Produce Proportional Views of Axonometric Projections

Unit: Oblique and Axonometric Projection

Problem Area: Oblique and Axonometric Projection

Lesson: Produce Proportional Views of Axonometric Projections

Student Learning Objectives.

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

1. **Define axonometric projection, and explain the purposes for each of the three types of axonometric drawings.**
2. **Sketch or draw isometric projections and isometric drawings from coded plans or orthographic drawings.**
3. **Sketch and draw dimetric projections from proportional orthographic examples.**
4. **Create trimetric projections from multiview orthographic drawings as technical illustrations or CAD drawings.**

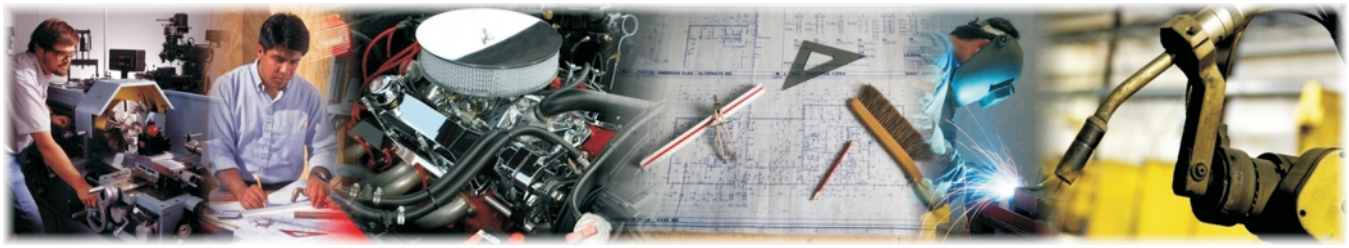
List of Resources.

The following resources may be useful in teaching this lesson:

Giesecke, Frederick E., et al. *Technical Drawing*, 12th ed. Prentice Hall, 2003.

Illinois Drafting Educators Association. *I.D.E.A. Curriculum*. Accessed June 18, 2008. <http://www.idea-online.org/curriculum.html>.

Madsen, David A. *Engineering Drawing and Design*, 4th ed. Cengage Learning, 2007.



"Microsoft Excel Template for Custom Graph Paper," *Microsoft Office Online*. Accessed July 27, 2008. <http://office.microsoft.com/enus/templates/TC101318341033.aspx?pid=CT101448201033>.

Trevisan, Camillo. *Cartesio 3.03*. Accessed Aug. 6, 2008. <http://www.camillotrevisan.it/intern01.htm>.

List of 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

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

- ➤ coded plan
- ➤ dimetric projection
- ➤ elevations
- ➤ foreshortened
- ➤ isometric drawing
- ➤ isometric projection
- ➤ receding axes
- ➤ trimetric projection
- ➤ visible surfaces

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

> *With permission to load software on school computers, download and install Cartesio 3.03 on student computers or on a teacher demonstration station prior to class to ensure that it is working properly. Use the application to create and demonstrate the basic types of axonometric projection: isometric, dimetric, and trimetric.*

> *Explain to students that an axonometric drawing is a type of pictorial drawing that attempts to represent three surfaces of an object from a more realistic point of view. In dimetric drawing, one or two axes may be equally foreshortened in an attempt to make the drawing less distorted, but it makes drawing circular shapes very difficult. In trimetric drawing, all three axes are unequally foreshortened to reduce distortion of the object. Dimetric and trimetric drawings can be drawn with many different angle combinations that make them much*

more time consuming to draw or sketch. Cartesio 3.03 provides the user with multiple views of the different types of axonometric projection and many different solid primitives. Use VM–A to show students a screen shot from Cartesio 3.03.

Tell the students that with the advent of CAD systems, hand-drawn dimetric and trimetric pictorial drawings have started to fade from use in industry. However, learning to sketch ideas as different types of axonometric projections is useful, especially when the designer uses a CAD station to prepare hose design models and present the models in a natural and realistic proportion with minimum distortion.

Finally, isometric drawing uses equal measurements and equal angles for all axes, making it the simplest type to draw. However, isometric projection foreshortens the object to make it look more natural with realistic proportions and minimum distortion. When discussing axonometric drawing, remind students that isometric is the easiest and most commonly used type of axonometric drawing. Most CAD systems will automatically create isometric views from solid models. Isometric pictorial drawing is found in many common assembly instructions. Refer to the following Web site for a sample axonometric projection: http://en.wikipedia.org/wiki/Image:Axonometric_projections.png.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Define axonometric projection, and explain the purpose of each of the three types of axonometric drawings.

Anticipated Problem: Why was axonometric projection developed? Which type of axonometric drawing is most used in industry? What makes one type of axonometric drawing easier than all of the rest?

I. The three basic types of axonometric projection are isometric, diametric, and trimetric.

   A. Isometric projection and isometric drawing

      1. ***Isometric drawing*** uses equal-angle axes and full-scale sizes along each axis.
      2. ***Isometric projection*** uses equal-angle axes, but it reduces proportions along those axes to 81 percent of the real size.
      3. ***Receding axes*** are those planes, surfaces, and edges that lead away from the vertical axis corner of axonometric projections.

B. ***Dimetric projection***

1. Dimetric projection may have two different axes angles with the width reduced, or two axes angles of less than 120 degrees with no width reduction.
2. Traditional dimetric projection uses one axis at 7 degrees and the other axis at 41 or 42 degrees, with the width distance of the object reduced by 50 percent.

C. ***Trimetric projection***

1. This type of projection uses three different angles and scales for measurement along different axes and is much more complex. However, trimetric projection also increases in realism.
2. It usually uses the orthographic top and side views to create the projection from the rotated top view and tilted side view angles.

Use VM–B to show examples of isometric drawing or projection. Ask students to bring in LEGO® bricks, and use them to build some simple rectangular cubic solids, using like-sizes and shape bricks. During construction, have the students count the bricks as they are stacked and record the number of like-size bricks in their stack. (This is the basis for the coded plans students will create later in the lesson plan using isometric drawings.)

Students should place their models on a table and view them while moving around the table. Point out that as people move more directly above the brick, they will see less of each side, and as they move more horizontal, they will see less of the top and more of the sides. Mention that looking at the models from different points of view helps to determine the most and least realistic views. Have the students make some random sketches of the brick models from different points of view—without the aid of graph paper—with the goal of capturing the most realistic point of view of the object. Sometimes what we might consider for an isometric drawing could be rotated to a different view position to make a dimetric or trimetric projection of the same object. You may also refer to http://en.wikipedia.org/wiki/Image:Axonometric_projections.png.

Objective 2: Sketch or draw isometric projections or isometric drawings from coded plans or orthographic drawings.

Anticipated Problem: What is a plane view? How do you determine front from back? How do you determine the right or left sides? What is a coded plan? What is the relationship between orthographic projection and the plane view?

II. Plan view for an orthographic projection

A. Just like a floor plan in an architectural drawing shows only the length and width of a room and not the height, a plane view only shows length and width.

1. To determine the front view, it is necessary to identify the most important or special-featured side view of the object.

2. The front and side views define the height of the object.

B. A ***coded plan*** defines three dimensions in one single view. (Refer to VM–C.)
   1. Length and width are defined in the plan view.
   2. Height is shown as numbered units on each square of the coded plan.

