# Math at Work 11: Chapter 3

February 20, 2012, 16:12

# 3 Volume and Capacity

The Colonial Building in St. John's was the home of the Newfoundland government from 1850 to 1959. This building, like many others, is made up of different 3-D figures.

1. How many different 3-D figures do you see in this image? Look for figures that make up parts of the building or the grounds.
2. How would you determine how much material was used to make the front steps?
3. How would you calculate the amount of topsoil needed to fill the flower garden?

**Key Words**

volume
capacity
composite figure

## Career Link

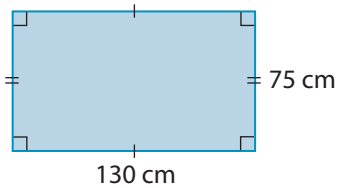
Kevin is an HVAC and refrigeration apprentice. HVAC stands for heating, ventilation, and air-conditioning. Kevin is learning how to install and service furnaces, duct work, and air-conditioning systems. One of the things he needs to consider is the size of the space that needs to be heated and cooled.

# 3 Get Ready

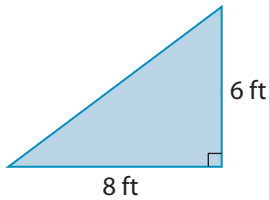
## Area

**1.** What is the area of each figure?

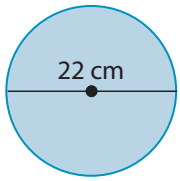
**a)**



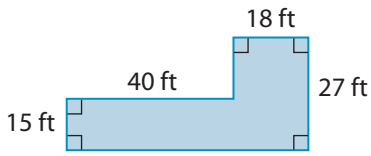

**b)**




**c)**




**d)**




## Convert Length and Area

**2.** Convert each SI length to the unit shown.

**a)** 2.2 metres = ■ centimetres

**b)** 85 centimetres = ■ metres

**c)** 10 kilometres = ■ metres

**d)** 4 m 40 cm = ■ cm
= ■ m

**3.** Show each SI area in the unit shown.

**a)** 50 cm × 50 cm = ■ m × ■ m
= ■ $m^2$

**b)** 10 cm × 10 cm = ■ m × ■ m
= ■ $m^2$

**c)** 1 $m^2$ = ■ m × ■ m
= ■ cm × ■ cm
= ■ $cm^2$

**d)** 25 $m^2$ = ■ m × ■ m
= ■ cm × ■ cm
= ■ $cm^2$

**4.** Convert each imperial length to the unit shown.

**a)** 6 inches = ■ feet

**b)** $2\frac{1}{2}$ feet = ■ inches

**c)** 68 inches = ■ feet ■ inches

**d)** 20′ 10″ = ■″

**e)** 10 yards = ■ feet

**5.** Show each imperial area in the unit shown.

**a)** 6 in. × 6 in. = ■ ft × ■ ft
= ■ $ft^2$

**b)** 1 $ft^2$ = ■ ft × ■ ft
= ■ in. × ■ in.
= ■ $in.^2$

**c)** 1 $yd^2$ = ■ yd × ■ yd
= ■ ft × ■ ft
= ■ $ft^2$

## Fluid Measure

**6.** Convert each SI measurement to the unit shown.

**a)** 1 litre → ■ millilitres

**b)** 2 L → ■ mL

**c)** 500 mL → ■ L

**d)** 250 mL → ■ L

**7.** How many litres of water are in a case of twenty-four 500-mL water bottles?


## Fractions

**8.** Evaluate. Express each answer as a fraction.

**a)** $\frac{1}{2}$ of 3

**b)** $\frac{1}{4}$ of 3

**c)** $\frac{1}{2}$ of $8\frac{1}{2}$

**d)** $\frac{1}{2}$ of $\frac{1}{2}$

**e)** $\frac{1}{4}$ of $\frac{1}{2}$

**f)** $\left(\frac{1}{4}\right)^2$

**g)** $\left(\frac{1}{2}\right)^3$

## Squares and Cubes

**9.** Determine each square.

**a)** $8^2$ **b)** $17^2$

**c)** $0.2^2$ **d)** $0.11^2$

**e)** $\left(\frac{1}{2}\right)^2$ **f)** $\left(\frac{5}{9}\right)^2$

**10.** Determine each cube.

**a)** $5^3$ **b)** $10^3$

**c)** $0.4^3$ **d)** $0.02^3$

**e)** $\left(\frac{1}{3}\right)^3$ **f)** $\left(\frac{5}{9}\right)^3$

## Algebra

**11.** Evaluate the expression when $x = 5$.

**a)** $2x$

**b)** $x + 7$

**c)** $x^2$

**d)** $2x^2$

**e)** $x^3$

**f)** $2x^3$

**12.** Solve for each unknown variable.

**a)** $P = 2l + 2w$
Solve for $P$ when $l = 8$ and $w = 11$.

**b)** $P = 2l + 2w$
Solve for $w$ when $l = 8$ and $P = 40$.

**c)** $A = \frac{b \times h}{2}$
Solve for $A$ when $b = 12$ and $h = 5$.

**d)** $A = \frac{b \times h}{2}$
Solve for $b$ when $h = 15$ and $A = 150$.

# 3.1 Volume

**Focus On . . .**

- estimating the volume of cylinders and of rectangular and triangular prisms
- calculating the volume of cylinders and of rectangular and triangular prisms

***Volume** refers to the amount of space something takes up. A swimming pool takes up space. If you look at a hole that has been dug for a pool, you see that it has length, width, and depth. That means a swimming pool is three-dimensional.*

**volume**

- the amount of space an object occupies
- measured in cubic units or units$^3$

**Materials**

- grid paper
- imperial rulers
- scissors
- masking tape
- yardsticks
- metre sticks

**Strategy**

**Draw or Model**

**F.Y.I.**

1 cubic inch can also be written as 1 cu. in. or 1 in.$^3$.

## Explore Volume

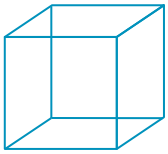
Work in a group.

### Part 1: Imperial Volume References

1. **a)** On grid paper, draw a net of a cube with sides that are 1 inch long. What is the surface area of the cube?

