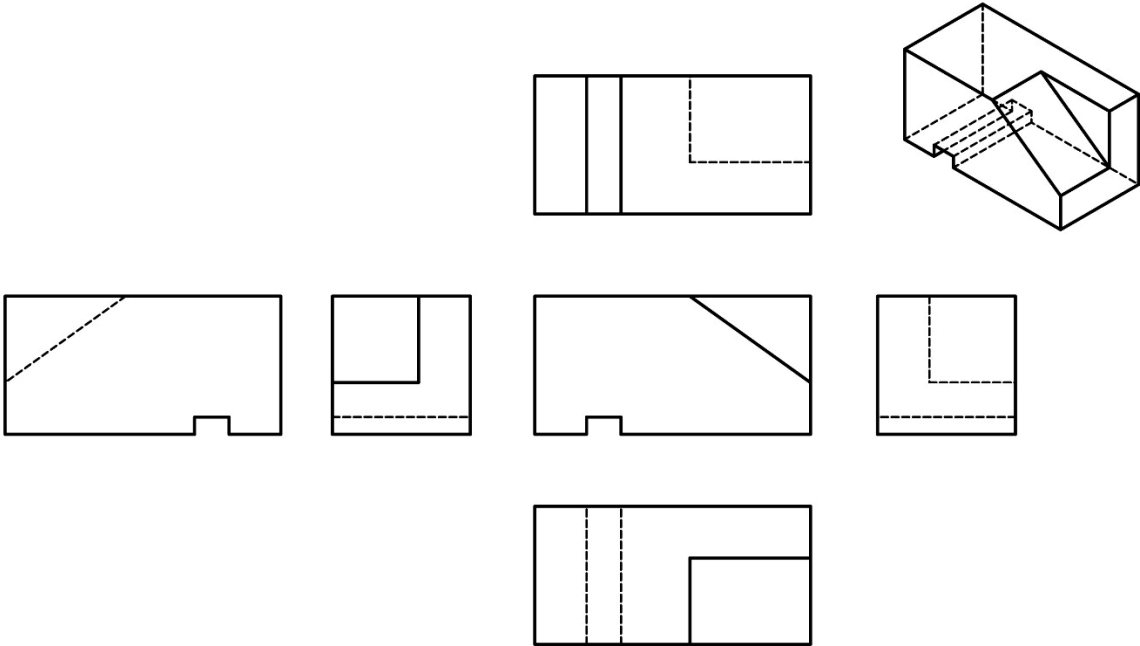
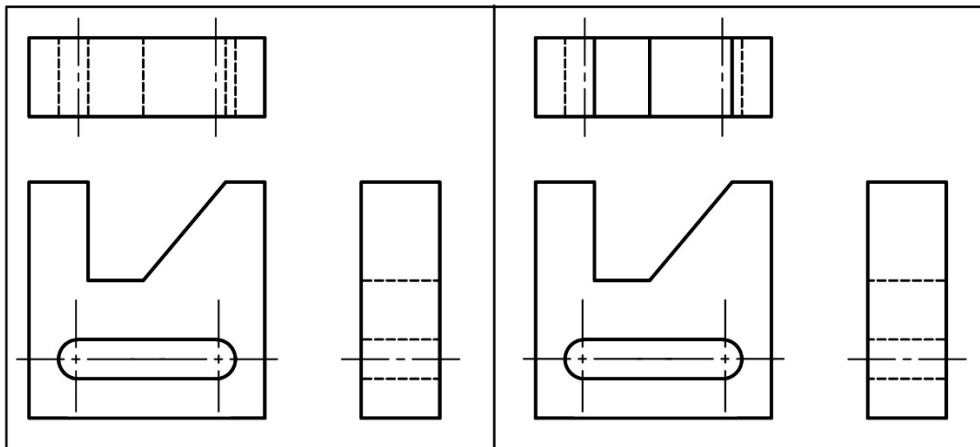
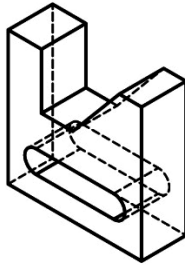
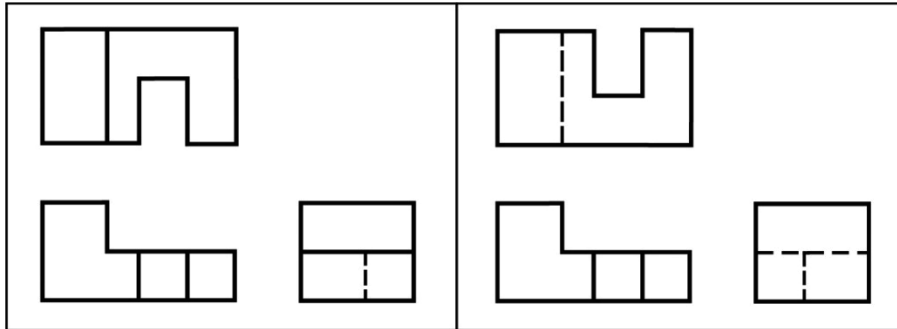
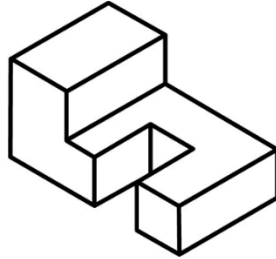