C. ***Elevations*** are another name for side views. (Refer to VM–D.)
   1. An elevation on a square indicates that the square is a three-dimensional cube and is equal on all surfaces.
   2. All elevations show height and length or width.
   3. In coded plans, each square is one unit.

D. Using coded plans (Refer to VM–E.)
   1. A coded plan may be used to make an orthographic drawing.
   2. A coded plan may be used to make an isometric drawing or, with calculations, an isometric projection.

E. ***Visible surfaces*** are those surfaces chosen by the drafter to be the principal views of the drawing or projection.
   1. Hidden lines are not drawn in any axonometric projection.
   2. Dimensions are not presented in coded plans.
   3. Alternative view positions may be determined from coded plans.

Use VM–F to show some examples of coded plans for isometric drawing or sketching, and have students sketch the coded plans as described. Then have the students bring in LEGO® bricks, build models, and sketch the samples on graph paper. You may also want to assign LS–A and refer to the IDEA curriculum at http://www.idea-online.org/curriculum.html.

Objective 3:

Sketch and draw dimetric projections from proportional orthographic examples.

Anticipated Problem: What angles and proportions are used for dimetric projections? How do you use coded plans to create dimetric projections? How do you use orthographic projections to create dimetric projections?

III. Critical features of a dimetric projection

A. Three projection planes
   1. Top: This shows the length and foreshortened width.
   2. Front: This shows the length and the height in full size.
   3. Side: This may be right or left, shown foreshortened, and with full size height.
      a. A ***foreshortened*** edge, surface, or view is not true length, true width, or true height.
      b. The axis showing width is the only foreshortened axis in dimetric projection.

B. Three axes angles (Refer to VM–G.)
   1. Vertical axis: 90 degrees to horizontal
   2. Right axis: 41 degrees above horizontal
   3. Left axis: 7 degrees above horizontal
      a. Approximate angles are common.
      b. These are the most commonly used, but there are others.

C. Foreshortening axes
   1. The length may be true size or foreshortened a small amount.
   2. The height may be true size or foreshortened a small amount.
   3. The width will be foreshortened and always about 50 percent.

D. The creation of construction lines parallel to principal axes
   1. They should be drawn thin and dark on paper.
   2. Sizes should be calculated based on percentages and then approximated.

E. Visible edge lines of the dimetric projection should be darkened.
   1. Edges that are not visible are not drawn.
   2. The most important details should be the front.
   3. Any edges that would be shown as hidden lines are not drawn.
   4. Dimension and extension lines may be used to clarify the drawing. Dimension lines should always be parallel to the line that they are measuring, and extension lines will project from the object perpendicular to the dimension line.

Use VM–H to show students the basic concepts of dimetric projection. Students should copy the drawing and terms, using a pencil and graph paper. Use LS–A, Part 3, to have students create four dimetric projections from the coded plan. Additional drawing activities and coded plans may be accessed at the Illinois Drafting Educators Association: http://www.idea-online.org/curriculum.html.

Objective 4: Create trimetric projections from multiview orthographic drawings as technical illustrations or CAD drawings.

Anticipated Problem: What are the critical features of trimetric projections? Considering the advent of the CAD system, what are the benefits of using trimetric projection?

IV. Angles necessary for the left, vertical, and right axis

A. Arbitrary axes angles are chosen.
   1. Shallow angles will show more emphasis on receding axes.
   2. A vertical axis should be drawn for construction purposes.

B. The true size and shape top view should be placed above the axes.
   1. Adequate room should be left for construction lines and labels.
   2. The top view should be rotated to realize length foreshortening.

C. The true size and shape side view should be placed below and to the right of the axes.
   1. There should be ample space for construction lines and labels.
   2. The side view should be tilted to realize width foreshortening.

D. Vertical construction lines should be drawn from top view into trimetric axes.
   1. Labeled points should be followed.
   2. Construction lines are parallel to the vertical axis.

E. Angled construction lines should be drawn from side view into trimetric axes. (Refer to VM–I.)
   1. Construction lines are parallel to the left trimetric axis.
   2. The labeled points should be followed.

F. Principal edges along or parallel to the trimetric axes should be darkened.
   1. Unnecessary constructions should be trimmed or erased.
   2. Top and side constructions should be removed, unless they are required by your instructor.

Use VM–J to show students samples of trimetric projection construction principles. Students should copy the drawing and terms, using a pencil and graph paper or a CAD system. Additional drawing activities can be accessed at http://www.idea-online.org/curriculum.html.

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.

Application. Use the included visual masters and lab sheets 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: Matching

1. e
2. d
3. a
4. c
5. b

Part Two: Short Answer

1. Axonometric drawing is a type of pictorial drawing that shows three surfaces of an object. The three most common types of axonometric drawing are dimetric, which uses two different angles and scales on different axes; trimetric, which uses three different angles and scales on different axes; and isometric, which uses the same angle and scale on all axes to reduce visual distortion of an object.
2. A coded plan is a simplified method of showing length, width, and height in a single, simple, two-dimensional drawing. Coded plans use squares with numbers in them to indicate the unit height of each specific square.
3. In an isometric drawing, the receding surfaces parallel to the isometric axes are true size and true shape. In an isometric projection, all surfaces are drawn with a foreshortened reduction of 81 percent.

Part Three: Completion

1. isometric, dimetric, trimetric
2. isometric scale
3. Isometric
4. parallel
5. oblique surface
6. length

Sample Test

Name _____

Produce Proportional Views of Axonometric Projections

Part One: Matching

Instructions: **Match the term with the correct definition.**

a. trimetric projection
b. vertical axis
c. isometric projection
d. dimetric projection
e. receding axes

_____1. An axis or that moves away from the vertical axis

_____2. An axonometric drawing that foreshortens one axis

_____3. An axonometric drawing that unequally foreshortens three different axes

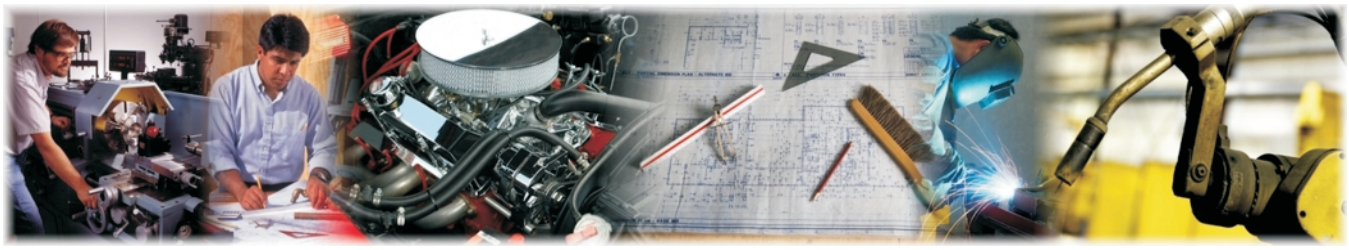
_____4. An axonometric drawing that equally foreshortens three different axes

