

From Drawings to Prototypes

Sections

- 5.1 The Graphic Language
- 5.2 Drafting Applications
- 5.3 Building Models and Prototypes

What You'll Learn

- **Compare** freehand sketching and technical drawing.
- **Describe** the alphabet of lines and drawing to scale.
- **Identify** the purpose of each kind of technical drawing.
- **List** examples of drafting applications.
- **Explain** the purpose of working drawings and schematic diagrams.
- **Explain** the purpose of models and prototypes.
- **Define** rapid prototyping.
- **Explain** the purpose of scientific and engineering visualization.

Explore the Photo



Blueprint for Success This architectural drawing shows the plan for the Freedom Tower in New York City with its surrounding towers and the World Trade Center memorial.

Does this drawing help you visualize what the site might look like when construction is completed? Why?





Launch the TECHNOLOGY LAB

Make a Back Massage “Vehicle”

At the end of this chapter, you will be asked to draft and make a model of a back massage machine. Get a head start by using this checklist to prepare for the Technology Lab.

PROJECT CHECKLIST

- ✓ Decide whether you will use a software program or hand sketching to create a design.
- ✓ Go to stores to find examples of novelty back massagers.
- ✓ Think of simple designs of small wooden cars or trucks.

The Graphic Language

Reading Guide

Before You Read

Preview What kinds of drawings are used for technology?

Content Vocabulary

- technical drawing
- drafting
- scale drawing
- multiview drawing
- dimension
- pictorial drawing
- isometric drawing
- oblique drawing
- perspective drawing
- section drawing
- CAD

Academic Vocabulary

- individual
- relationship

TECHNOLOGY STANDARDS

- STL 8** Attributes of Design
- STL 12** Use & Maintenance
- STL 17** Information & Communication Technologies

ACADEMIC STANDARDS

- Science**
- NSES Content Standard F** Science and technology in society
- Social Studies**
- NCSS 8** Science, Technology, and Society

Graphic Organizer

Draw the section diagram. Use it to organize and write down information .

Pictorial Drawings	
1.	
2.	Oblique Drawing
3.	

 Go to glencoe.com to this book's OLC for a downloadable graphic organizer and more.

- STL** *National Standards for Technological Literacy*
- NCTM** *National Council of Teachers of Mathematics*
- NCTE** *National Council of Teachers of English*
- NSES** *National Science Education Standards*
- NCSS** *National Council for the Social Studies*

Understanding Graphic Languages

What are some different ways to create drawings?

There is a saying: “A picture is worth a thousand words.” This is why drawings are used to construct the machines, buildings, highways, products, and systems of our technological world. These drawings can be created by freehand sketching, **technical drawing**, and computer-aided design and drafting. You will see how the graphic language is the foundation of our designed world.

As You Read

Compare What is the difference between a technical drawing and an artistic illustration?

Drafting

Drafting refers to all the drawing techniques that are used to describe the size, shape, and structure of objects. The drawings are used by architects, designers, engineers, technicians, trades people, and many others to help people make things. Drawing techniques are also used in science and engineering to help people understand data. Drafting is also used to create images for video games and for movies.



Reading Check

Explain What are graphic languages?

Mainly Metrics Drawings and models made for the international market must be made using the metric system of measurement. The United States is one of the only countries in the world that does not use the metric system as its standard.

Apply Select a drawing or model you have made for this course and convert the measurements to metrics. If you use CAD, you can do it automatically.



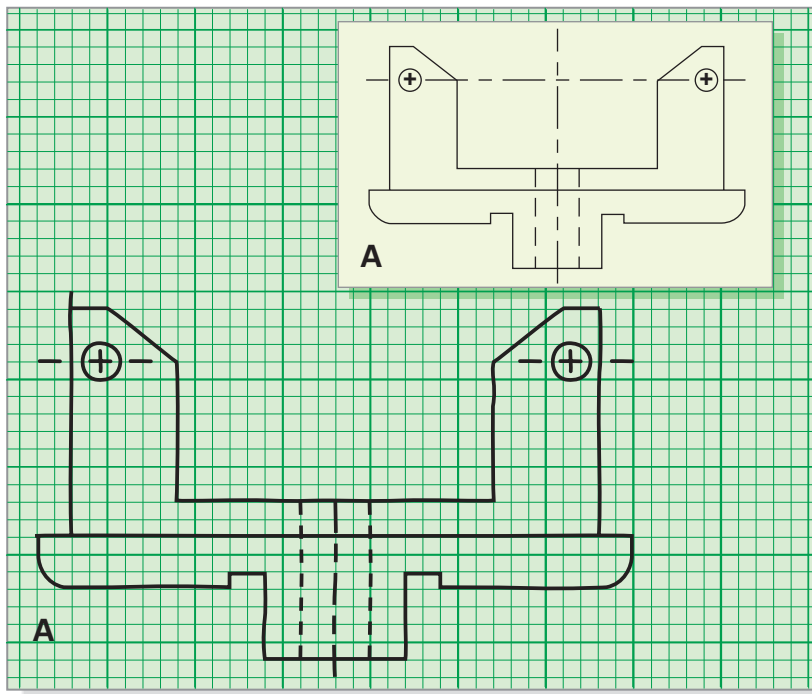
Freehand Sketching

How are freehand sketches used for technology?

Freehand sketching can be the first stage in the development of a drawing that will be used to construct a building, bridge, or automobile. Designers often make many freehand sketches of possible designs to get their ideas down on paper. They use the sketches to evaluate their designs and pick the best one.

Designers draw freehand sketches using only pencil and paper. To make your first sketching experience easier, try drawing on graph paper. See **Figure 5.1**. In the technology laboratory, you will use freehand sketching to show the size and shape of a project you plan to construct. Drawing is one of the simplest ways of communicating ideas to other people.

Figure 5.1 Freehand Drawing



Precise Drawing This freehand sketch was drawn on graph paper. *If you had a choice, would you prefer freehand sketching on graph paper or blank paper? Explain why.*

Technical Drawing

How does a technical drawing differ from a freehand sketch?