   **b)** Cut out the net and build the cube. The volume of the cube is 1 cubic inch.

2. **a)** Use imperial rulers to build the frame of a cube with sides that are 1 foot long.

   **b)** What is the volume of this cube?

   **c)** Place the cube you built in step 1b) inside the frame. How many cubic inches would it take to fill the space in the larger frame?

3. **a)** Use yardsticks to build the frame of a cube with sides that are 1 yard long.

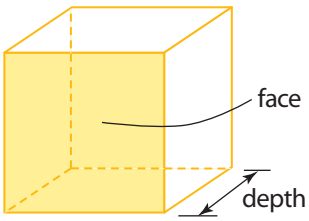
   **b)** What is the volume of this cube?

   **c)** Place the cube you built in step 2a) inside the frame. How many cubic feet would it take to fill the space in the larger frame?

   **d)** Place the cube you built in step 1b) inside the frame. How many cubic inches would it take to fill the space in the larger frame?

4. a) What is the area of one face of the largest cube?

b) Multiply this area by the depth of the largest cube. Compare this result to your answer to step 3b).




## Part 2: SI Volume References

5. a) On grid paper, draw a net of a cube with sides that are 1 centimetre long.

b) Cut out the net and build the cube. The volume of the cube is 1 cubic centimetre.

**F.Y.I.**

1 cubic centimetre can also be written as 1 $cm^3$.

6. a) Use metre sticks to build the frame of a cube with sides that are 1 metre long.

b) What is the volume of this cube?

c) Place the cube you built in step 5b) inside the frame. How many cubic centimetres would it take to fill the space in the larger frame?

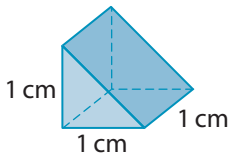
7. a) What is the area of one face of your large cube?

b) Multiply this by the depth of your large cube. Compare this result to your answer to step 6b).

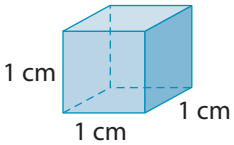
8. **Reflect** What is a formula for the volume of a rectangular prism?

9. **Extend Your Understanding**

a) How is the volume of the triangular prism related to the volume of the rectangular prism?




b) What is the volume of the triangular prism?

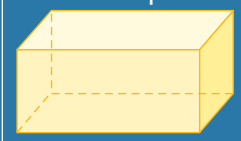



c) What is the area of one triangular face of the triangular prism? Multiply this area by the depth of the triangular prism. Compare this result to your answer in step 9b).

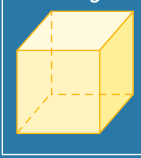
d) What is a formula for the volume of a triangular prism?

**F.Y.I.**

A rectangular prism is any prism with two rectangular bases that are the same size and shape.



A cube is a type of rectangular prism.



## On the Job 1

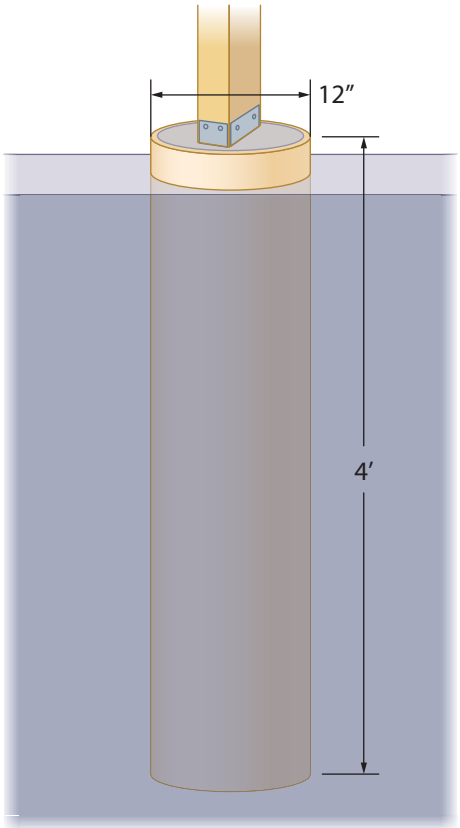
### Work With Volume Calculations

Decks and other structures are often built on concrete footings. The concrete is poured into cylindrical cardboard tubes.

**a)** A tube that is 12 inches in diameter will be filled with concrete to a depth of 4 feet. What is the volume of concrete needed? Express your answer to the nearest cubic foot.

**b)** What is a formula for the volume of a cylinder?

**c)** A different cardboard tube has a diameter of 0.43 m and a volume of about 0.22 $m^3$. What is the depth of the tube, to the nearest tenth of a metre?




**F.Y.I.**

*The depth of a concrete footing depends on where you live. Generally, the colder the winter is, the deeper the concrete has to be.*

**F.Y.I.**

*Height and depth are two ways of referring to the same thing: the dimension that is perpendicular to the area of the base.*

### Solution

**a)** You can calculate the volume of a prism this way:

Volume = area of base of prism × height (or depth)

A cylinder has a circular base.

The diameter is 12″ or 1′.
So, the radius is 6″ or half a foot.

Area $= \pi r^2$

$A = \pi \times 0.5 \times 0.5$

$A = 0.785\ldots$


The area of the base is approximately 0.7853 square feet.

The cylinder has a depth of 4 feet.

Volume = area of base × depth

$V = 0.785\ldots \times 4$

$V = 3.141\ldots$

The volume of concrete needed is approximately 3 cubic feet.

**Strategy**

**Develop a Strategy**

What other strategy might you use to calculate this volume? Which strategy do you prefer? Why?

**b)** The volume of a cylinder is the area of the base multiplied by the height, $h$.

Area of base $= \pi r^2$

The formula for the volume of a cylinder is $V = \pi r^2 h$.

**c)** Use the formula for the volume of a cylinder.

The diameter is 0.43 m.
So, the radius is 0.215 m.

The volume is 0.22 $m^3$.

$$V = \pi r^2 h$$
$$0.22 = \pi \times 0.215^2 \times h$$
$$0.22 = \pi \times 0.046\ldots \times h$$
$$0.22 = 0.145\ldots \times h$$
$$\frac{0.22}{0.145\ldots} = h$$
$$h = 1.514\ldots$$

The depth of the tube is 1.5 m.