_____5. An axis or line that is drawn at an angle of 90-degrees from the horizontal

Part Two: Short Answer

Instructions: **Complete the following.**

1. Define axonometric projection.



2. Explain the purpose of a coded plan drawing.

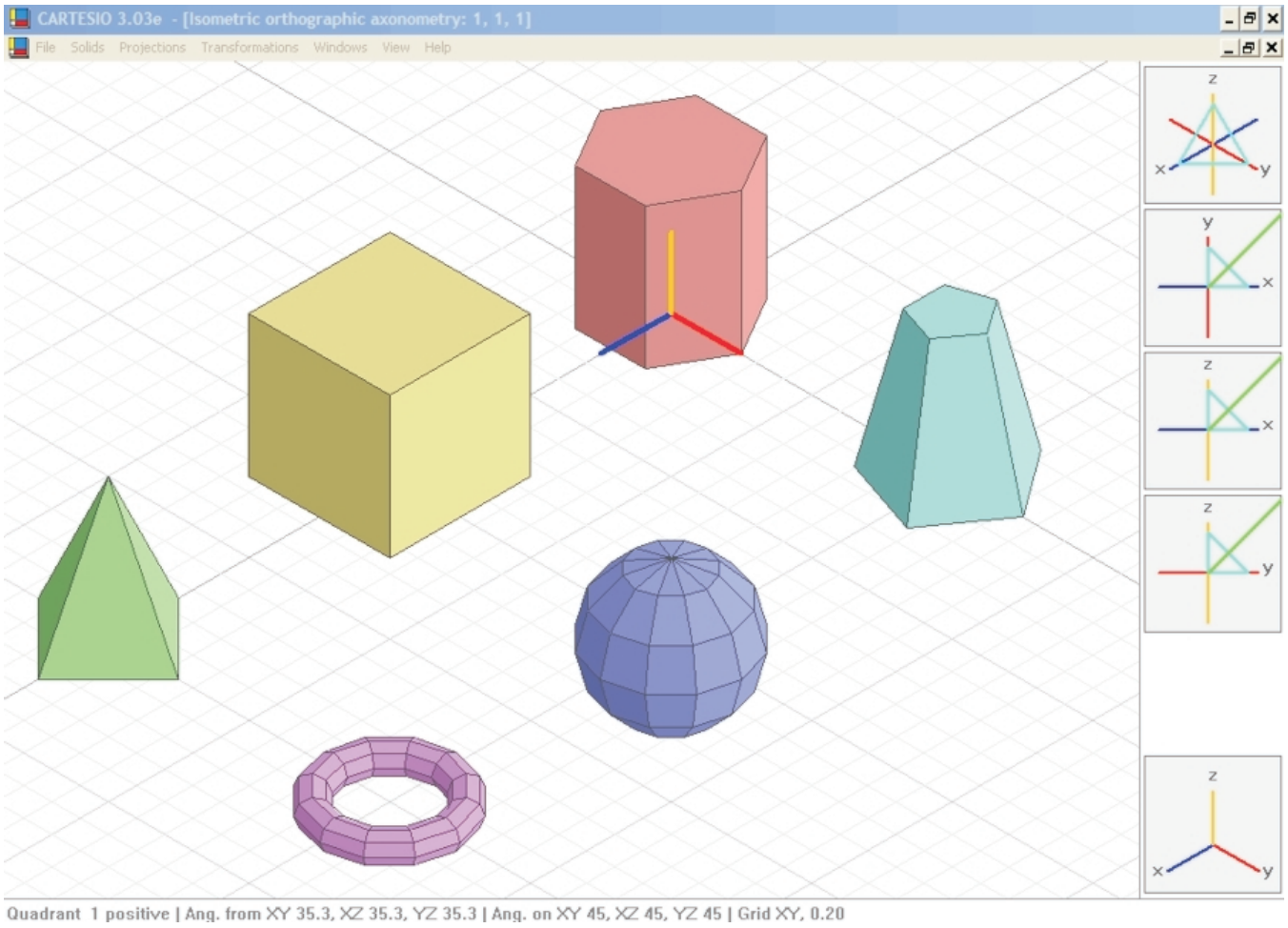
3. Explain the difference between an isometric drawing and an isometric projection.

Part Three: Completion

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

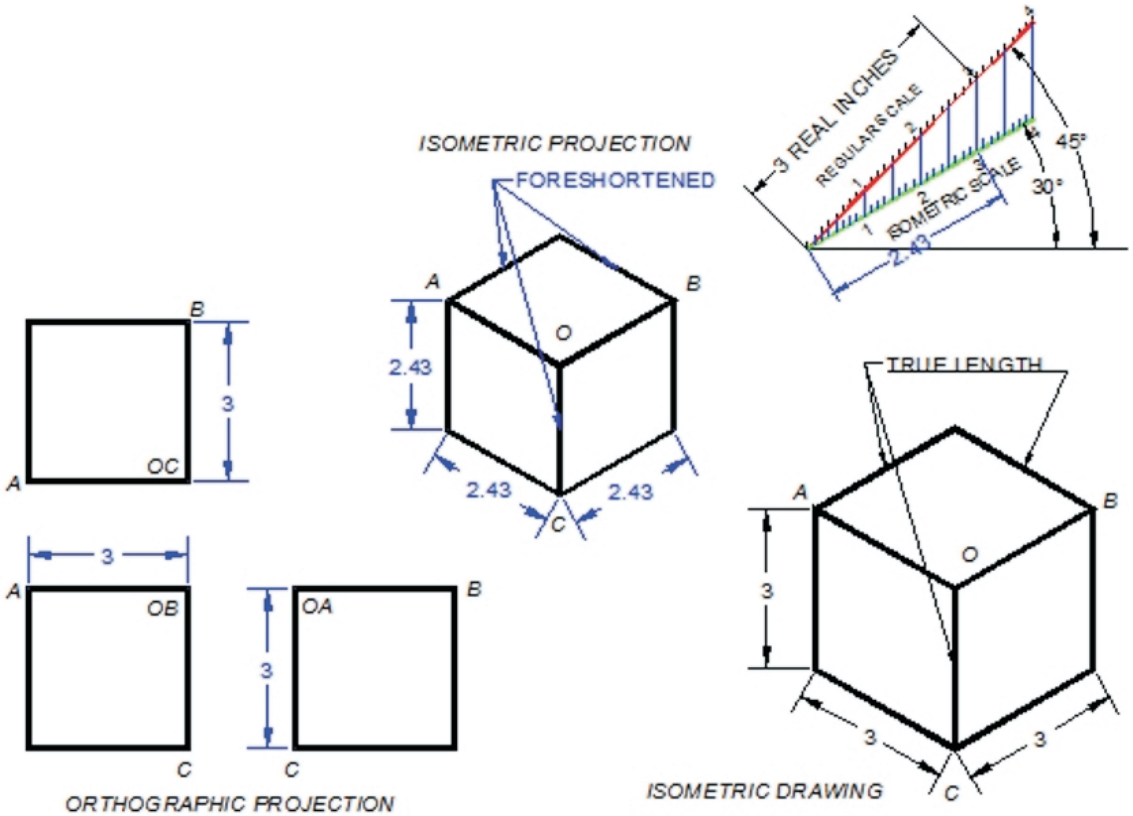
1. The three types of axonometric projection are _____, _____, and _____.
2. The _____ gives a foreshortened length of about 81 percent.
3. _____ means equal measure.
4. When drawing any isometric, all measurements are marked off _____ to an isometric axis.
5. A(n) _____ is not parallel or perpendicular to any of the primary surfaces.
6. The _____ of an object is usually shown along a receding axis in axonometric drawings.