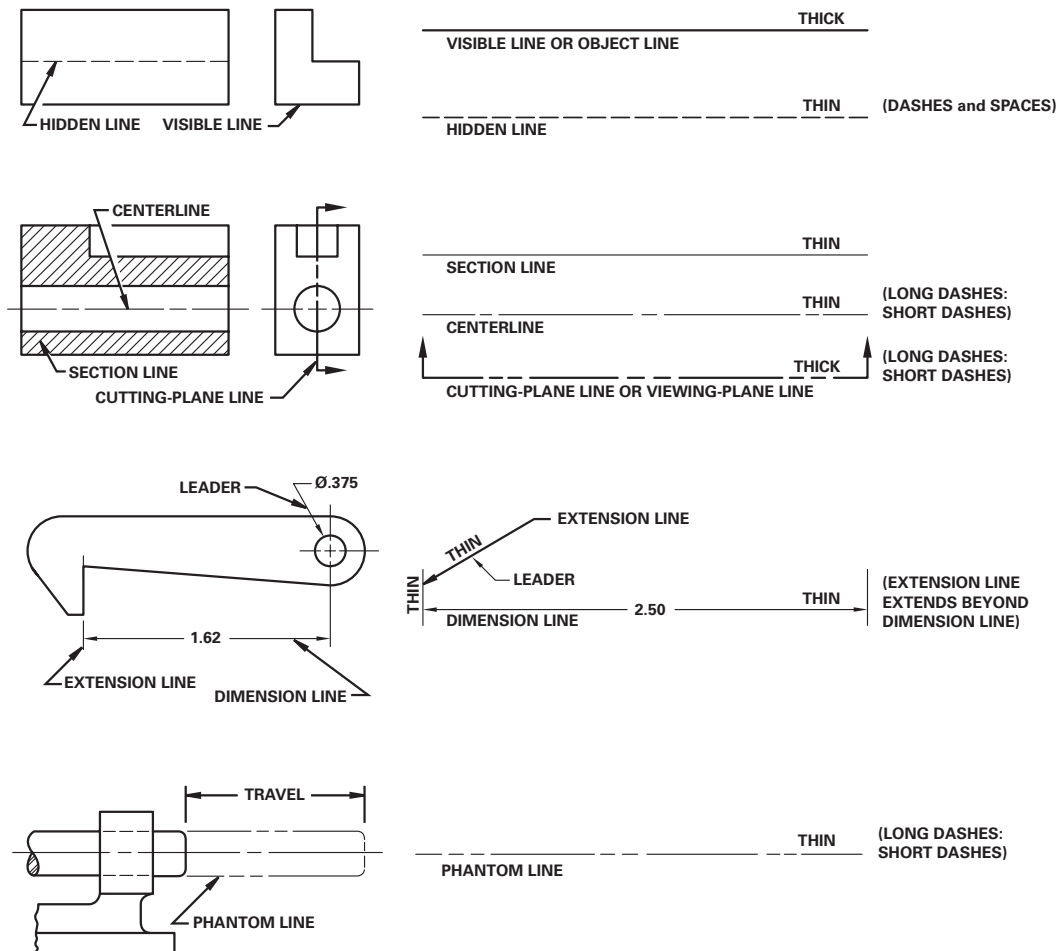
Many simple projects can be made from freehand sketches. As the project becomes more complex, it becomes necessary to have more accurate plans. If the project consists of many parts that will be made by different people, plans must be very accurate.

Technical drawing, or mechanical drawing, uses mechanical or electronic tools to accurately show the size and shape of objects. When you produce a technical drawing, you may use pencils, pens, paper, a drawing board, rulers, triangles, compasses, and a computer with special software. These tools give the drafter the ability to draw perfectly straight, round, or curved lines.

Drawing Techniques

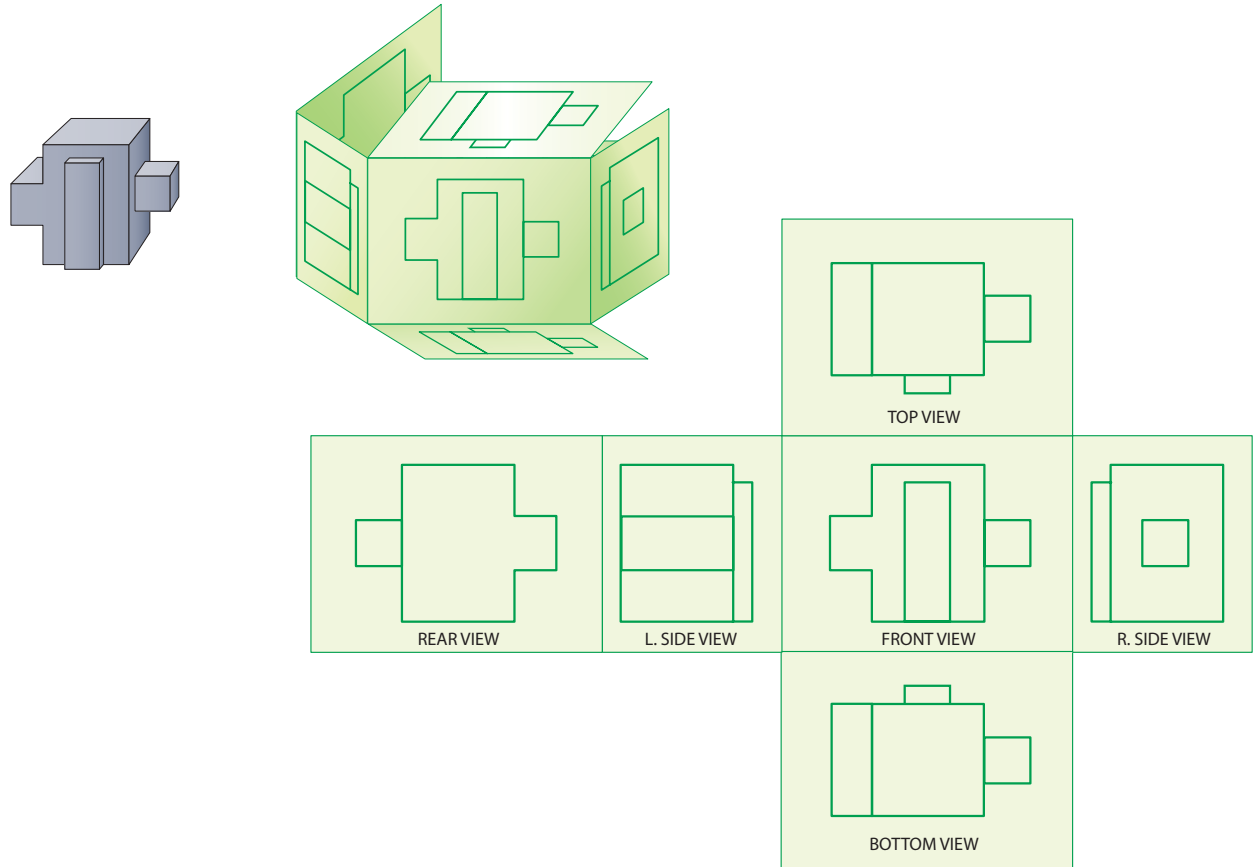
Drafting has rules about how to draw each type of line. These lines are “the alphabet of lines.” See Figure 5.2.

Figure 5.2 The Alphabet of Lines



A Line for Every Purpose Lines in a drawing vary depending on their purpose. *Can you tell the difference between a hidden line and a visible line?*

Figure 5.3 Multiview Drawings



 **A Full-Shape Description** A multiview drawing shows an object as if you took pictures of it through each side of a glass box. *Which of these views might not be necessary? Why?*

Can you imagine carrying a set of house plans that are as big as a house? To make them easy to carry and use, most technical drawings are drawn to scale. A **scale drawing** shows an object's actual shape drawn smaller or larger than its actual size. House plans might be drawn so one-quarter inch equals one foot.

Multiview Drawings

Imagine an object placed inside a square glass box. If you were to photograph this object through each side of the box, you would have six photographs that show each **individual** side of the object.

If you were to draw, rather than photograph, these different views of the object, you would have a **multiview drawing**.