Figure 2.6-4b: First-angle projection methods

**Exercise 2.6-1: Projection methods**

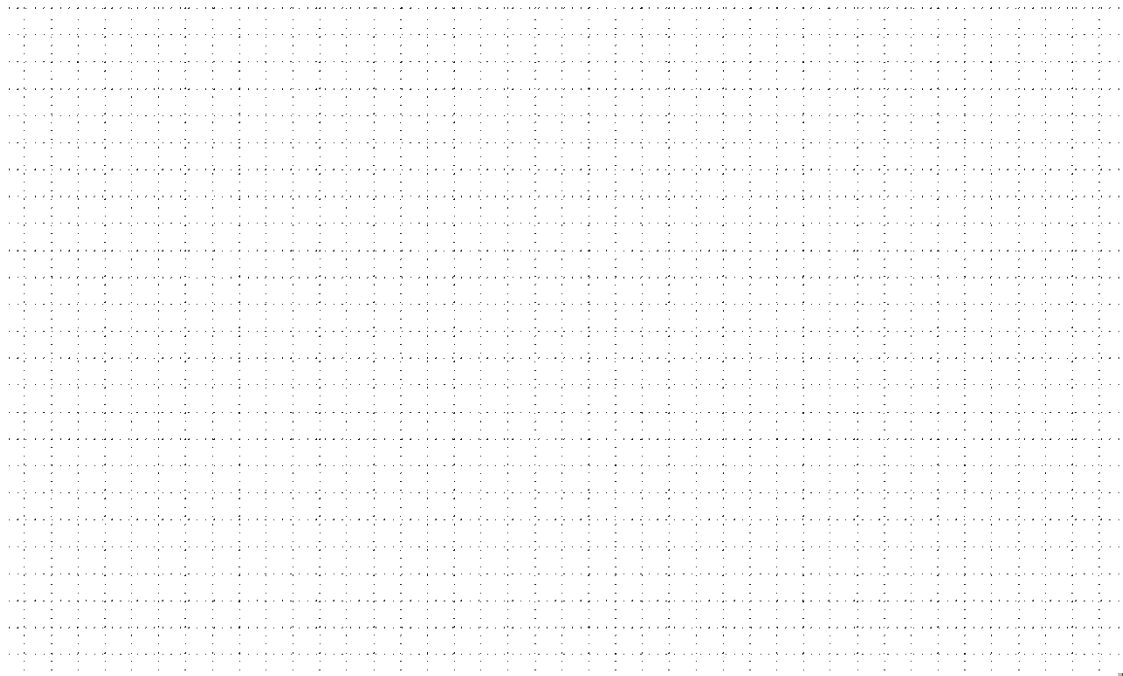
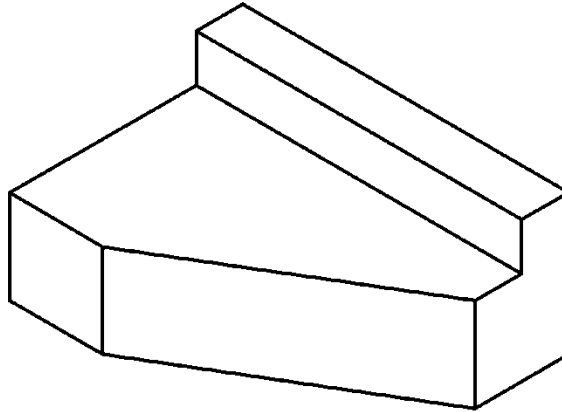
Identify which drawing was created using third-angle projection and which was created using first-angle projection.