**F.Y.I.**

Volume = area of base of prism × height

So, the following are formulas for volume:

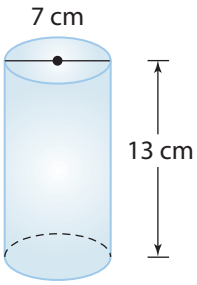
Rectangular prism: $V = lwh$

Triangular prism: $V = \frac{1}{2}lwh$

Cylinder: $V = \pi r^2 h$

## Your Turn

**a)** Determine the volume of a candle mould with a diameter of 7 cm and a height of 13 cm. Round your answer to the nearest 100 cubic centimetres.




**b)** A different candle mould has a diameter of 2 inches and a volume of 12 cubic inches. What is the height of the mould, to the nearest inch?

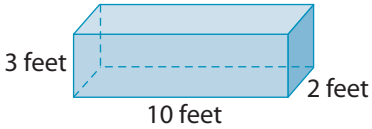
## Check Your Understanding

### Try It

**1. a)** What shape is the base of the prism?

**b)** Calculate the area of the base of the prism.

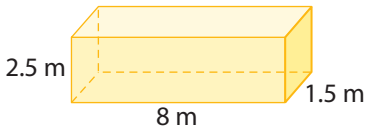
**c)** Multiply your answer to part b) by the height to determine the volume of the prism.




**2. a)** Write a formula for the volume of a rectangular prism.

**b)** Use your formula to calculate the volume of the prism in #1. Did you get the same answer as you did in #1c)? Explain.

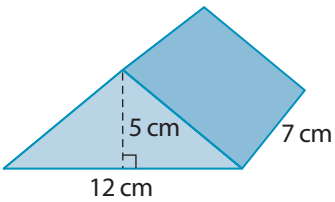
**3.** What is the volume of the rectangular prism?




**4. a)** What shape is the base of the prism?

**b)** Calculate the area of the base of the prism.

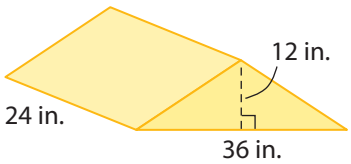
**c)** Multiply your answer to part b) by the height to determine the volume of the prism.




**5. a)** Write a formula for the volume of a triangular prism.

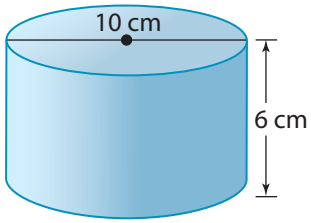
**b)** Use your formula to calculate the volume of the prism in #4. Did you get the same answer as you did in #4c)? Explain.

**6.** What is the volume of the triangular prism?




**7. a)** Calculate the area of the base of the cylinder. Round your answer to the nearest square centimetre.

**b)** Multiply your answer to part a) by the height to calculate the volume of the cylinder.

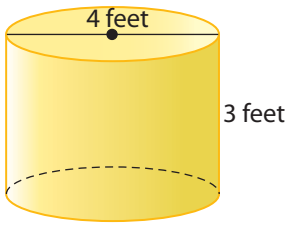


**F.Y.I.**

1 cu yd = 27 cu ft

8. a) Use the formula $V = \pi r^2 h$ to calculate the volume of the cylinder, to the nearest tenth of a cubic foot.

   b) Show the answer to part a) to the nearest tenth of a cubic yard.




## Apply It

9. A box has a volume of 60 $ft^3$. The area of the base of the box is 15 $ft^2$. What is the height of the box?

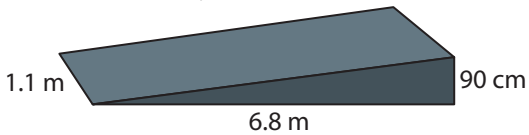
10. A storage space in the shape of a rectangular prism has a length of 9 metres and a width of 6 metres. The volume is 162 $m^3$. What is the height of the space?

11. Heating and air-conditioning installers need to calculate volume.

    a) A banquet room has dimensions of 50 feet by 50 feet by 12 feet. What is the volume of air in the banquet room?

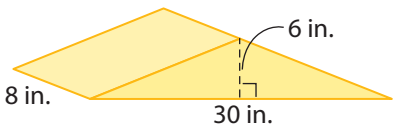
    b) Express your answer to the nearest cubic yard.

12. Determine the volume of concrete needed to build the ramp shown. Round your answer to the nearest tenth of a cubic metre.




13. Fence posts are usually set in concrete. A bag of concrete mix, when mixed with water, makes about $\frac{1}{2}$ $ft^3$ of concrete. A cylindrical hole has a diameter of 8 in. and a depth of 3 ft. How many bags of concrete mix will fill the hole?

14. a) What is the volume of the triangular prism, in cubic inches?




    b) Predict whether the volume of the figure is greater than or less than 1 cu ft.

    c) Express the volume to the nearest tenth of a cubic foot.

    d) Was your prediction correct? Explain why it might not be easy to make this kind of prediction.

**Strategy**

**Develop a Strategy**

What strategy might you use to solve #13? Find a peer who uses a different strategy. Compare and discuss your answers.

**F.Y.I.**

1 cu ft = 1728 cu in.

**F.Y.I.**

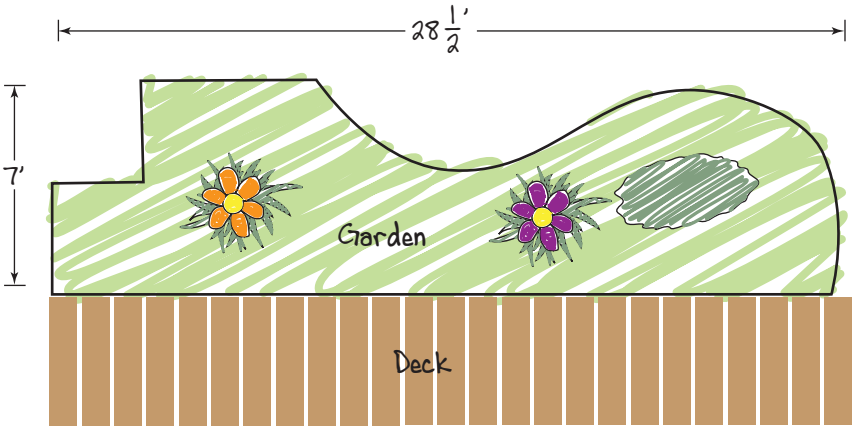
Sometimes it is better to estimate high because then you do not have to go back to the store to get more supplies. Sometimes it is better to estimate low because if you have extra you may not be able to bring it back to the store.