Although six drawings can be produced, most objects can be explained by drawing the front, top, and right side. **Figure 5.3** shows a multiview drawing. A drawing needs only as many views as necessary to provide the full-shape description. When necessary, the drafter creates additional, detailed views.

Leonardo da Vinci

Artist, Engineer, Inventor

Most people know Leonardo da Vinci as a famous Italian Renaissance artist. He painted *The Last Supper*, completed in 1498, and the *Mona Lisa* in 1504. However, da Vinci was a master of both arts and science. He was a painter, sculptor, writer, and musician. He was also an architect, engineer, inventor, mathematician, anatomist, and scientist. Some have called him the most diversely talented person who ever lived.



Da Vinci's early ideas of solar power and calculators were ingenious. The Duke of Milan hired him to design dozens of devices. Among these were a water-powered saw and a machine that cut threads onto small rods to make screws.

Flying Fascination With a keen interest in flying, da Vinci was far ahead of his time. He created designs for an airplane and a helicopter centuries before the Wright brothers succeeded in flight in the early 1900s.

English Language Arts/Writing Write a few paragraphs about what you know of Leonardo da Vinci and what impresses you about him. Do research if needed.



Go to glencoe.com to this book's OLC to learn about young innovators in technology.

It is easy to place exact dimensions on a multiview drawing.

Dimensions give the size of the object and the exact size and location of holes, cutouts, and other features.

When the drawings are finished, copies are given to people who check for drawing errors and design problems. If licenses, patents, or permits must be obtained, copies of the drawings are filed with the appropriate government agencies. Additional copies are sent to the construction site or factory where the finished product will be made.

Pictorial Drawings

It is sometimes hard to visualize what an object actually looks like from a multiview drawing. For this reason, drafters often include a **pictorial drawing**, which is a realistic-looking drawing of a three-dimensional (3D) object.

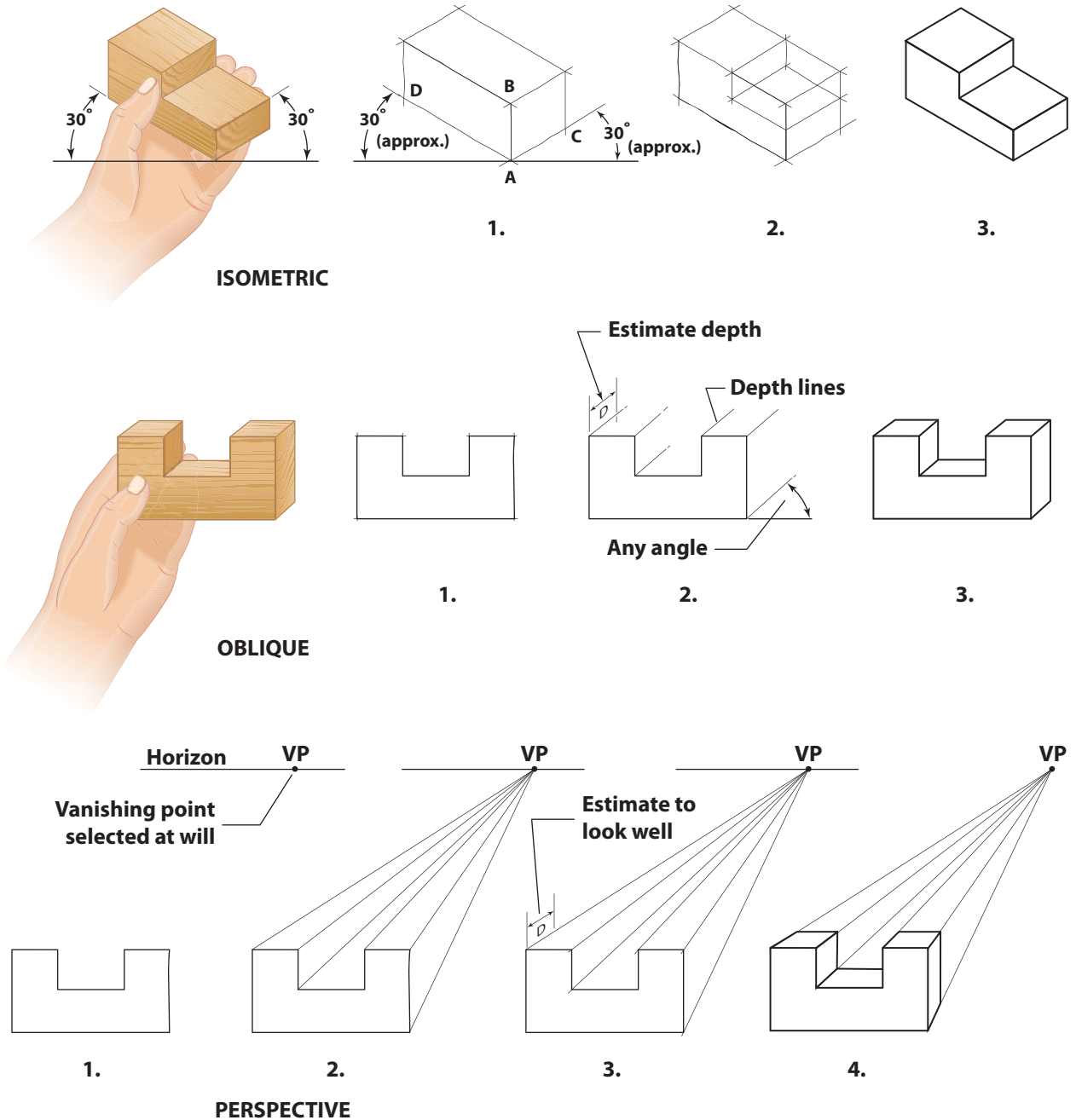
Isometric Drawings

In an **isometric drawing**, the object being drawn is rotated 30 degrees and tilted forward 30 degrees so three sides are shown. The surfaces of the object in **Figure 5.4** that face toward you are all equally distorted. An isometric drawing is the only pictorial drawing that can be measured along all three axes.

Oblique Drawings

In **oblique drawings** you see a perfect undistorted front view of the object that is combined with a distorted angle view of the other two sides. See Figure 5.4. again. Oblique drawings do not always present a clear picture of an entire object. Therefore, they are the least drawn pictorials. They are most often used for making furniture.

Figure 5.4 Pictorial Drawings



Three of a Kind Three kinds of pictorial drawings are isometric, oblique, and perspective. *Why is a perspective drawing the easiest one to understand?*

Perspective Drawings

In a **perspective drawing**, the object appears as it would in real life. See Figure 5.4 again. Here more distant parts of the object appear smaller, and parallel lines vanish at a distant point, commonly referred to as a *vanishing point*.

This is the hardest of the pictorial drawings to create. Yet, with certain objects, it is the easiest drawing to understand when viewing it.

Can you see how positioning of the object before it is drawn can affect your final drawing? Can you see why isometric, oblique, or perspective drawings are better suited for some objects than they are for other objects? Study the examples to see the **relationships** among the object, the drawing, and the observer.

Section Drawings

If you wanted to see what was inside a candy bar, what would you do? You would cut open the candy bar. In the same way, a drafter can show the insides of objects by cutting them open and drawing a view of the interior. Drawings that show the inside of an object are called **section drawings**. See Figure 5.5. These drawings are used when the insides of objects are complex.