SCREENSHOT OF TYPES OF AXONOMETRIC PROJECTIONS AND SOLID PRIMITIVES FROM CARTESIO 3.03

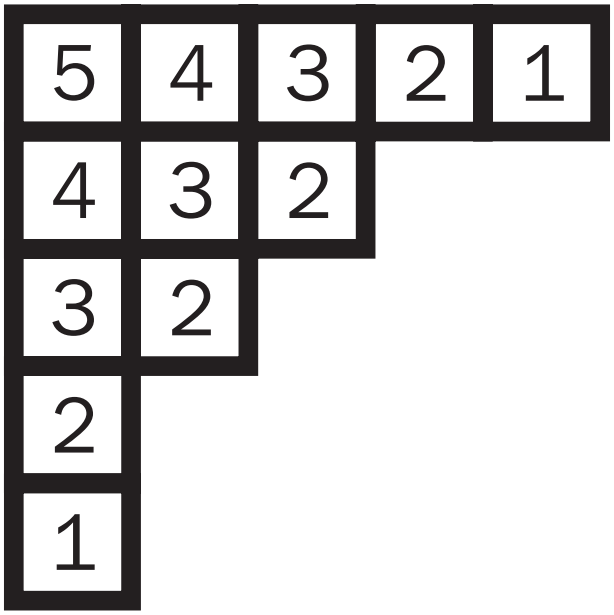


PRODUCE PROPORTIONAL VIEWS OF AXONOMETRIC PROJECTIONS: ISOMETRIC DRAWING OR PROJECTION

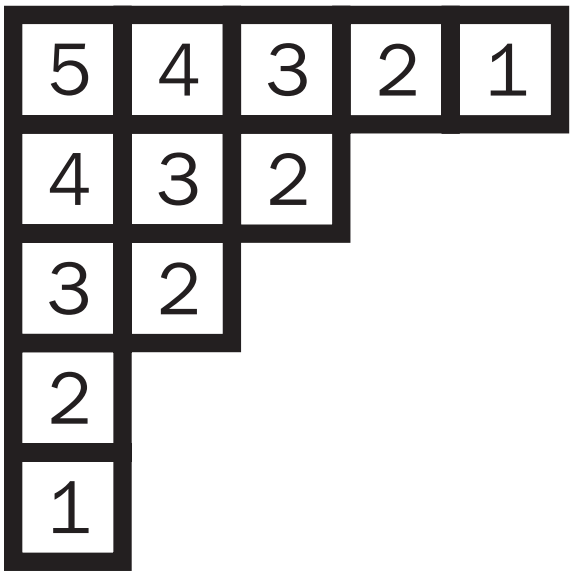
- Isometric pictorials are used to illustrate an object's details by showing two-dimensional and three-dimensional objects.
- There are three typical axis positions for isometric drawings.
- Construction lines, object lines, and center lines are used to describe an object.
- Usually, isometric drawings are not fully dimensioned but will include important reference dimensions: length, width, height, and perhaps location dimensions.
- Isometric projections are foreshortened along all axes to reduce distortion, whereas isometric drawings are drawn full size along all axes.



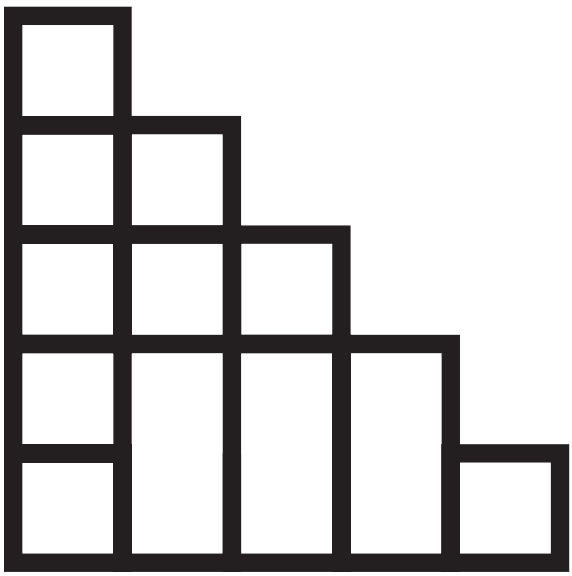
CODED PLAN SAMPLE

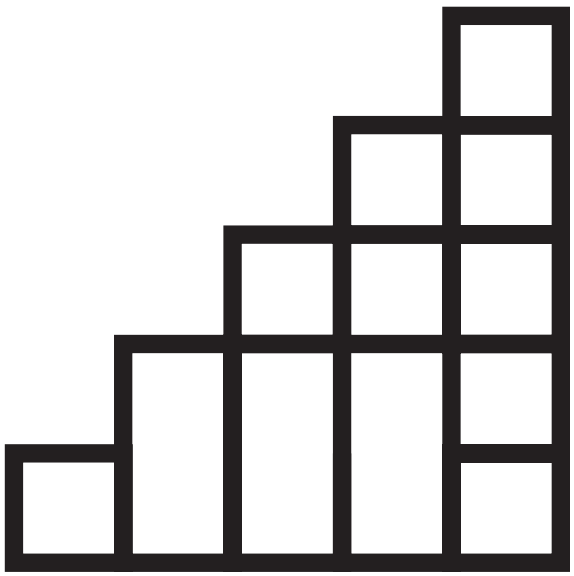


NUMBER-CODED PLAN AND ORTHOGRAPHIC PROJECTION



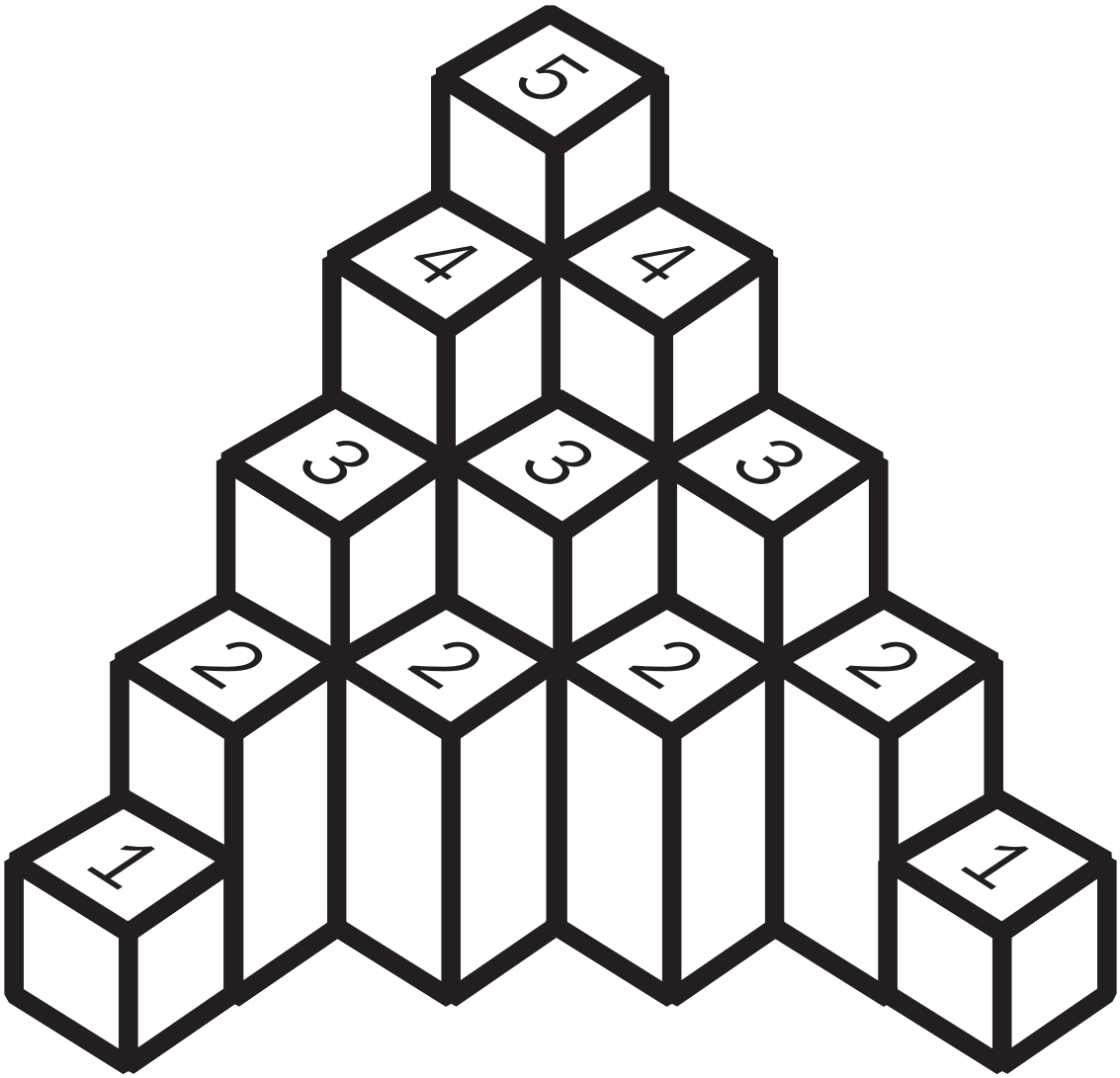
Number coded top view with front and right side view