## On the Job 2

### Estimating Volume

Sometimes an estimate of volume is all that is necessary. Garden mulch is often sold by the cubic yard. So, all you need is an estimate of how much to buy.

Kelly wants to spread mulch on an irregularly shaped garden beside her deck. She made the sketch shown. She wants to spread the mulch about 4 in. deep throughout the garden. Mulch is sold in cubic yards. Determine the amount of mulch Kelly should order.




**Tools of the Trade**

Mulch is any natural material applied to the soil surface to protect or improve the ground area. It is used by homeowners and landscapers to keep gardens healthy and to promote growth. For more information on mulch, go to www.mcgrawhill.ca/school/learningcentres and follow the links.

### Solution

***Method 1: Work With Feet***

Kelly needs to estimate the dimensions of the garden.

Length: The length of the garden is about 28 ft.

Width: The maximum width of the garden is 7 ft. It is narrower in some spots. Kelly estimates the average width of the garden to be 6 ft.

Height: The depth is 4 in., which is $\frac{1}{3}$ ft.

$V = lwh$

$V = 28 \times 6 \times \frac{1}{3}$

$V = 56$

The volume of mulch needed is about 56 $ft^3$.

Mulch is sold in cubic yards. Since 2 $yd^3$ = 54 $ft^3$, Kelly should order 2 $yd^3$ of mulch, which is close to her estimate of 56 $ft^3$.

**Strategy**

**Develop Alternative Approaches**

***Method 2: Convert Feet to Yards***

Kelly can convert the dimensions to yards first.

Length: 9 yd = 27 ft

1 yd = 3 ft

27 ft is close to the length of 28 ft. So, the approximate length is 9 yd.

Width: Kelly estimated the average width of the garden to be 6 ft.

2 yd = 6 ft

So, the approximate width is 2 yd.

Height: The depth is 4 in., which is $\frac{1}{3}$ ft.

$\frac{1}{3}$ ft = $\frac{1}{9}$ yd

3 ft = 1 yd

1 ft = $\frac{1}{3}$ yd

$\frac{1}{3}$ ft = $\frac{1}{9}$ yd

$V = lwh$

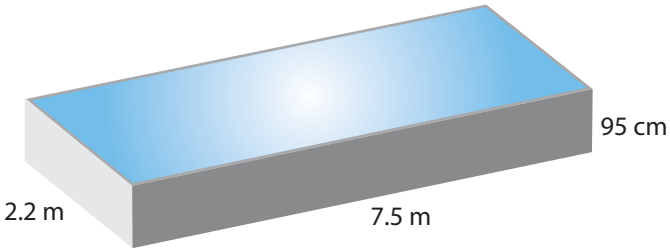
$V = 9 \times 2 \times \frac{1}{9}$

$V = 2$

Kelly should order 2 $yd^3$ of mulch.

## Your Turn

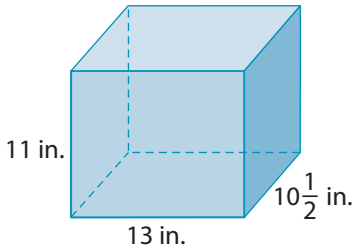
Approximately how much water does this pool hold? Estimate the volume to the nearest cubic metre.



## Check Your Understanding

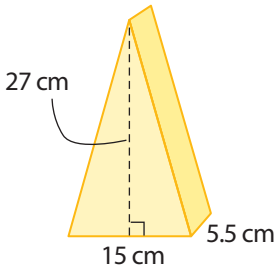
### Try It

**1. a)** Estimate the volume of the rectangular prism.




**b)** Calculate the volume. Compare it to your estimate.

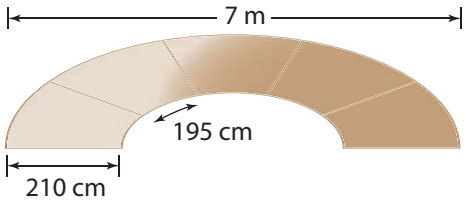
**2. a)** Estimate the volume of the triangular prism.




**b)** Calculate the volume. How close is your estimate to your calculation?

**c)** Now, estimate the volume in a different way. How close is your estimate this time?

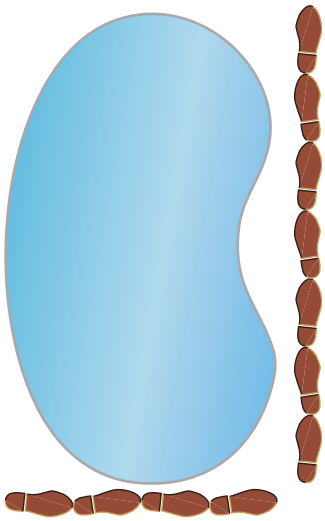
**3. a)** Estimate the area of this irregularly shaped concrete walkway.




**b)** The concrete has a depth of 10 cm. Estimate the volume of concrete needed.

## Apply It

**4.** A contractor has built an irregularly shaped pond in a backyard. The contractor knows that his foot is about 1 ft long. He uses his foot as a reference to estimate the dimensions of the pond. The pond is $1\frac{1}{2}$ ft deep. What volume of water is needed to fill the pond?



**5.** **a)** Estimate the volume of air in your classroom. Use your reference for 1 metre.

**b)** Estimate the volume of air in your classroom. Use your reference for 1 foot.

**c)** Write your answer from part b) to the nearest cubic yard.

**F.Y.I.**

$9\ ft^3 = 1\ yd^3$

**6.** Scott and Shanna have a circular sandbox in their backyard for their daughter. The diameter of the sandbox is 182 cm. They want the sand to be 10 cm deep.