Reading Check

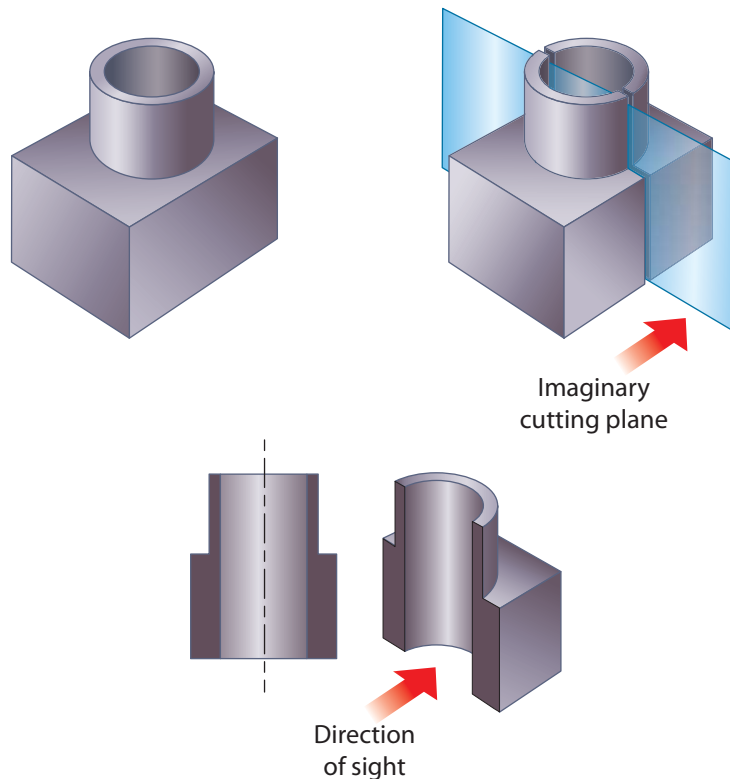
Recall What is the purpose of section drawings?

Figure 5.5 Section Drawings



The Inside View

Section drawings show the internal features of an object. *What is the purpose of the imaginary cutting plane?*



Computer-Aided Drafting and Design

How does CAD differ from traditional design and drafting?

Today most drafters use a computer instead of a drawing board, paper, T-square, and triangles to make a drawing. The use of computers to do design and drafting is known as **CAD** (computer-aided design).

The computer serves as a very powerful tool because it lets you change and test your design while you are still drawing it. For example, an automotive design can be tested for wind resistance right on the computer. Even an expensive CAD system, however, cannot turn poor designs or drawings into good ones.

With CAD, the drafter selects the type of lines to be drawn from an assortment of drawing tools. The drafter enters the location of the line into the computer by indicating the starting and ending points. The computer program also contains many pre-drawn symbols that the drafter wants to include. The drafter picks what is needed, and then cuts and pastes it into the drawing.

Computer-aided drafters can increase or decrease the size of their drawings. For fine detail work, they magnify an area of a drawing, add the details, and then reduce the area down to size.



Reading Check

Explain What kind of testing can be done with CAD?



Screen Savers

Did you know that a screen saver displaying moving images causes your monitor to use as much electricity as it does in active use? A blank screen saver is only slightly better. Also, leaving your computer on overnight is less efficient than shutting it down and rebooting.

Try This Turn off your monitor when you are not using it to reduce energy consumption and carbon dioxide emissions.



Computerized Drawing

Most technical drawings are now drawn using CAD. *Why do you think drafters prefer CAD over traditional mechanical drawing methods?*

When the drawing is finished, the computer will add the dimensions, draw the pictorial, and rotate the object so that you can see what the other side looks like. The computer can also send the drawing to a printer or plotter.

Modeling, Rendering, and Animation

Using a computer, a drafter can produce a three-dimensional (3D) model. The model is built by combining various shapes, lines and arcs to create a surface structure. There are three kinds of models in 3D CAD:

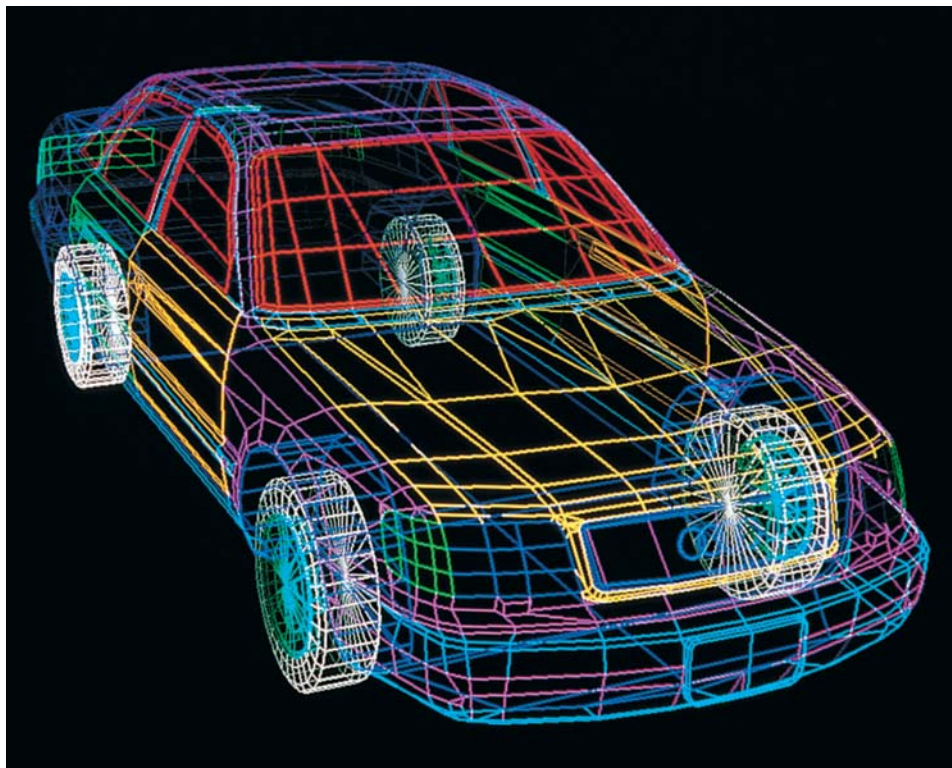
- Wireframe models
- Surface models
- Solid models


Wireframe Models

A wireframe model appears to be built out of wire mesh rather than solid surfaces, as illustrated in the picture below. You can use a wireframe to determine the amount of space between objects. Wireframes do not provide as much information as surface or solid models.

Surface Models

CAD surface models can give more information. The actual area of the object can be shown. Surface models can look like the shape of the object when viewed only one way.



 **Wired Model** After a wireframe object is drawn, a drafter can change it in many ways. *What advantage might a wireframe structure have over a rendered object if testing shows structural weaknesses?*

Automated Animation Physical movement in an animation could include thousands of individual drawing cells. *What advantage would an animator using a computer have over an animator who is drawing individual cells on paper?*



Solid Models

The most realistic kind of modeling uses solid models. They show the shape, area, and volume of an object, or how much an object can hold of something.

