



# Spatial Visualization

## Workshop 2: Isometric Drawings and Coded Plans

### Overview

**Grade level:** undergraduate engineering students

**Estimated time required:** 2 hours

**Expendable materials:** isometric paper printouts, scrap paper and pencils

**Reusable materials:** workbooks, software, computers, snap cubes (used for all workshops).

See *Materials List (below)* for details.

### Summary

In a series of four group-oriented activities, students learn about isometric drawings and how to use coded plans to envision and draw 3D objects. They practice creating coded plans, building simple cube objects from coded plans, and then sketching the respective isometric views on isometric paper. Individually, they practice associating coded plans with isometric views in workbook and software exercises. They also choose two viewpoints from a provided coded plan and draw the associated isometric views. A PowerPoint® presentation and isometric paper printout are provided.

### Engineering Connection

Isometric means “equal measure.” Isometric drawings depict three sides of an object in which each side appears to be the same size. This technique helps to provide depth to drawings on (2D) paper. Isometric drawings enable engineers to communicate their ideas and help others visualize their designs. With many languages across the world, visual representations are the best way to communicate design intent. Architectural engineers provide clients with isometric views of potential home ideas while chemical engineers study the isometric views of molecules to better understand their structures.

### Pre-Requisite Knowledge

Knowledge from the previous lesson, *Orthographic Views*, is helpful but not required. A mathematical understanding of the Cartesian coordinate system is required when drawing and labeling the three-dimensional axes.



## Learning Objectives

**After this workshop, students should be able to:**

- ✓ Draw a coded plan from an object composed of cubes.
- ✓ Use a coded plan to build an object composed of cubes.
- ✓ Define and explain the meaning of isometric.
- ✓ Draw a 3D object on isometric paper.

## Materials List

Item	Description & Amount	Source/Supplier/Cost	Station #s
Isometric paper	Isometric, three-dot paper for sketching, 2+ per student	Isometric Paper (pdf); print double-sided as needed	1, 2, 3
Snap cubes	Interlocking cubes, 8 cubes per student	Such as: Higher Ed Services (\$3 for 15 cubes) or Amazon (\$85 for 200)	1, 3
Pencil with eraser	Any erasable pencil; pens are not recommended	School/students provide	1, 2, 3
Colored pencils	To associate drawings to the snap cubes; to share among all students	Such as: Crayola colored pencils at Amazon (\$8 for 50)	1, 3
Developing Spatial Thinking Workbook & Instructional Software	1 per student pair; includes web-based software used with workbook	\$40 for workbook/software from Higher Ed Services	2 (workbook) 4 (software)
Computer or laptop	1 per student pair	School/students provide	4
Workbook answers	For the instructor and for students to check their work	Workbook Answer Key (pdf)	2
PowerPoint® presentation	For the instructor, slides 12-21	Spatial Visualization Presentation (pptx)	NA



## Introduction & Motivation

**Have the slide presentation up and displayed to the class, starting with slide 12.**

Today, we are going to develop our skills in drawing three-dimensional objects. Spatial visualization skills help you in many engineering subjects that require the imagination of three-dimensional shapes, such as calculus, chemistry, physics, manufacturing and various arts. Practicing spatial visualization enables you to understand three-dimensional figures and representations more readily and perform better in these subjects, setting you up for a successful career.

### **Part 1: Isometric Drawings.**

During the planning phase of engineering projects, engineers need to be able to illustrate their ideas on paper or computer screens. This process—visualizing the item as a three-dimensional object—includes the dimensions of depth, width and height. Without spatial visualization skills, engineers would be unable to envision new ideas and communicate them to others. Isometric views are useful for displaying three-dimensional objects on two-dimensional paper. More specifically, we use isometric paper to draw objects isometrically.

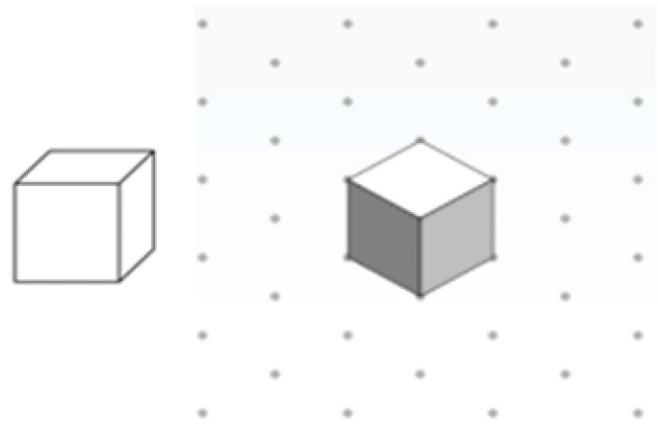
**Display slide 13, which is the same as Figure 1.**