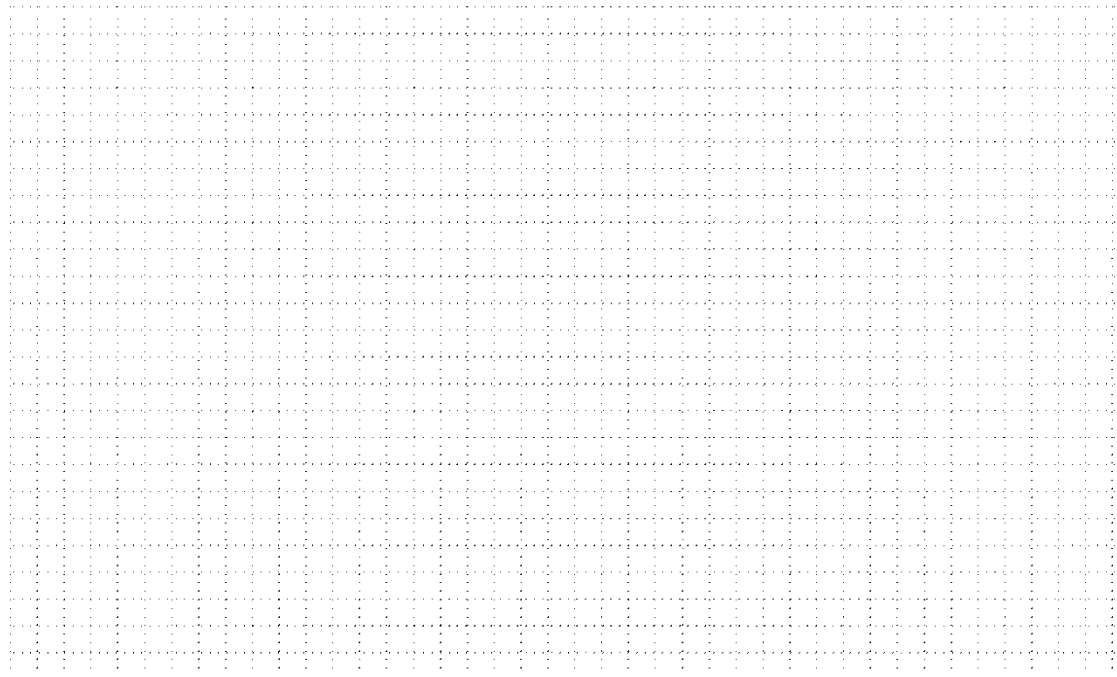
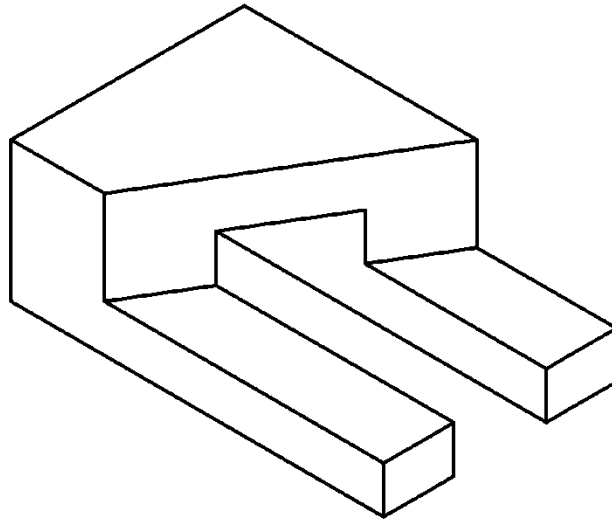
**Video Exercise 2.6-2: Beginning Orthographic Projection**

This video exercise will take you through creating an orthographic projection for the object shown.