Rendering

Rendering give a drawing depth. It produces the reflections that are created when light hits an object. A powerful computer and rendering software can help make 3D models look lifelike.

Animation

To make a drawing move, the drafter adds animation. By simulating moving parts, engineers can use special software to test a design before it is ever built. By combining 3D drawing, rendering, and animation, drafters can create images for architectural presentations, scientific visualization, electronic games, and motion pictures.

section

5.1

assessment

After You Read Self-Check

1. Give three reasons why people make freehand sketches.
2. Name the three types of pictorial drawings.
3. Identify an object that is represented by an isometric drawing. An oblique drawing. A perspective drawing. A section drawing.

Think

4. What scale would you use to sketch a multiview drawing of a simple shape, such as a box of tissues? On a separate sheet of paper, freehand sketch this shape. Be sure to use accurate dimensions.

Practice Academic Skills

English Language Arts/Writing

5. Explain in one paragraph what is meant by the saying: "A picture is worth a thousand words."

STEM Mathematics

6. Jonas designed a new tool by using CAD software. In the specifications for the tool, its measurements are in inches. He would like to sell the tool in Europe where people use the metric system. So he needs to convert the measurements. He knows that 1 inch equals 25.4 millimeters. If the tool is 18 inches long, what is its length in millimeters?

Math Concept Measurement Conversion Either multiply or divide to convert measurements.

1. You know that 1 inch = 25.4 millimeters.
2. To find the value for 18 inches, multiply both sides of the equation by 18.



For help, go to glencoe.com to this book's OLC and find the Math Handbook.

Drafting Applications

Reading Guide

Before You Read

Connect How is

drafting used in the real world?

Content Vocabulary

- working drawing
- assembly drawing
- schematic diagram

Academic Vocabulary

- specific
- consider

Graphic Organizer

Draw the section diagram. Use it to organize and write down information as you read.

Criteria and Constraints When Designing

1. _____
2. _____
3. Size of rooms _____
4. _____



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TECHNOLOGY STANDARDS

- STL 3** Relationships & Connections
- STL 8** Attributes of Design
- STL 17** Information & Communication Technologies
- STL 19** Manufacturing Technologies

ACADEMIC STANDARDS

Science

NSES Content Standard E Abilities of technological design

Mathematics

NCTM Geometry Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.

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The Importance of Drafting

Why do designers and builders need drafting?

Architects, engineers, technicians, scientists, and tradespeople need technical drawings that will help them complete jobs. For example, drawings that provide all the information needed to build a house look very different from drawings used to build a computer. Drafters become specialists in fields such as architecture, map making, engineering, manufacturing, and electronics.

As You Read

Identify What are the different types of drawings?

Drafting for Manufacturing

How does industry use drawings?

Without technical drawing, modern industry would never have developed. The machines that are used by manufacturers and all the products made by these machines started out on the drawing boards of drafters.

Manufactured objects begin as **working drawings** that include all the information necessary to build the **specific** product or structure without any further instructions. The complete working drawing package consists of:

- Multiview drawings
- Pictorial drawings
- Assembly drawings

The **assembly drawings** show workers or consumers how to put parts together to make different objects, from a house to a piece of furniture. See Figure 5.6.



Reading Check

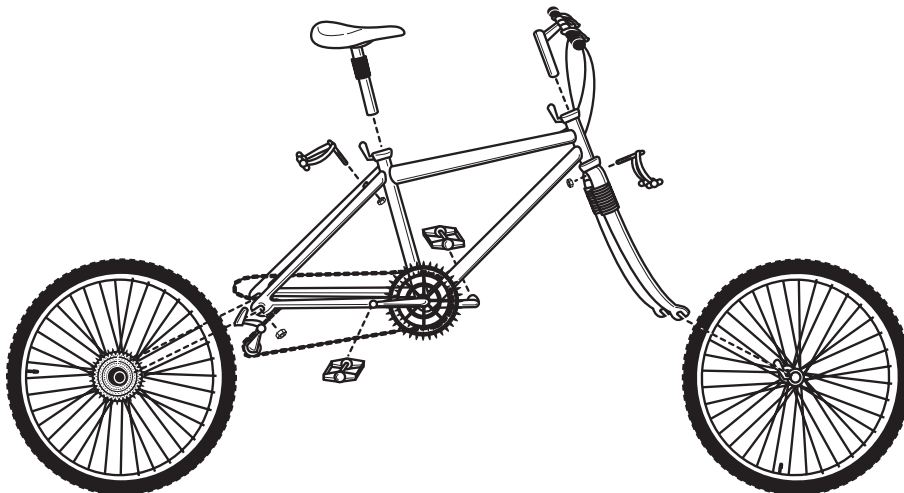
Define What information is included in working drawings?

Drafting for Electricity and Electronics

Why do electrical drawings look different than other drawings?

Electrical items have circuits, electric components, and electronic components. Just as you have your own way of talking to your friends, drafters who work in the electric/electronics field have their own way of expressing things.

Figure 5.6 Assembly Drawing



Following Instructions

An assembly drawing shows how an object should be put together. *Why do assembly drawings usually show parts in unassembled but aligned locations?*

Imagine This...

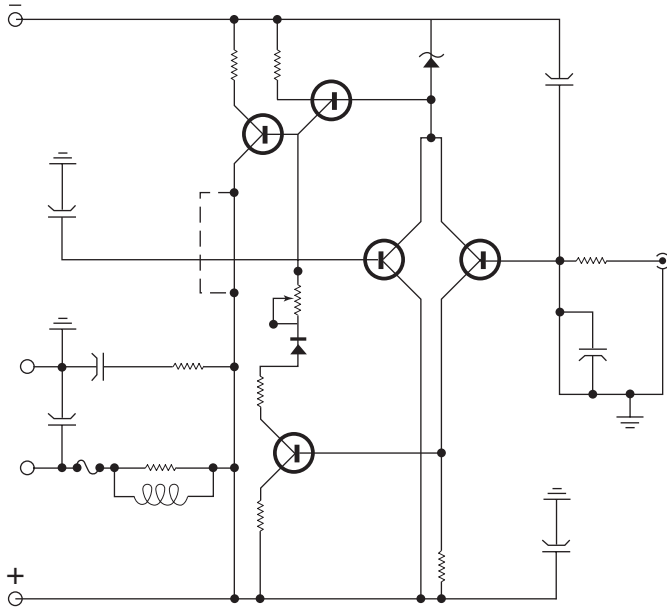
Like Star Trek

On the TV show *Star Trek*, replicators made real things, not just models. Researchers at the Sandia National Laboratories have been working to turn this sci-fi idea into real technology. They call it “Laser Engineered Net Shaping” (LENS®). Their model uses CAD and a laser-guidance system to make an almost-finished product from powdered metals. The final machine will produce finished parts and products. *What other use might LENS technology have?*



Go to glencoe.com to this book’s OLC for answers and to learn more about new rapid prototyping technology.

Figure 5.7 Symbols and Lines



Drawings that show how electric and electronic components are connected together are called **schematic diagrams**. See Figure 5.7. Drafters have created symbols to represent all electrical parts, such as a battery or plug, switch, light bulb, socket, transistors, and integrated circuits. These symbols help make the drawings immediately understood by the people who will manufacture a product from a design.