**a)** Estimate the area of the base of the sandbox, in square metres.

**b)** Estimate the volume of the sand needed, in cubic metres.

**c)** They can buy sand in 0.5-$m^3$ bags. How many bags should they buy?

**7.** **a)** Estimate the dimensions of one Canada Post mailbox using a unit of your choice.

**b)** Estimate the volume of one mailbox using a unit of your choice.

## Work With It

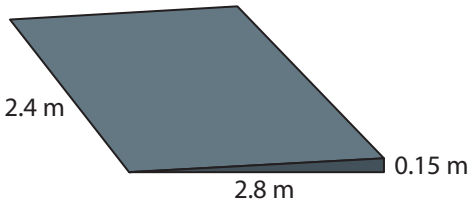
**1.** A swimming pool builder is digging a hole for an in-ground pool. It will be 34 feet long by 18 feet wide, with an average depth of 4 feet.

**a)** Calculate the volume of dirt to be removed.

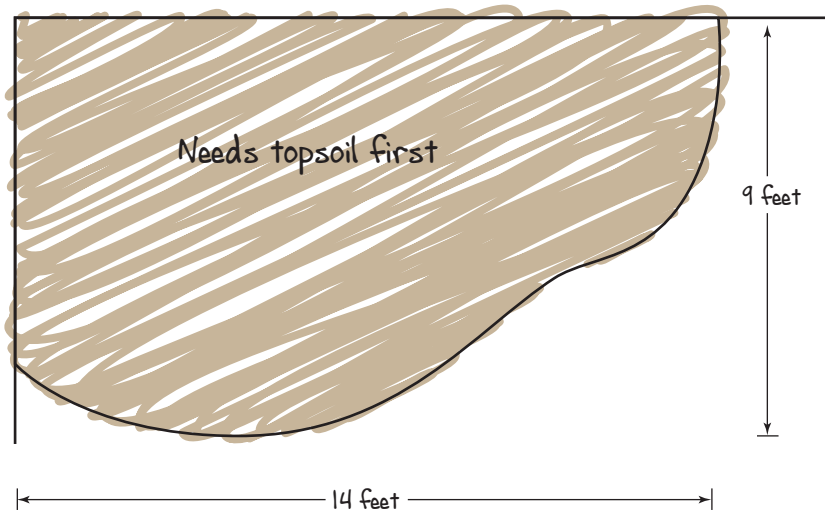
**b)** A standard dump truck can carry about 135 cubic feet. How many loads will the dump truck need to haul away?

**2.** A rectangular swimming pool that is 32′ by 16′ lost a depth of about 1″ of water due to evaporation. To the nearest cubic foot, what was the volume of water lost?

**3.** To the nearest 0.1 $m^3$, determine the volume of concrete needed to construct a ramp to the entrance of a building. The ramp is in the shape of a triangular prism.



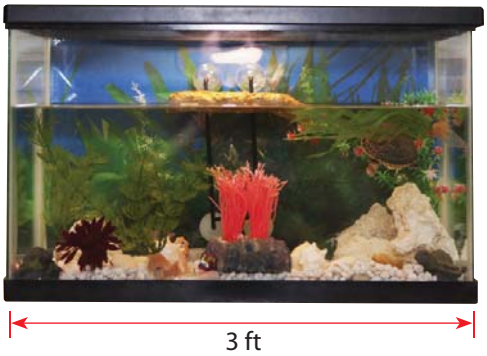

**4.** Estimate the number of cubic yards of topsoil Gary needs to fill his garden. He wants the depth of the soil to be about 9 inches.




**Tools of the Trade**

When a construction job requires concrete, it is important to know how to calculate the volume of concrete that you will need to use. For web sites that have "concrete calculators," go to www.mcgrawhill.ca/school/learningcentres and follow the links.

5. Dana works at a pet store. She is cleaning a fish tank. Estimate the volume of water needed to fill the fish tank.




6. A meeting room in an office building has no windows. The room measures 8.5 m by 5.3 m by 3.2 m.
   a) Calculate the volume of air in the room.
   b) A circulation system draws approximately 3 $m^3$ of air per minute. How long does it take to change all the air in the room?

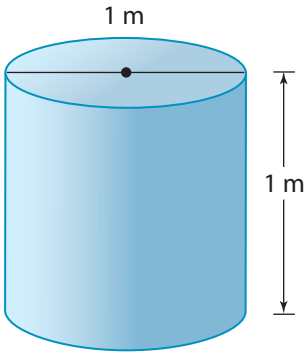
## Discuss It

7. Discuss with a partner a situation that would require an accurate calculation of volume and a situation that would require only an estimate.

8. The surface area of a box is 108 $cm^2$. The volume of the box is 72 $cm^3$. Explain why surface area is measured in square units and volume is measured in cubic units.

9. Which scenario involves surface area and which involves volume? Explain how you know.
   a) the amount of foam chips needed to fill a carton
   b) the amount of spray paint needed to cover a vase

10. a) Predict whether the volume of the cylinder shown is less than, greater than, or equal to 1 $m^3$. Justify your prediction.
    b) Calculate the volume, to the nearest tenth of a cubic metre. Compare it to your prediction.
    c) Would doubling the height of the cylinder double the volume? Explain why or why not.
    d) Would doubling the diameter of the cylinder double the volume? Explain why or why not.



# 3.2 Volume and Capacity

**Focus On . . .**

- comparing capacity and volume
- converting between units of capacity
- estimating capacity or volume using a reference

***Capacity and volume are slightly different. Notice that the pool is not completely full. The capacity of something is the greatest amount it holds. Here, the capacity of the pool is greater than the volume of the water in it.***

**capacity**

- the greatest amount that a container can hold
- measured in cubic units or units$^3$

## Explore Liquid Measure

**Materials**

- 1-cup, 1-pint, and 1-quart measuring cups
- gallon container

Often, but not always, dealing with capacity involves liquid measures. So does dealing with volume.

### Part 1: Imperial Capacity and Volume

Common imperial liquid measures are the fluid ounce, cup, pint, quart, and gallon.