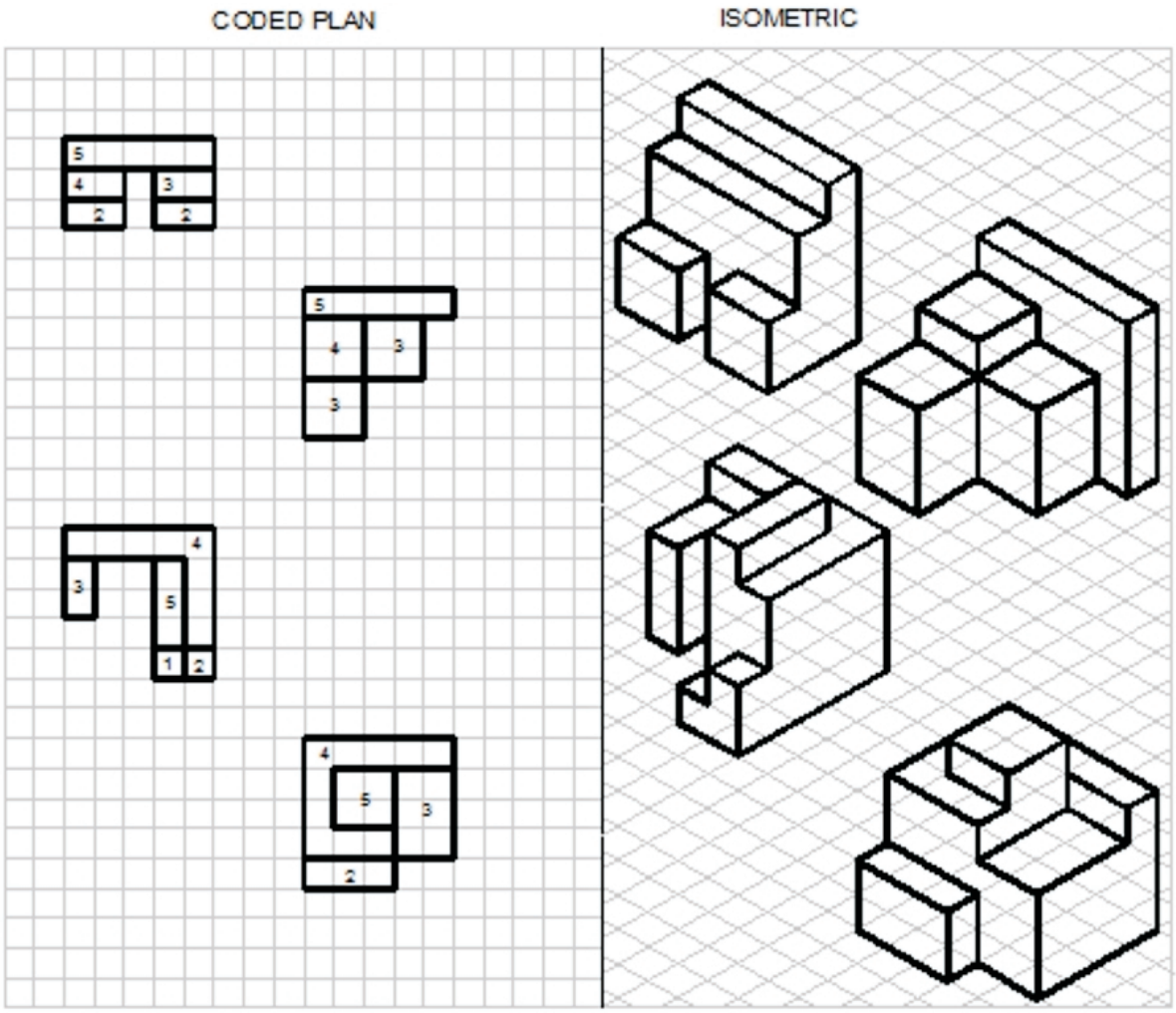
VM–E

CODED PLAN ISOMETRIC VIEW

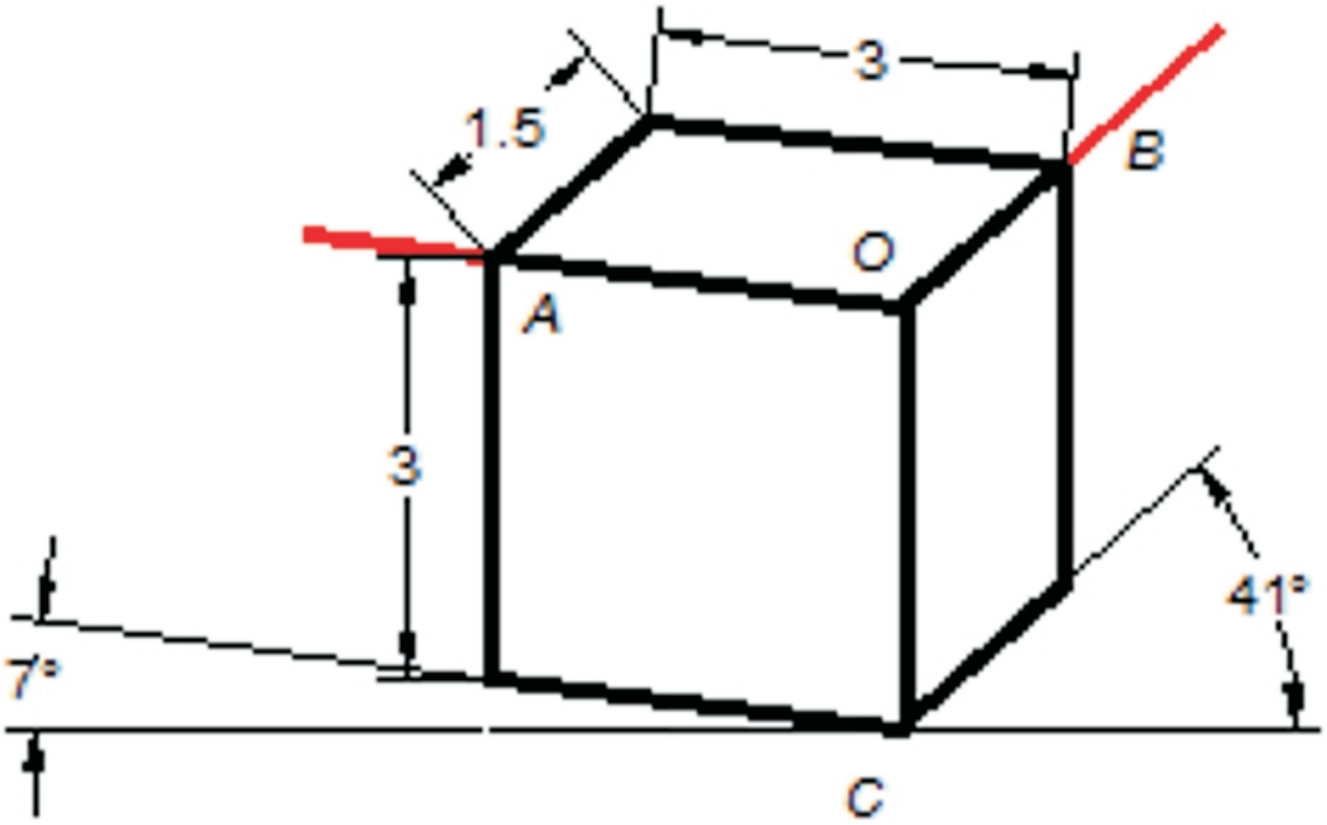


PROPORTIONAL VIEWS OF AXONOMETRIC PROJECTIONS: CODED PLAN AND ISOMETRIC

- Visualize rectangular and isometric grid sheets or screens necessary to create axonometric projections from orthographic projection drawings or coded plans.
- Coded Plans: Part 1: Solutions compare each square on the grid to the isometric grid then use the square size to complete the isometric sketch from the coded squares.