 **Reading Check**

Explain How are symbols used by drafters?

 **Schematic Symbols**

A schematic drawing uses lines and symbols to show electrical circuits and components. *Why are symbols and lines used rather than small pictures?*

Drafting for Engineering and Construction

What information is included in drawings for a construction project?

Architects and engineers use design and construction knowledge that has been developed over centuries. The first designers probably outlined plans for their structures in the dirt or on cave walls so that helpers could work together to build or create.

A set of construction drawings includes a complete description of the shape and size of the structure's foundation, the inside and outside of the structure, the electrical system, and the plumbing. See Figure 5.8. Pictures are included that show how the structure should look when finished. The drawings might also include driveways, parking lots, landscaping, and roads.

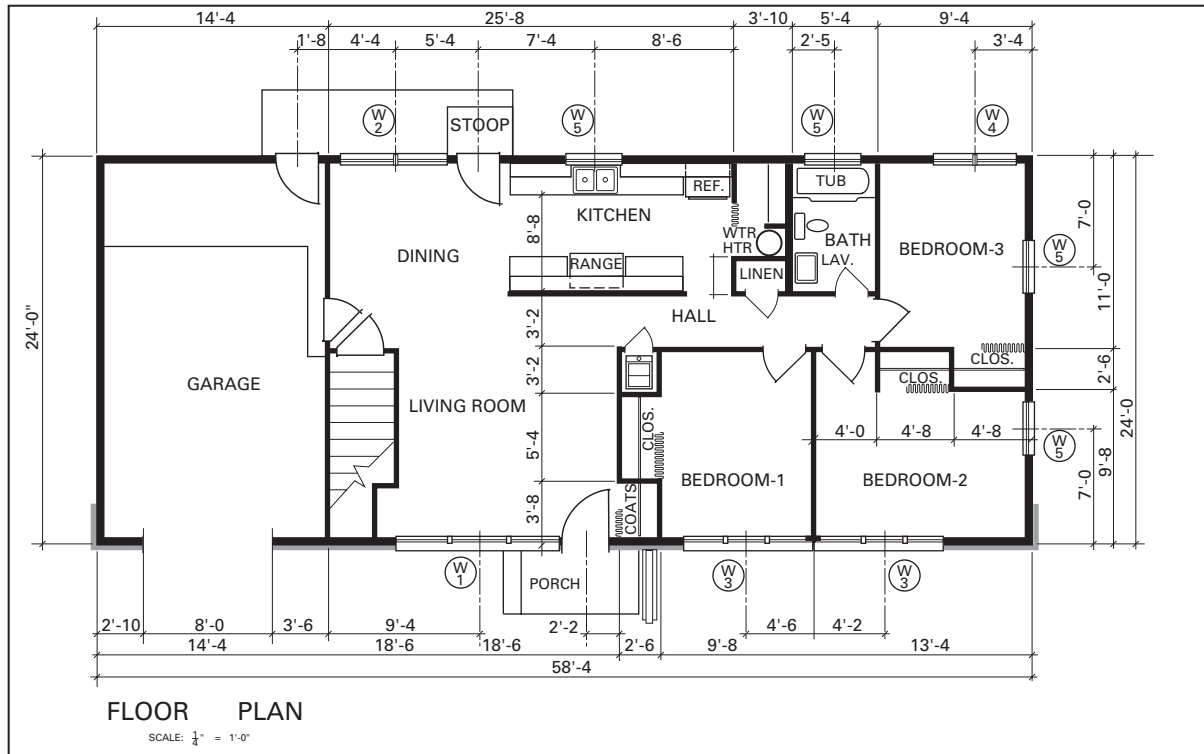
 **Reading Check**

Explain Is all design and construction knowledge new?

Drafting with Criteria and Constraints

Certain locations are susceptible to earthquakes, termites, floods, and ground slides. When building in these areas, people must plan and build a structure that can survive the elements. The architect's goal is to design a structure big enough to meet the client's needs and small enough to fit the client's pocketbook. Designers must **consider** all criteria and constraints when developing a design.

Figure 5.8 Architectural Drawing



Building from a Drawing An architectural drawing gives the size and shape of the structure. Accuracy is very important. *If the plans are not accurate, what will happen when they are used to build the structure?*

section **5.2** assessment

After You Read Self-Check

1. List the different types of drawings included in a set of working drawings.
2. Describe schematic diagrams.
3. Identify the architect's goal when designing a structure.

Think

4. Explain why you think the builders of the Pyramids in Egypt used or did not use construction plans.

Practice Academic Skills

English Language Arts

5. Create a list of instructions for a simple task, such as brushing your teeth or making a peanut butter sandwich. Then make sketches that describe the steps. Your goal is to make the process clear to someone who is learning the English language.

STEM Mathematics

6. Marcus is designing a cabinet for his brother's bathroom. He needs to figure out the volume so his brother will know how much it will hold. The cabinet is 13 inches wide, 20 inches long, and 9 inches deep. What is the volume?

Math Concept **Determining Volume** When determining volume, be sure to express your answer in cubic units.

1. Multiply the length times the width times the height (or depth).
2. Write the answer in cubic inches.



For help, go to glencoe.com to this book's OLC and find the Math Handbook.

Building Models and Prototypes

Reading Guide

Before You Read

Preview What are models and how are they used?

Content Vocabulary

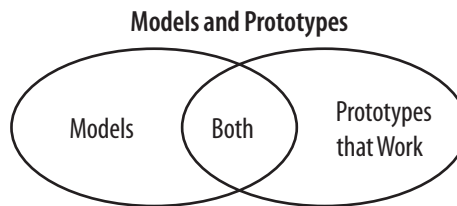
- model
- prototype
- rapid prototyping
- visualization software

Academic Vocabulary

- structure
- accurate

Graphic Organizer

Draw the section diagram. Use it to organize and write down information as you read.



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TECHNOLOGY STANDARDS

- STL 3** Relationships & Connections
- STL 9** Engineering Design
- STL 11** Design Process
- STL 12** Use & Maintenances

ACADEMIC STANDARDS

Science

NSES Content Standard E Abilities of technological design

English Language Arts

NCTE 10 Use first language to develop competency in English language arts and content across the curriculum.

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- NSES** *National Science Education Standards*
- NCSS** *National Council for the Social Studies*

Using Models and Prototypes

What is the difference between a model and a prototype?

Many projects require construction of models and prototypes. A **model** does not actually work; it just shows how the product, building, or system will look when it is built. But a **prototype** is a *working* model of a proposed project. Models and prototypes can be crafted by hand, by machine, or with a computer system.

A prototype can be used to test product reliability and safety before it is mass-produced. The drawings might be changed many times.

As You Read

Predict How are models and prototypes made?

Ethics in Action

Can Designs Be Stolen?

Designers and inventors often build on the work of others. When Steve Jobs and Steve Wozniak built the Apple II, they were improving on the personal computer, not inventing it. What is the difference between building on someone else's work and stealing it?

Give Credit When you steal an idea, you use it without giving the designer credit and/or payment. When you build on someone's idea, you might improve on it or add to it in some way.