**F.Y.I.**

There are two different sets of imperial capacities: U.S. and British.

- The British fluid ounce is *less than* the U.S. fluid ounce.
- The British pint, quart, and gallon are *larger than* the U.S. pint, quart, and gallon.

Note: All imperial measures in this book are in U.S. units.

**1.** Explore how the units of liquid measure are related to each other. Copy the table and record your results. For example, there are 4 quarts in 1 gallon. See the two highlighted boxes in the table.

| Unit | Fluid Ounces | Cups | Pints | Quarts | Gallons |
|---|---|---|---|---|---|
| 1 fluid ounce | 1 | | | | |
| 1 cup | | 1 | | | |
| 1 pint | | | 1 | | |
| 1 quart | | | | 1 | $\frac{1}{4}$ |
| 1 gallon | | | | 4 | 1 |

## Part 2: SI Capacity and Volume

In SI, the litre (L) is the basic unit of liquid measure. Another unit that is commonly used is the millilitre (mL).

**2.** You may have personal references for common SI capacities. Work with a partner to come up with personal references for these common capacities: 10 mL, 100 mL, 250 mL, 500 mL, 1 L, and 2 L.

**3. Reflect** Estimate the capacity of the bottle of laundry detergent, in SI units and in imperial units. Explain how you determined the estimates.

**F.Y.I.**

You used different SI units depending on whether the material being measured is solid or liquid.

Solid:
1 cubic centimetre or 1 $cm^3$

Liquid:
1 cubic centimetre or 1 cc or 1 mL

**4. Extend Your Understanding** Create approximate conversions between U.S. imperial units and SI units. Copy and fill in the tables.

| Imperial Unit | Approximate SI Equivalent |
|---|---|
| 1 fluid ounce | |
| 1 cup | |
| 1 pint | |
| 1 quart | |
| 1 gallon | |

| SI Unit | Approximate Imperial Equivalent |
|---|---|
| 10 millilitres | |
| 250 millilitres | |
| 500 millilitres | |
| 1 litre | |
| 2 litres | |

## On the Job 1

### Convert Between Units

**F.Y.I.**

**Short Forms**
fluid ounce = fl oz
cup = c
pint = pt
quart = qt
gallon = gal

When travelling in the United States, you buy fuel by the gallon. Josh is in Minnesota. He filled up his rental car with gas. The display on the gas pump read 14.738 gallons.

**a)** Approximately how many quarts of fuel did Josh purchase?

**b)** Why might Josh want to know the number of quarts of gas that he purchased?

### Solution

**Strategy**

**Make a Systematic List**

**a)** 14.738 gallons is a little less than 15 gallons.

Josh knows that 1 gal = 4 qt.
5 gal = 20 qt
10 gal = 40 qt
15 gal = 60 qt

Josh purchased a little less than 60 qt of gasoline.

**F.Y.I.**

1 qt = 0.9464 L
So, 1 qt ≈ 1 L

**b)** Josh wants to find out approximately how many litres of fuel his rental car uses.

He knows that 1 quart ≈ 1 litre.

60 qt ≈ 60 L

The symbol ≈ represents "is approximately equal to."

So, he determines that he had to fill his rental car with approximately 60 L.

### Your Turn

**a)** Convert 7.844 gallons to quarts. Round your answer to the nearest quart.

**b)** Approximately how many litres is this?

## Check Your Understanding

### Try It

1. What imperial unit is most appropriate for each measurement?
   a) the capacity of a drinking glass
   b) the capacity of a swimming pool
   c) the volume of cow's milk in a pail
   d) the volume of formula in a baby bottle

2. What SI unit is most appropriate for each amount in #1?

3. Convert each measurement in gallons to quarts.
   a) 2 gallons
   b) 3 gallons
   c) 10 gallons
   d) 20 gallons

4. Convert each amount.
   a) 2 cups = ■ fl oz
   b) $\frac{1}{2}$ cup = ■ fl oz
   c) 4 cups = ■ fl oz
   d) 12 fl oz = ■ cups
   e) 2 fl oz = ■ cups
   f) 40 fl oz = ■ cups

5. Convert each amount.
   a) 2 qt = ■ cups
   b) $\frac{1}{2}$ qt = ■ cups
   c) 3 qt = ■ cups
   d) 1 qt = ■ fl oz
   e) 2 qt = ■ fl oz
   f) 1 gal = ■ fl oz

## Apply It

**6.** Mike purchases ketchup for his restaurant in 5-L bottles. Customers are served 300-mL ketchup bottles at their table. How many 300-mL bottles will one 5-L bottle fill?

**7.** The capacity of the gas tank of Raj's motorcycle is 5 gallons.

**a)** Convert the capacity of the gas tank to quarts.

**b)** Using today's price for 1 litre of gas, estimate the cost of 1 full tank of gas for the motorcycle.

**8.** The plastic water bottle shown has a capacity of 18.9 L.

**a)** Why do you think the manufacturer of the bottle makes them with a capacity of 18.9 L and not an even number of litres, such as 19 L or 20 L?

**b)** When the bottle is half full of water, what is the capacity of the bottle?

**c)** When the bottle is half full of water, what is the volume of the water in the bottle?

**9.** While watching an American TV station, Jordan sees an advertisement for a grocery store. The store sells half a gallon of milk for US$1.99.

**a)** How many quarts make a half gallon?

**b)** What is the milk's approximate price per litre in U.S. dollars?

## On the Job 2

### Estimating Capacity and Volume Using References

Amy's family lives on a small farm. They currently have a few cows and a week-old calf. Amy needs to estimate the amount of milk replacer that the calf is drinking. She wants to make sure that the calf is getting enough nutrients.

Amy uses feeding bottles that have an approximate capacity of 2 L. The bottle shows how much the calf has consumed so far in the morning feeding.

**a)** Estimate the amount consumed by the calf, in millilitres.

**b)** Approximately how much fluid remains in the bottle, in litres?

### Solution

**a)** The calf consumed about $\frac{1}{3}$ bottle.

1 bottle = 2 L

$\frac{1}{3}$ bottle = $\frac{2}{3}$ L

$\frac{2}{3}$ L ≈ 600 mL to 700 mL

The calf consumed about 600 mL to 700 mL.