- This image shows a 3D cube depicted in two different ways. The left view (*Figure 1-left*) is a non-isometric drawing, while the right (*Figure 1-right*) is isometric. In the left view, notice that the corner angles are different and each side has a different area. Compare that to the view on the right; its sides connect at a “corner,” creating equal right angles of  $120^\circ$ .
- To help you remember, isometric means “equal measure,” so isometric drawings depict three equal-sized sides of an object.
- This, in combination with the angle between any two intersecting lines being  $120^\circ$ , is what makes an isometric view and enables us to draw 3D objects so neatly in 2D.

During this workshop, we are going to practice drawing shapes isometrically.

**Slide 14 shows an AutoCAD-created house design depicted isometrically.**

**For more examples, show slides 15 and 16. Use slide 17 to demonstrate how to create an isometric drawing. The right side of the slide is isometric paper; if your technology permits, such as by using PowerPoint® on a tablet computer, use this area to draw the figure shown on the left. Go through the provided drawing tips. Begin by making sure the paper is in landscape orientation. Next, define the x, y and z axes on the paper, making sure equal  $120^\circ$  angles are between the axes. Pick a corner that is easy to identify and start drawing from there. Draw lines only where edges exist. An edge is defined as a change in depth along a surface plane. If you run your fingers along a surface and must lift your finger, then you have found an edge.**



*Figure 1. A non-isometrically drawn cube (left) and an isometrically drawn cube (right).*



## Introduction & Motivation Continued

### Part 2: Coded Plans

Next, we are going to learn about coded plans. A coded plan defines the shape of a structure or object composed of blocks.

**Click to reveal slide 18, which is the same as Figure 2—a coded plan.**

Take a look at this coded plan. Notice that the four corners of the coded plan are labeled by letters. Also, notice that the numbers inside the coded plan represents the number of cubes that are stacked on top of each other. Next, we will do some activities to practice making coded plans and isometric drawings.

**Use slide 19 to demonstrate drawing an isometric drawing from a coded plan. Again, isometric paper is provided on the right side of the slide, for use if your technology permits. Start by defining the axes and then start drawing from perspective. Use the same drawing tips explained for slide 17.**

**Slide 20 recaps the four workshop stations. Leave slide 20 up so students know what to accomplish at each station. See slide 21 for the Station 3 answers.**

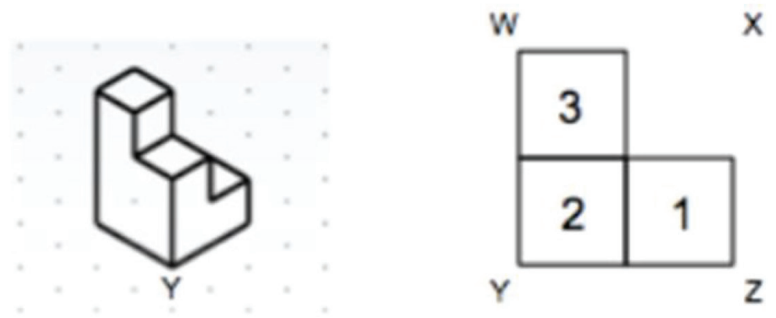


Figure 2. An object drawn isometrically (left) and its coded plan (right).

## Vocabulary

Term	Definition
coded plan	A two-dimensional depiction of an object that defines the volume based on the top view of the object.
isometric	Of or having equal dimensions. The isometric view of an object is the angle at which an equal angle (120°) exists between all axes (such as looking down a corner of the object).
isometric paper	A grid of dots arranged equidistant from one another. Used in making isometric sketches. Also called three-dot paper.



## Lesson Procedure

### Before the Workshop

- ✓ Gather materials.
- ✓ Make copies of the Isometric Paper. Print double-sided to reduce paper use and increase drawing area per page.
- ✓ Prepare a way to digitally get students the web-based software link they will need for this lesson such as by email or by preparing a workshop website with the link.
- ✓ Prepare to project the Spatial Visualization Presentation, a PowerPoint® file, and use its content to aid in your instruction, as makes sense for your class. Slides 12-21 support this lesson. The slides are animated so a mouse or keyboard click brings up the next graphic or text.
- ✓ Prepare the four stations, as described in slide 20 and Figure 3.