English Language Arts/Writing

Getting a Patent Patents issued by the government can protect inventors. Find out how to apply for a patent and what kind of protection is offered.

1. Write a short report on the patent process.
2. Present the report to your class.

At one time, airplane manufacturers had no choice but to build wood models of their airplane designs. They would fly these models in wind tunnels. If the model had good flying characteristics, the next step would be to build a prototype that actually worked.

Powerful computers allow designers and engineers to create virtual 3D models and prototypes. For example, NASA uses the oldest and the newest technologies to create designs for future flight.



Reading Check

Connect What products that you use might have prototypes?

Rapid Prototyping

What is rapid prototyping?

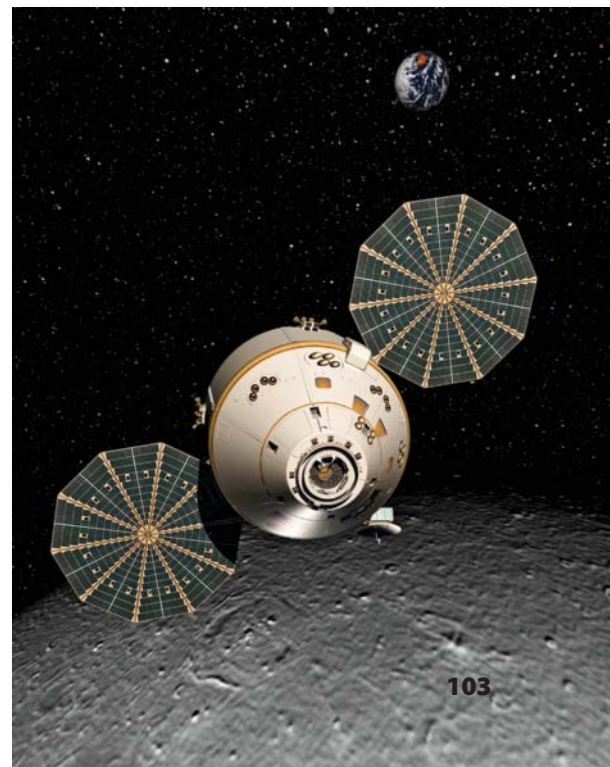
Rapid prototyping takes place in a special machine that can turn CAD drawings into 3D models. **Rapid prototyping** uses a laser and a vat of special light-sensitive plastic to create 3D models. Thin layers of plastic build the object.



Reading Check

Define What is rapid prototyping?

A green circle with a white play button icon. **Space Test** Many people think that the Orion Crew Exploration Vehicle (CEV) is a design throwback to the Apollo program that took us to the moon more than a half century ago. *Do you think a vehicle that travels in space requires a model or a prototype or both? Why or why not?*





Computer Visualization

How do computer models help scientists and engineers understand data?

In the past, to understand tiny **structures**, scientists turned to LEGO® blocks and Tinker Toys® to construct models. CAD **visualization software** is now used to create virtual models of these structures.

For example, scientists used CAD to create a model of a heart. Medical equipment gathered the data on the size and shape of the heart's muscles,

veins, arteries, valves, and chambers. This information was used to create a 3D drawing. The drawing was then rendered and animated. Scientists are using this **accurate** heart model to test new medicines and explore possible cures.

Engineers use the same tools to develop models, gather data, and perform data analysis. Huge structures like dams can be tested for strength during simulated earthquakes. Models of skyscrapers can be tested for wind resistance.

Instant Prototype

A rapid prototyping machine allows a designer to quickly create a model or prototype of a product. *Before rapid prototyping, how did craftspeople create models and prototypes?*

section

5.3

assessment

After You Read

Self-Check

1. Define rapid prototyping.
2. Explain the purpose of a model. A prototype.
3. Identify the type of software used for computer visualization.

Think

4. Explain why scientists or designers might use LEGO® blocks or Tinker Toys® to build models. List some advantages and some disadvantages of using these materials.

Practice Academic Skills



English Language Arts/Writing

5. Do some Internet research to find designs of model airplanes. Choose one and build it, and then test it in a wind tunnel. Write a technical, step-by-step, one-page instruction sheet of how to build it, and then write a report on the test results.



Science

6. Design software has changed the design industry in many ways. The way things are designed and put into production relies more and more on computers. Everything from pop cans to airliners has part or all of its design created on computers using computer design programs. Research several different design applications. Write a paragraph describing different design applications and their uses.

Exploring Careers *in* Technology

Nathan Gross GRAPHIC DESIGNER

Q: *What do you do?*

A: I design graphics that are displayed on products, such as bicycles. Before I start the design, I visit retail stores and browse through catalogs, magazines, and the Internet for trends and ideas. I may sketch some ideas for graphics first. If I already have an idea in mind, I will start designing graphics on the computer. Once the design is complete, it is printed on a special film and applied directly to the bicycle. The bicycle is then approved and shown to buyers for stores. If the buyers decide to buy the bicycle, the design files are shipped out for production.

Q: *What kind of training and education did you need to get this job?*

A: As a child, I was always drawing and painting. I decided to take some computer-design and art classes in college. When I discovered the world of graphic design, I realized what I was born to do. I learned the fundamentals of graphic design and how to use current software that enables graphic designers to do their jobs.

Q: *What do you like most about your job?*

A: The coolest thing about my job is being able to go to a retail store and see a product on the shelf that I helped create. Equally satisfying is that no two work days are alike. Almost every day I get to start a new project that has the potential to be seen by a worldwide audience.



English Language Arts/Writing

Design and Promote Think of and create some colorful graphic designs that might appear on a bicycle, a skateboard, or another product of your choice.

1. Choose a product for which you will create designs.
2. Freehand sketch or use a computer graphics program to illustrate the designs.
3. Write a one-page report, describing the designs, how they will be used, and why they might help the sale of the product.



Go to glencoe.com to this book's OLC to learn more about this career.

Real-World Skills

Listening, observation, creativity

Academics and Education

English language arts, technology, computer design, graphic arts, marketing

Career Outlook

Growth as fast as average for the next ten years

Source: *Occupational Outlook Handbook*

Chapter Summary

Section 5.1 Drawings are used by scientists, architects, engineers, designers, and illustrators to show what objects look like. A drafter makes a freehand sketch to show the shape and size of an object. To draw an accurate picture, drafters use rulers, compasses, and other mechanical drawing tools. A multiview drawing shows the front, top, and right views. A section drawing shows internal structure. Pictorial drawings are also done.

Section 5.2 Drafters represent an object by using different kinds of lines. Thickness and length are determined by the rules of drafting. Dimensions give the size and location of the object's features. In CAD, the designer creates and tests his or her designs on the computer. Most made objects are first drawn. Drawings larger or smaller than the real object are drawn to scale; the parts are in the correct proportions.

Section 5.3 A model is a replica of the product; however, it does not work. A prototype does work and may be tested for reliability or safety. Rapid prototyping makes replicas from plastic. The replicas are first drawn with CAD software, which is also used to make models for scientific and engineering visualization for research and testing.

Review Content Vocabulary and Academic Vocabulary

- On a sheet of paper, use each of these terms and words in a written sentence.