1 L = 1000 mL
$\frac{2}{3}$ L ≈ 600 mL to 700 mL

**b)** 2 L − 0.6 L = 1.4 L

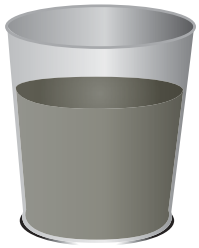
2 L − 0.7 L = 1.3 L

The calf's bottle has about 1.3 L to 1.4 L remaining.

1000 mL = 1 L
600 mL = 0.6 L
700 mL = 0.7 L

### Your Turn

**a)** The pail shown here has a capacity of about 6 L. Estimate the volume of the maple sap in the pail, in litres.



**b)** Sap is poured out of the pail until it is $\frac{1}{4}$ full. What is the amount of sap in the pail, in millilitres?

## Check Your Understanding

### Try It

1. Estimate the volume of the liquid remaining in each container.

   a) 

   b) 

2. For each item in #1, what is the approximate volume of liquid that has been consumed?

3. a) What is the approximate capacity of this large plastic pop bottle?

   b) Claire tries to drink this much water every day. How much has she consumed if her bottle is about $\frac{1}{4}$ full?

### Apply It

4. **MINI LAB** You can determine the volume of an object by how much water it displaces.

   **STEP 1**
   Completely fill a container with water. Place the container on a pan. Drop in a golf ball. The volume of water that spilled from the container into the pan is the approximate volume of the golf ball. Pour the water from the pan into a measuring cup or a graduated cylinder. What is the volume of a golf ball in SI units? What is the volume of a golf ball in imperial units?

   **STEP 2**
   Redo Step 1with a hockey puck.

   **STEP 3**
   Redo Step 1 with other small objects.

   **STEP 4**
   How might you be able to use a golf ball, a hockey puck, and the other small objects as references for volume?

**Materials**

- container
- pan
- water
- measuring cup or graduated cylinder (that shows SI and imperial units)
- golf ball
- hockey puck
- other small objects that sink

5. What is the approximate volume of a chocolate candy that is about the size of half a golf ball?

6. A glass paperweight is in the shape of a cylinder that is about the size of four hockey pucks stacked on top of each other. What is the approximate volume of the glass paperweight?

**Materials**

- sand, salt, sugar, or sawdust
- imperial and SI measuring spoons

**F.Y.I.**

**Short Forms**
teaspoon = tsp
tablespoon = tbsp

7. **MINI LAB** Estimate the volume of small amounts of non-liquids.

**STEP 1**

**a)** Scoop out 1 tsp of sand. Make sure it is level. Place the contents in the palm of your hand. Notice the quantity of sand in your hand. Then, put the sand back.

**b)** With your fingers, scoop out an estimate of the amount that you think is 1 tsp. Place it in your hand.

**c)** Carefully transfer the contents from your hand into a teaspoon. How close was your estimate? If your estimate was not close, try again.

**STEP 2**

Redo Step 1 for $\frac{1}{4}$ tsp, $\frac{1}{2}$ tsp, and 1 tbsp.

**STEP 3**

Redo Step 1 for 5 mL, 10 mL, and 15 mL.

**STEP 4**

How might you use these estimates as references for volume?

8. Maggie is making cabbage rolls. The recipe calls for 7.5 mL or $1\frac{1}{2}$ tsp paprika. She cannot find her measuring spoons. Determine two ways that she could estimate the correct amount.

## Work With It

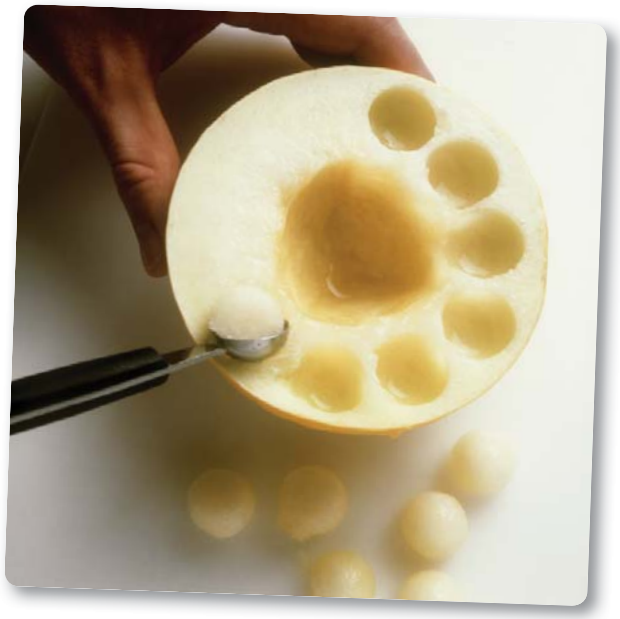
1. Marnie works as a caterer. To plan for a wedding reception, Marnie estimates $1\frac{1}{2}$ six-ounce cups of coffee for each of the 90 guests. Marnie owns a 3-gallon coffee urn and a 10-gallon coffee urn.
   - **a)** Which coffee urn should she bring to the reception? Explain.
   - **b)** Is your answer the same if the number of guests doubles? Explain.

2. A certain brand of toilet is made in the United States and sold in Canada. It uses about 1.6 gallons per flush.
   - **a)** Convert the water usage per flush to quarts.
   - **b)** Approximately how many litres is this?
   - **c)** If the average person flushes 6 times per day, how much water is used per person?
   - **d)** About how many litres of water would the toilet of a typical family of four use in one day?
   - **e)** About how many litres of water would the toilet of a typical family of four use in one year?

3. Hilda's doctor says that she should not have more than two cups of coffee per day. One morning, Hilda drinks two large coffees at the local coffee shop. A large coffee is 20 fluid ounces.
   - **a)** How many cups of coffee did Hilda actually drink?
   - **b)** Express the amount Hilda drank in an imperial unit other than fluid ounces and cups.

4. a) Estimate the volume of a ball formed by using a melon baller.

   b) Estimate the total volume of seven melon balls.