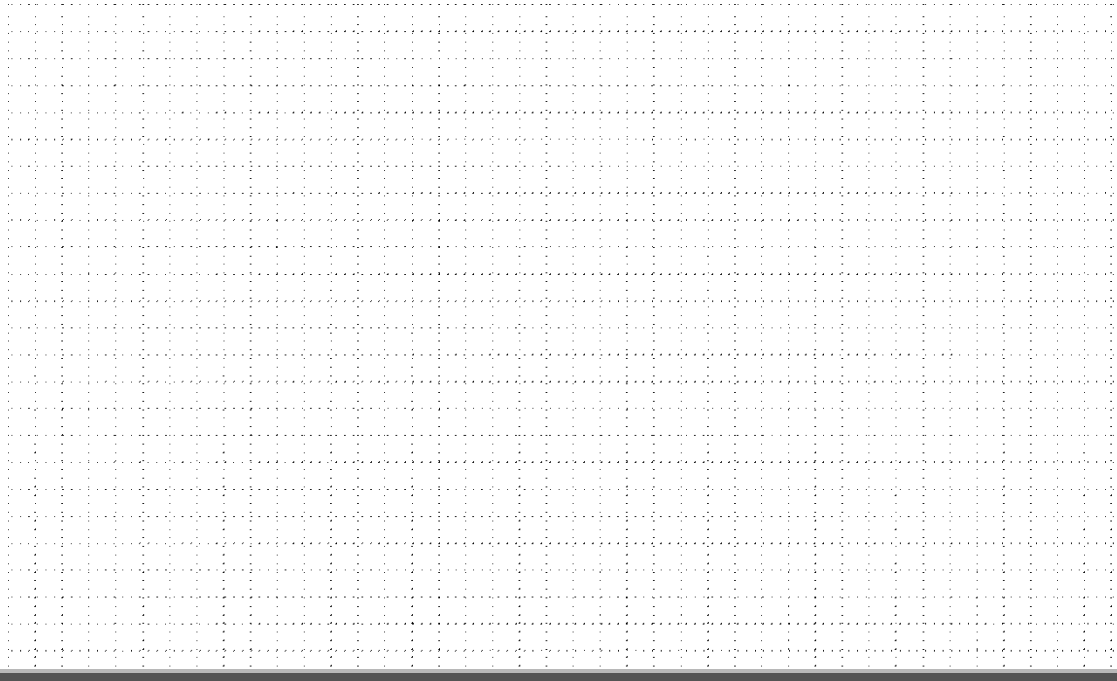
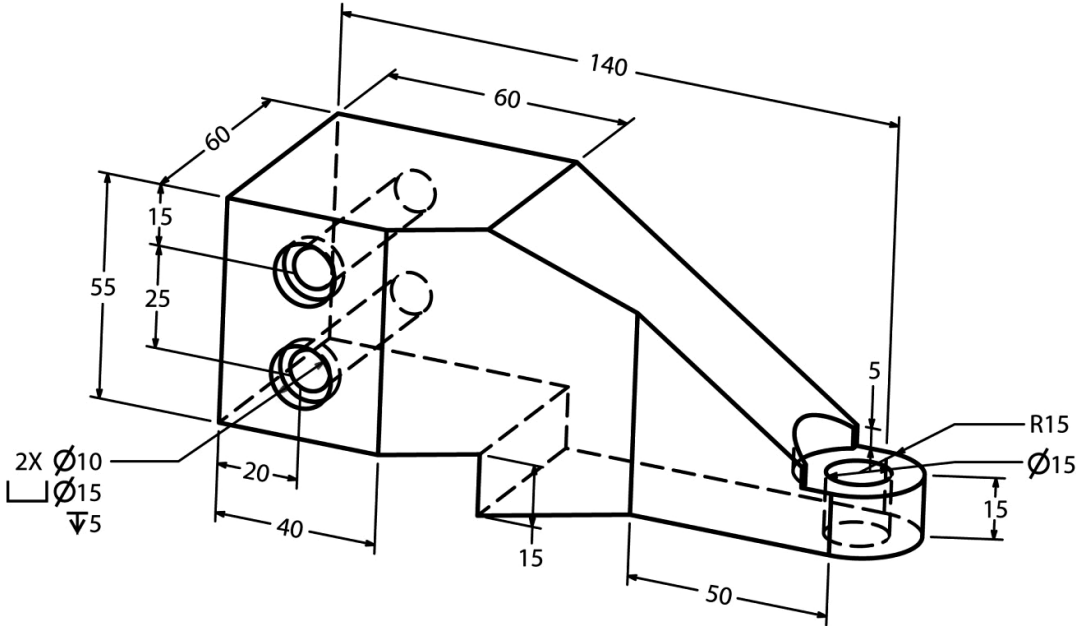
**Video Exercise 2.6-3: Intermediate Orthographic Projection**

This video exercise will take you through creating an orthographic projection for the object shown.



**Video Exercise 2.6-4: Advanced Orthographic Projection**

This video exercise will take you through creating an orthographic projection for the object shown. Note: The object is not completely dimensioned; however, the missing dimensions will be made apparent in the video.