Content Vocabulary

- technical drawing
- drafting
- scale drawing
- multiview drawing
- dimension
- pictorial drawing
- isometric drawing
- oblique drawing
- perspective drawing
- section drawing
- CAD
- working drawing
- assembly drawing
- schematic diagram
- model
- prototype
- rapid prototyping
- visualization software

Academic Vocabulary

- individual
- relationship
- specific
- consider
- structure
- accurate

Review Key Concepts

- Explain** the difference between freehand sketching and technical drawing.
- Describe** the alphabet of lines and scale drawing.
- Identify** the purposes of technical drawing.
- Give** examples of drafting applications.
- Identify** the purpose of working drawings.
- Identify** the purpose of models and prototypes.
- Describe** rapid prototyping.
- Explain** the purpose of scientific engineering.
- Explain** the purpose of electrical drawings.



Real-World Skills

- 11. Graphic Communication** Consider the different aspects of an object needed to produce it. Sketch of an item you use every day. Include information a manufacturer would need to make it.



Technology Skill

- 12. Writing Directions** Directions are often given in a simple step-by-step manner.
- Use the Internet to find a map of your community.
 - Write step-by-step directions to get from your school to another location, but do not indicate the location. Give your directions to another student to test them.



WINNING EVENTS

Automotive Engineer

Situation Your team will design and build a dragster model. It must meet certain criteria and constraints for safety, weight, and size. The model will be powered by a CO₂ cartridge.

Activity Make a series of sketches of the model and produce a technical drawing of it. Then make a wooden model and conduct wind tunnel tests. Make changes as needed. Use these specifications: minimum weight = 50g; dragster body dimensions with wheels: length: minimum = 200mm, maximum = 305 mm, height: maximum = 75 mm; width at axles: minimum = 35mm, maximum = 42mm.

Evaluation The sketches and technical drawings will be evaluated by these criteria:

- Clearly communicates your design ideas
- Technically correct

The dragster:

- Safety (Stays on the track, does not break)
- Speed
- Appearance



Go to glencoe.com to this book's OLC for information about TSA events.

Academic Skills



English Language Arts

- 13.** Choose a product that could benefit from using computers in its design. Write a few paragraphs describing the item and how CAD and manufacturing could improve it.



Mathematics

- 14.** The design software for a manufacturing company costs \$5,400; 75 cents of the selling price of each item will pay for the software. How many items must be sold to pay for the software?



Expense Determining expense involves dividing the cost of one item by the number of items sold.



Standardized Test Practice

Directions Choose the letter of the best answer. Write the letter on a separate piece of paper.

- What is the area of a 12 feet by 48 feet piece of sheet metal?
A 144 square feet
B 1,248 square feet
C 4 square feet
D 576 square feet
- Rapid prototyping can turn drawings into three-dimensional objects.
T
F

Test-Taking Tip When taking a test, do not worry about how quickly other test-takers finish; take your time and concentrate.

Make a Back-Massage “Vehicle”

The wooden van in the drawing has hexagonal wheels. It is sold in novelty stores as a back massager. When you roll it on someone’s back, it can help the person relax and feel better. A technical drawing “breaks down” a three-dimensional object, and shows how it looks from different angles. Multiview drawings help a builder create the same object by using only these drawings as a guide.

Tools and Materials

- ✓ Drawing board
- ✓ Drawing tools
- ✓ Computer
- ✓ Computer printer
- ✓ Drawing software
- ✓ Toy factory software
- ✓ Modeling clay
- ✓ 2 × 4 lumber
- ✓ 3/4-inch plywood
- ✓ Woodworking tools
- ✓ Thumbtacks
- ✓ Sandpaper
- ✓ Drill set
- ✓ Drill press
- ✓ Wood glue
- ✓ Paper
- ✓ Pencils
- ✓ Dowels
- ✓ Scroll saw
- ✓ Wood vises

Set Your Goal

Your goal for this lab is to design your own back-massaging car or truck. You will then build it by using your own technical drawings as guides.

Know the Criteria and Constraints

In this lab, you will:

1. Make a multiview drawing that provides the size and shape of your vehicle and any other information needed to build it.
2. Make a pictorial drawing of your vehicle.
 - Your drawings may be done by hand or with a CAD program.
 - Your vehicle can have small or large wheels of any shape *except* round shape.
3. Prepare a list of materials needed to construct the vehicle.

Design Your Project

Follow these steps to design your project and complete this lab.

1. Draw sketches of different car or truck shapes using drawing software or by hand, or design these shapes using modeling clay.
2. Select the design that best meets the requirements.
3. Prepare full-size drawings or models of front, top, and right side views of your final design. These views should give a complete description of your vehicle’s shape.
4. Measure all the dimensions and add these numbers to the drawings.
5. Make a pictorial drawing of your vehicle.
6. Prepare a list of all materials needed to construct your vehicle.

! SAFETY

Reminder

In this lab, you will be using tools and materials. Be sure to follow appropriate safety procedures and rules so you and your classmates do not get hurt.

7. Build your vehicle:

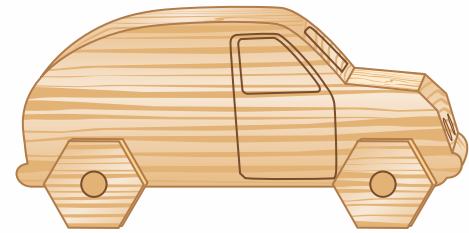
- Make the body out of 2 × 4 lumber.
- Make the wheels out of plywood.
- Cut the axles for the wheels from dowels.
- Locate and drill the holes for the axles. The holes must be large enough for the axles to turn freely.
- Locate and drill the wheel axle joints.
- Sand all parts.
- Slip the axles through the body, and slip the wheels onto the ends of the axles.
- Glue the axle ends into the wheels. Be sure that no glue gets into the body of your vehicle or your wheels will not be able to turn.

8. Try out your massager on a classroom volunteer.

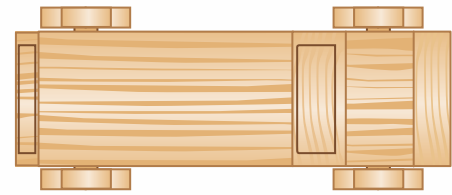
Evaluate Your Results

After you complete the lab, answer these questions on a separate piece of paper.

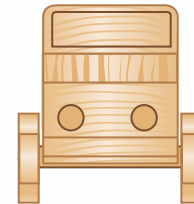
1. Could you build your vehicle using only the size and shape descriptions on your drawing?
2. How could you have improved your multiview drawing?
3. If other students built your vehicle from your plans, would they end up with exactly the same finished product? Explain why or why not.



SIDE VIEW



TOP VIEW



FRONT VIEW

Academic Skills Required to Complete Lab

Tasks	English Language Arts	Math	Science	Social Studies
Research different vehicle and wheel shapes and design several of them.	✓		✓	
Draw with computer software or drawing tools, or build clay models, of three views of the vehicle design, measuring and labeling all dimensions.		✓	✓	
Build final vehicle.	✓	✓	✓	
Create presentation.	✓		✓	
Present to the class.	✓		✓	