<b>Station 1: Coded Plan Relay</b>	<b>Station 3: Peer Teach</b>
<ul style="list-style-type: none"> <li>• Draw a <b>coded plan</b></li> <li>• Then, build the object</li> <li>• Draw the <b>isometric view</b></li> <li>• Pass the coded plan to a neighbor and repeat</li> <li>• Check drawings for accuracy with neighbor</li> </ul>	<ul style="list-style-type: none"> <li>• In pairs, choose 2 viewpoints of the provided <b>coded plan</b></li> <li>• Draw the <b>isometric views</b> from the <b>2 viewpoints</b></li> <li>• Then, redraw the <b>isometric view</b> while describing out loud how you did it</li> </ul>
<b>Station 2: Workbook Drill</b>	<b>Station 4: Computer-Aided Visualization</b>
<ul style="list-style-type: none"> <li>• Individually, answer workbook questions on pages iso1 to iso12 on scrap paper</li> <li>• Check your answers with the answer key</li> </ul>	<ul style="list-style-type: none"> <li>• Read <i>Module 3 - Isometric Drawings and Coded Plans</i></li> <li>• Complete the <b>isometric drawings and coded plans</b> exercises</li> </ul>

Figure 3. The four stations for Workshop Two.

### With the students: Introduction

- ✓ Present to the class the Introduction & Motivation content, supported by slides 12-21.
- ✓ Divide the class into four groups that will rotate through the four stations.
- ✓ Give each student 2 pieces of isometric paper and 8 cubes.
- ✓ Explain that students are to primarily work independently on their drawings, but feel free to share and troubleshoot with their partners.
- ✓ Direct students to work on one piece of isometric paper until it is full.



## Lesson Procedure Continued

### Station 1: Coded Plan Relay

Students begin by drawing a coded plan and labeling the different viewpoints. Next they should build the object with snap cubes and draw the isometric view from their desired viewpoints. Then switch coded plans with a neighbor and repeat the process. Drawings should follow the tips provided in slide 17 and look like the example provided in Figure 2. They should individually work on their drawings, but when they are finished check drawings for accuracy with their neighbors.

### Station 2: Workbook Drill

Have students individually answer the workbook questions on pages iso1 to iso12, recording their answers on scrap paper. After they have completed the problems, have them check their answers with the answer key. Then have them communicate with neighboring students about answers they may have gotten wrong and collaborate on ways to understand and solve the problems.

### Station 3: Peer Teach

Working in pairs, have students each choose two different viewpoints of the coded plan on slides 20 and 21 (also shown in Figure 4). Then have them draw the isometric views associated with their chosen viewpoints. Once each student has drawn two isometric views, direct the pairs to explain to each other how they produced their drawings.

### Station 4: Computer-Aided Visualization

Have students individually read *Module 3 – Isometric Drawings and Coded Plans* from the *Developing Spatial Thinking Software* and complete all isometric drawings and coded plan exercises.

#### Authors + Contributors

Jacob L. Segil, Zoe A. Welz, Denise W. Carlson

#### Supporting Programs

Engineering Plus Degree Program, University of Colorado Boulder  
Engineering Excellence Fund, University of Colorado Boulder

#### Acknowledgments

This workshop was developed by the Engineering Plus degree program in the College of Engineering and Applied Science at the University of Colorado Boulder, initially as a component of a first-year engineering design course. This workshop is part of a seven-workshop series developed and taught by Dr. Jacob L. Segil for undergraduate engineering students. The authors express their appreciation to Dr. Sheryl Sorby for her extensive work on this topic, which provided a foundation on which we could build.

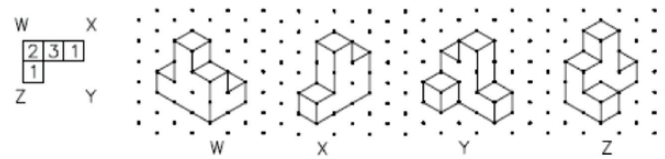


Figure 4. Four views of a cube shape drawn from a coded plan on isometric paper.

### Instructor Tips

- If students struggle to align their drawings with the axes or draw from specific perspectives, reassure them by suggesting they first draw the axes on the paper. Then, place pencils or other similar linear objects around the built object to represent the axes. Explain that the object is sitting at the origin. This physical representation of what to draw usually helps them identify a starting point.
- Halfway through the workshop, have students stop building objects and instead go directly from coded plans to isometric drawings.
- Have some colored pencils in class for students who like to color-code their drawings, matching the block colors to the drawings. This helps some students align the drawings to the objects and better understand the coded plan/isometric views.
- In Station 3, additional explanation is often needed to describe what the four different viewpoints relate to. It helps to rotate a sample cube shape to help students understand this station.
- For Station 3, if possible, laser cut a template for the shape with labeled viewpoints so students can physically see how the viewpoints correspond with the corners.