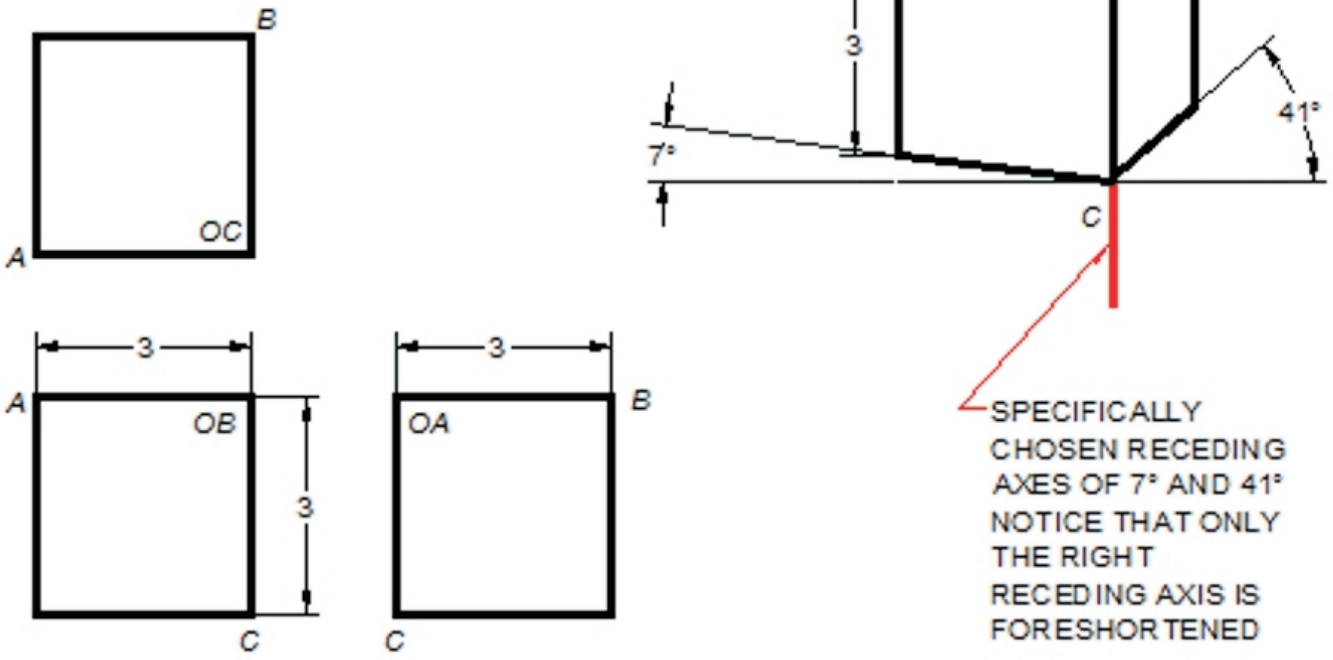


DIMETRIC AXES

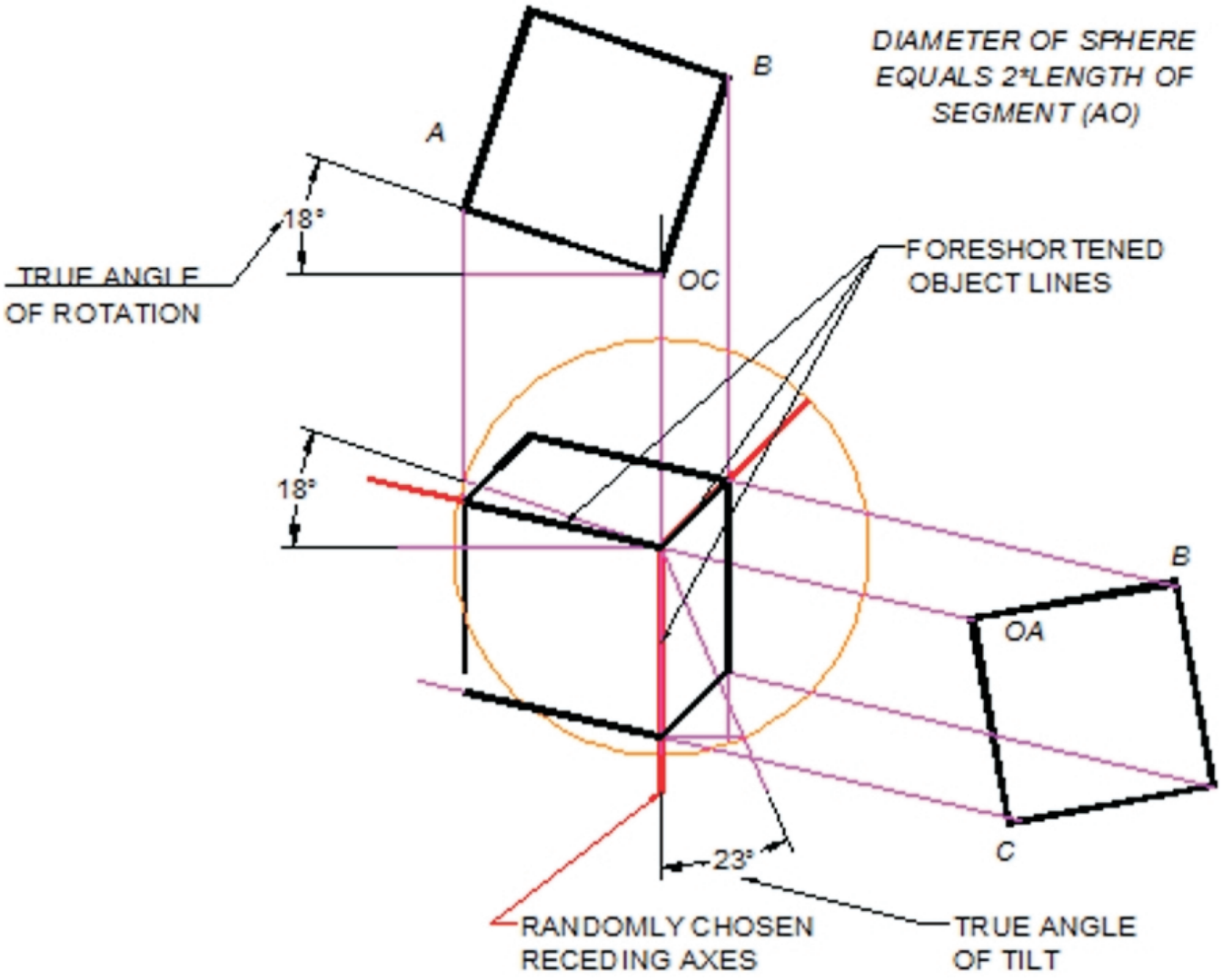


PRODUCE PROPORTIONAL VIEWS OF AXONOMETRIC PROJECTIONS: DIMETRIC PROJECTION

- Visualize the axes and angles necessary to create dimetric projection drawings.
- This shows why one axis is foreshortened.
- Use a simple ratio of 1:1½ for the major axes height:length:width.
- Circles and arcs in this type of projection are difficult to draw, but there are ellipse templates that can make them easier.

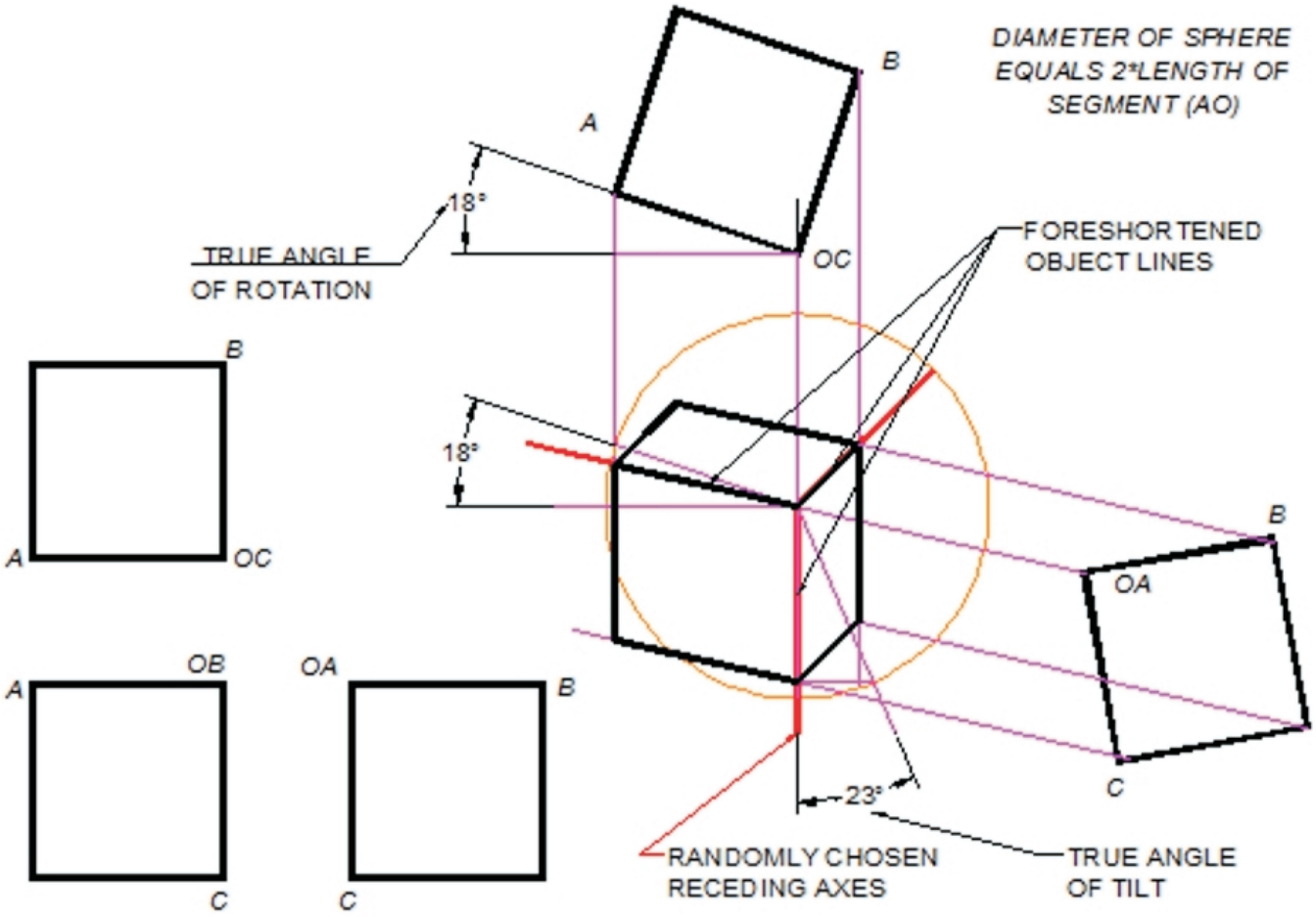


TRIMETRIC CONSTRUCTION PROJECTION