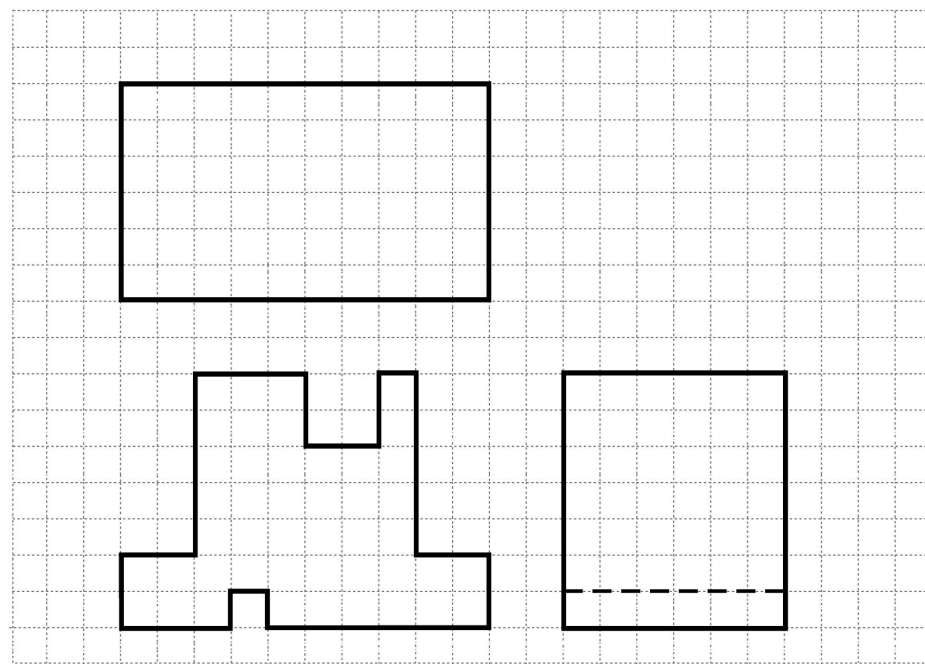
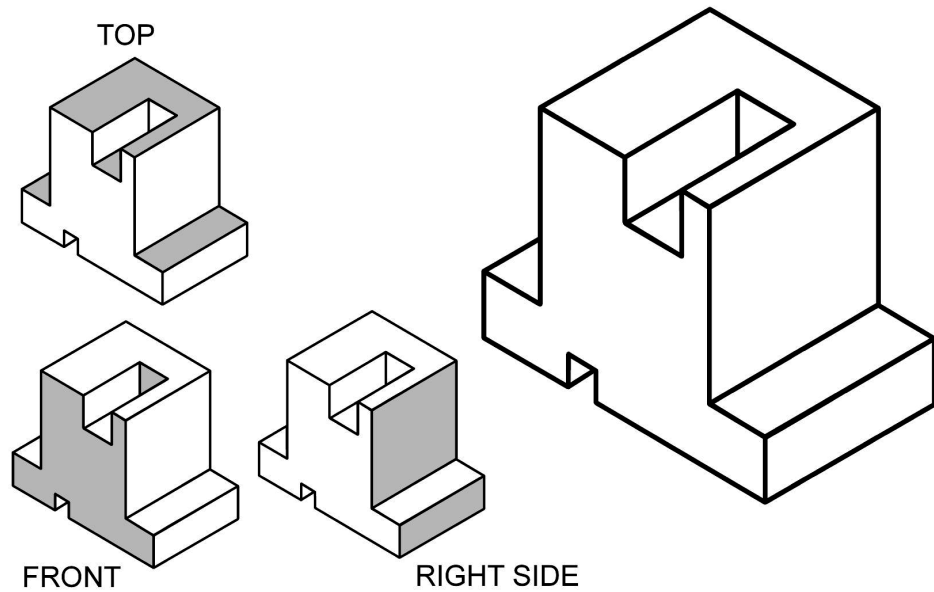
NOTES:

## 2.7) APPLYING WHAT WE HAVE LEARNED

### Exercise 2.7-1: Missing lines 1

Name: \_\_\_\_\_ Date: \_\_\_\_\_

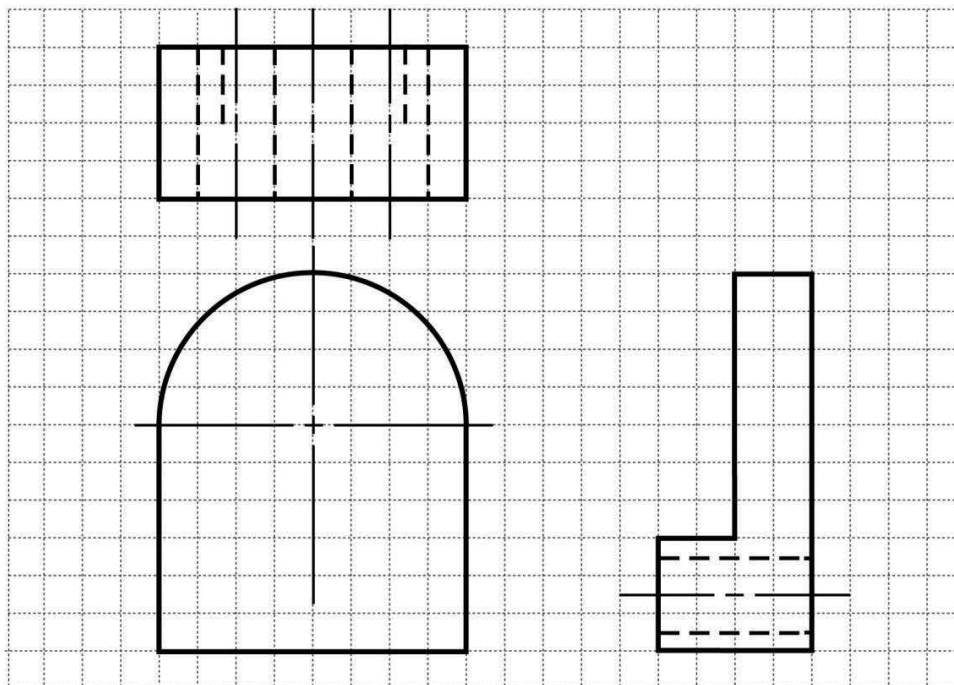
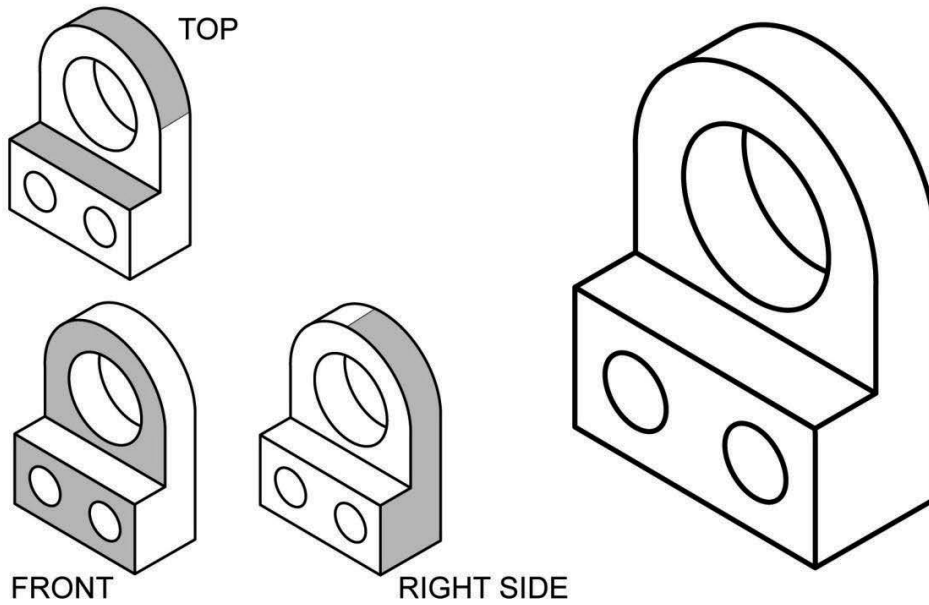
Fill in the missing lines in the front, right side, and top views. **Hint:** The front view has one missing visible line. The right side view has one missing visible line and two missing hidden lines. The top view has five missing visible lines and two missing hidden lines.