PRODUCE PROPORTIONAL VIEWS OF AXONOMETRIC PROJECTIONS FROM ORTHOGRAPHIC PROJECTIONS: TRIMETRIC PROJECTION

- Visualize the axes and angles necessary to create trimetric projection drawings.
- This shows why all three axes are foreshortened.
- Foreshortening occurs due to rotation and tilt of the axes.



LS–A

Name _____

Produce Proportional Views of Axonometric Projections: Coded Plans

Purpose

The purpose of this activity is to create orthographic and isometric drawings from coded plans.

Objective

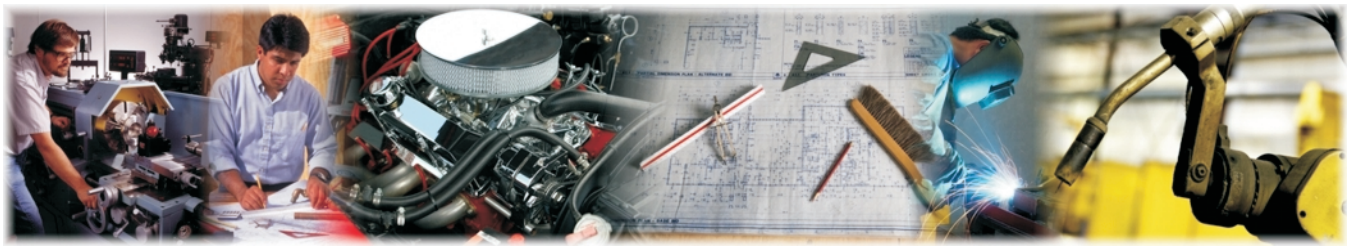
Create orthographic and isometric drawings from coded plans.

Materials

- lab sheet
- drawings from text or I.D.E.A. online curriculum
- answer sheet (paper)
- pencil
- eraser

Procedure

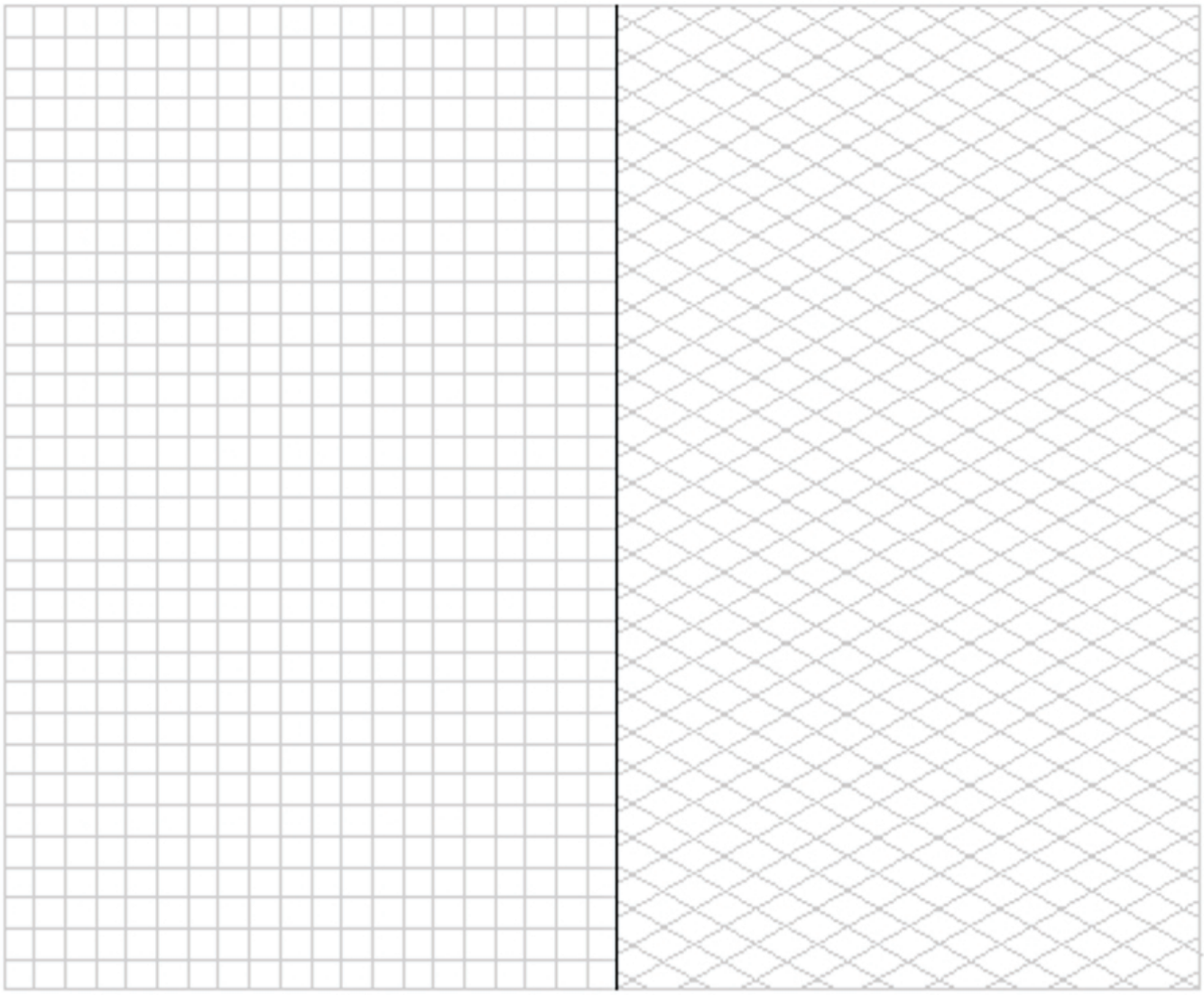
1. Using the example in your text, handouts from your instructor or from the IDEA curriculum, compare each square on the grid to the isometric grid then use the square size to complete the sketch from the coded squares. Complete an orthographic sketch and an isometric sketch for each assigned problem.
2. Determine the front view position.
3. Using the grid sheet below, create a three-view, orthographic projection from each coded plan.



4. Using the grid sheet below, create an isometric drawing from each coded plan by using the previously made orthographic drawing for additional guidance.

ORTHOGRAPHIC

ISOMETRIC



LS–B

Name _____

Produce Proportional Views of Axonometric Projections: Coded Plans

Purpose

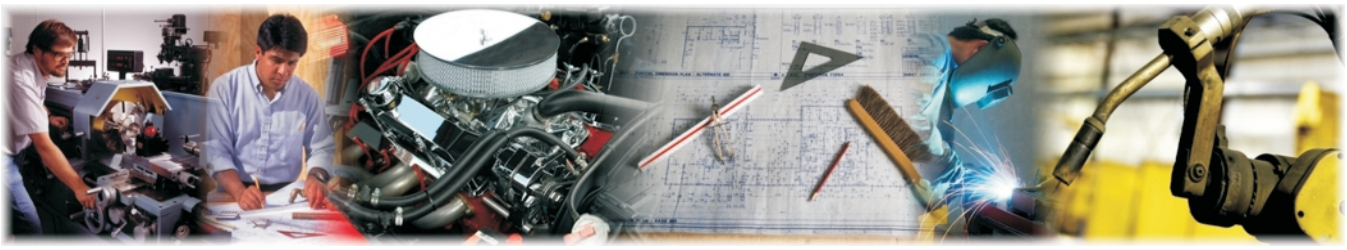
The purpose of this activity is to practice creating isometric projection drawings or sketches by following a coded plan. Additional activities include creating dimetric or isometric projections from previously drawn orthographic or coded plan drawings.

Objectives

1. Complete the four isometric drawings on the grid sheet provided, using the provided coded plans.
2. Complete an isometric projection of each of the four previous drawings; use a scale of one square equals ½ inch by drawing using technical drawing equipment or by using a CAD system to draw the solutions.
3. Create a dimetric projection for each of the four previous drawings; use 7 degrees and 41 degrees for the receding axes by drawing using technical drawing equipment or by using a CAD system to draw the solutions.

Materials

- lab sheet
- paper on which to sketch or draw
- pencil
- eraser
- CAD system



Procedure

1. Look closely at the orthographic coded example.
2. Visually rotate each coded example 90 degrees counter-clockwise along the vertical axis.
3. Create your left and right trimetric axes at the angles given.
4. Create construction lines parallel to each of the axes.
5. Measure along the axes height, length, and foreshortened widths.
6. Darken object edges.
7. Erase or trim construction lines.

ORTHOGRAPHIC

ISOMETRIC