**Exercise 2.7-2: Missing lines 2**

Name: \_\_\_\_\_ Date: \_\_\_\_\_

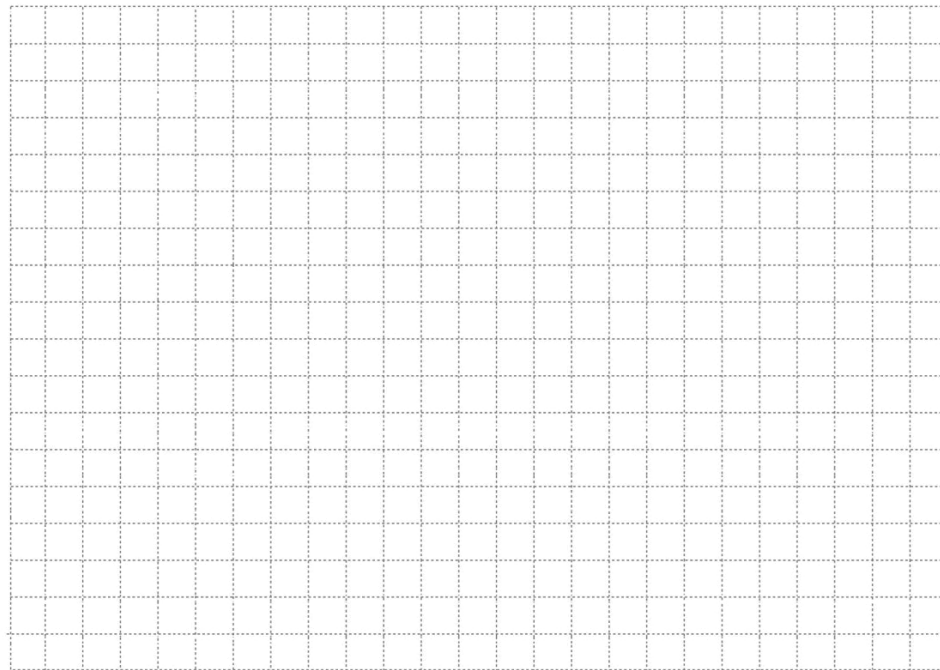
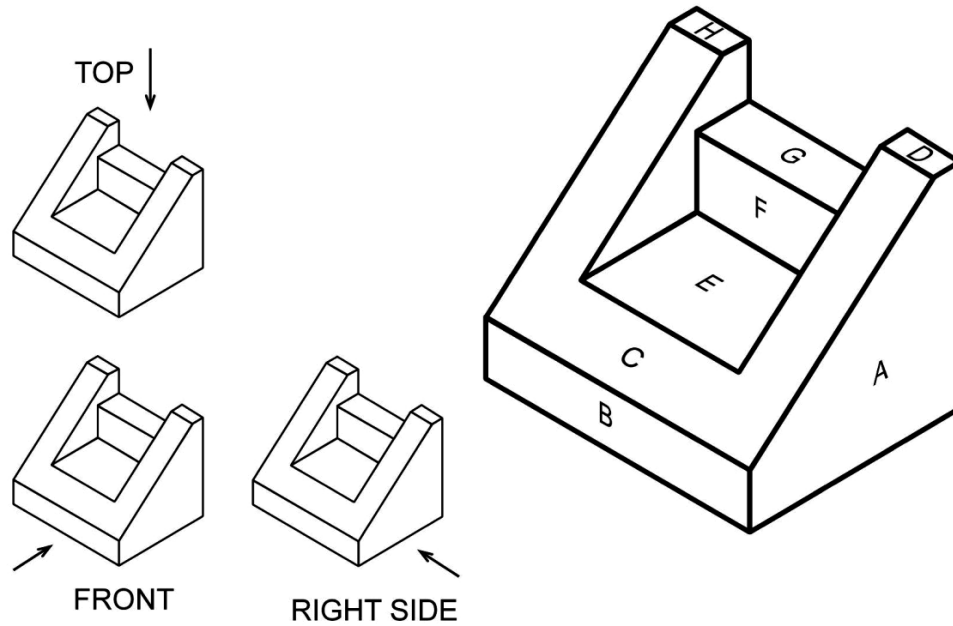
Fill in the missing lines in the top, front, and right side views. **Hint:** The top view has one missing visible line. The front view has four missing visible lines and four missing center lines. The right side view has two missing hidden lines and one missing center line.



**Exercise 2.7-3: Drawing an orthographic projection 1**

Name: \_\_\_\_\_ Date: \_\_\_\_\_

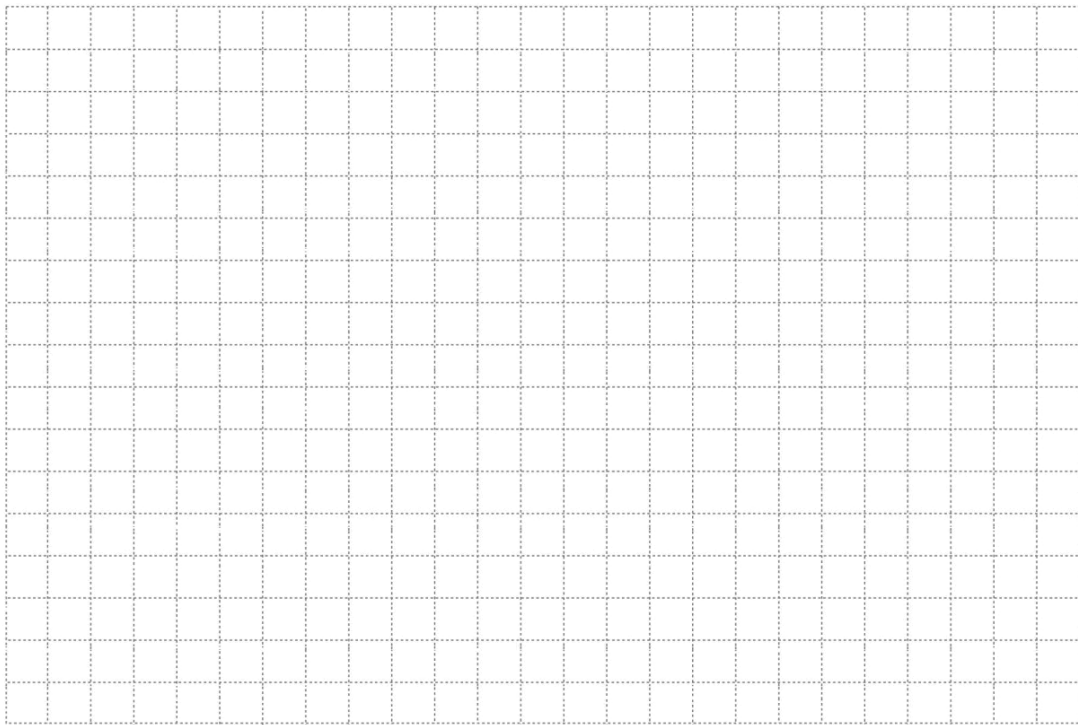
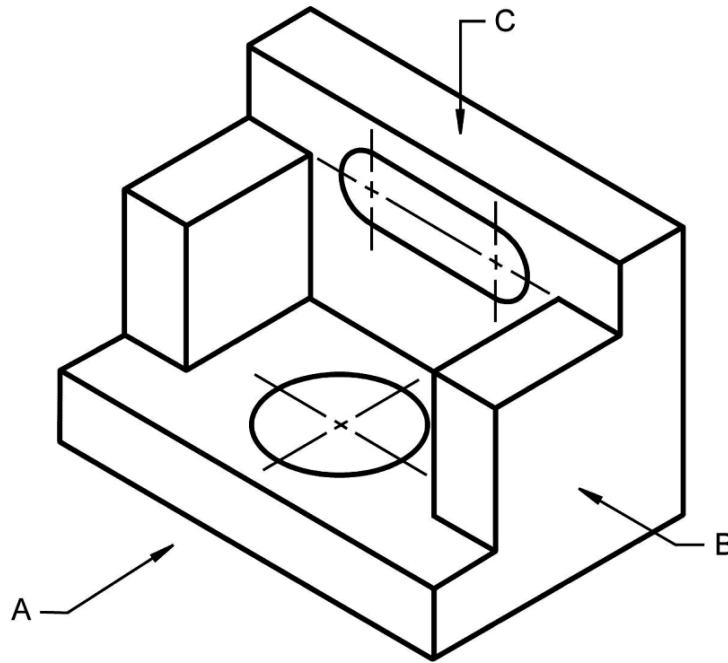
Shade in the surfaces that will appear in the front, top, and right side views. Estimating the distances, draw the front, top, and right side views. Identify the surfaces with the appropriate letter in the orthographic projection.



**Exercise 2.7-4: Drawing an orthographic projection 2**

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Identify the best choice for the front view. Estimating the distances, draw the front, top, and right side views.





## ORTHOGRAPHIC PROJECTIONS QUESTIONS

Name: \_\_\_\_\_ Date: \_\_\_\_\_

### Orthographic projection

**Q2-1)** An orthographic projection is a \_\_\_\_\_ representation of a three-dimensional object? (fill in the blank)

**Q2-2)** In the United States, is first or third-angle projection used as the standard?

**Q2-3)** Are the front and right side views aligned vertically or horizontally?

**Q2-4)** Are the front and top views aligned vertically or horizontally?

**Q2-5)** The projection symbol, indicating the projection method used to create the drawing, is placed in the \_\_\_\_\_ block. (fill in the blank)

**Q2-6)** The standard views used in an orthographic projection are... (circle all that apply)

- a) front
- b) top
- c) back
- d) right side
- e) left side
- f) bottom

**Q2-7)** The view that generally shows the most characteristics of the part and contains the least number of hidden lines.

- a) front
- b) top
- c) right side

### **Line types and their uses**

**Q2-8)** Hidden lines are used to indicate...

- a) edges and boundaries that you can see.
- b) edges and boundaries that you cannot see.
- c) imaginary features.
- d) symmetric features.

**Q2-9)** Phantom lines are used to indicate... (circle all that apply)

- a) alternate positions.
- b) repeated detail.
- c) related parts.
- d) change in surface direction.

**Q2-10)** Center lines are used to indicate... (circle all that apply)

- a) axes of symmetry.
- b) paths of motion.
- c) circles of center.
- d) change in surface direction.

**Q2-11)** To indicate line importance we draw lines using different line...

- a) texture
- b) thicknesses
- c) colors
- d) symbols

**Q2-12)** The thickest line type on a non-sectioned orthographic projection.

- a) visible
- b) hidden
- c) center line
- d) dimension

**Q2-13)** If a hidden line and center line appear in exactly the same location on a drawing, which one do you delete?

**Q2-14)** Projection or construction lines are not shown on the final drawing. (true, false)

**Q2-15)** Should a center line end at the boundary of an object? (yes, no)