## Discuss It

5. Describe a situation in which someone might need only an approximate conversion of a capacity or volume instead of an exact conversion.

6. Describe a situation in which someone would prefer to have an exact conversion of a capacity or volume instead of an approximate conversion.

7. Explain how you could use a conversion between imperial units to estimate an SI capacity.

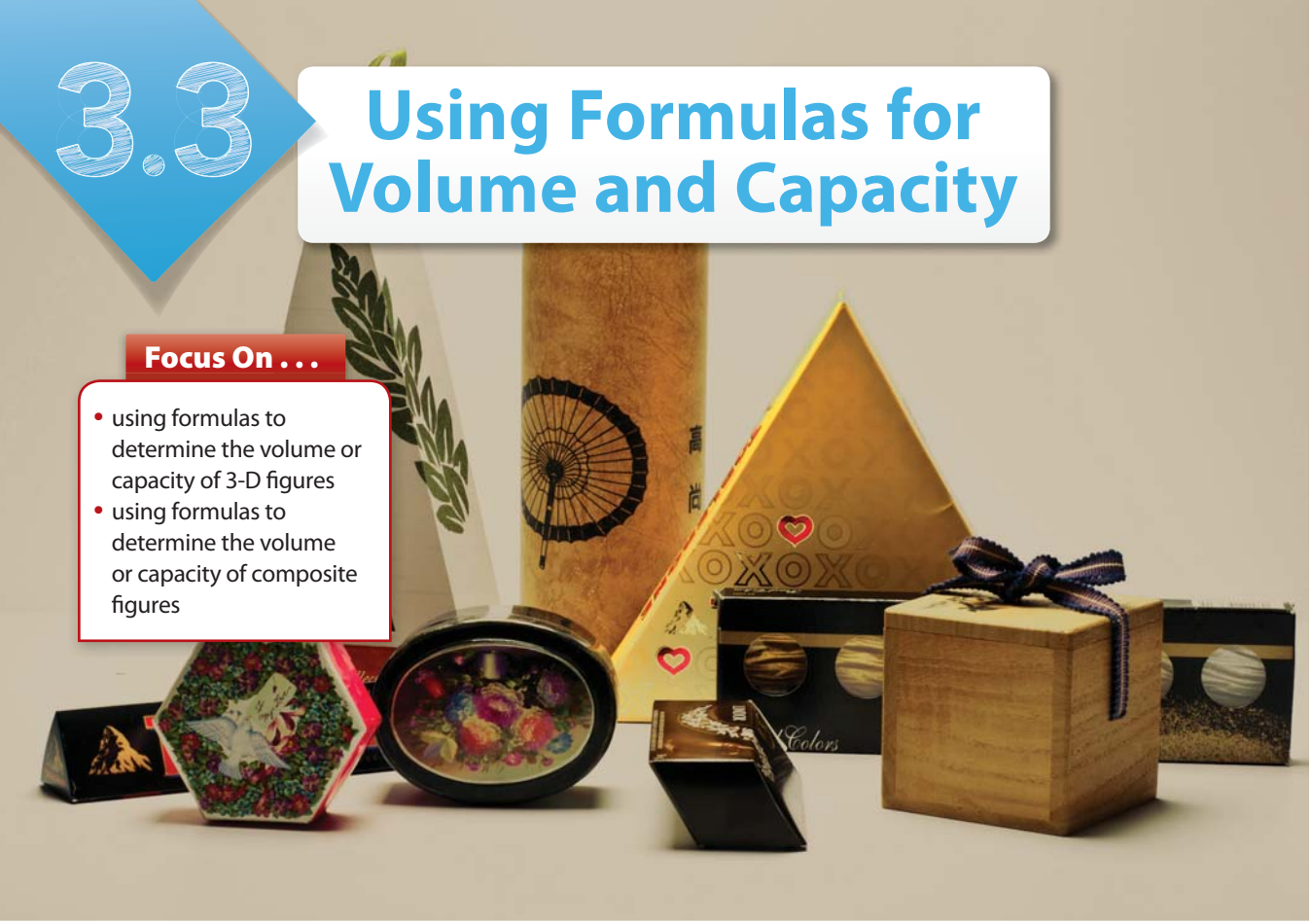
8. Explain the difference between the capacity of a bathtub and the volume of a bathtub.

9. With a partner, discuss each of your personal references for SI units of volume and imperial units of volume.

   a) Would you change any of your personal references based on your discussion?

   b) If so, which ones and why?

# 3.3 Using Formulas for Volume and Capacity



**Focus On . . .**

- using formulas to determine the volume or capacity of 3-D figures
- using formulas to determine the volume or capacity of composite figures

***The packaging for products comes in a number of different 3-D shapes. Sometimes a certain shape is used because it is interesting to the eye. Sometimes a shape is used because it holds more. How do you know which shape will have the greatest capacity?***

## Explore the Capacity/Volume of Related 3-D Figures

**Materials**

- Classroom Products™ View-Thru™ Geometric Solids Set
- water

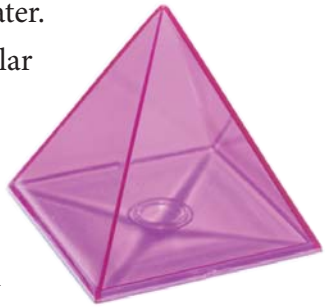
### Part 1: Pyramid and Prism

**1. a)** Fill the square-based pyramid with water.

**b)** Pour the water into the large rectangular prism.

**c)** Repeat parts a) and b) until the rectangular prism is full.

**d)** Record how many times you had to pour from the pyramid into the prism to fill it.



2. **Reflect**

   a) The capacity of the rectangular prism is how many times as large as the capacity of the square-based pyramid?

   b) The capacity of the square-based pyramid is what fraction of the capacity of the rectangular prism?

3. **Extend Your Understanding**
   The formula for the volume/capacity of a rectangular prism is
   $V = l \times w \times h$,
   where $l$ is length,
   $w$ is width,
   $h$ is height.

   Remember, you can calculate the volume of all prisms using
   Volume = area of base × height

   Write a formula for the capacity or volume of a square-based pyramid.

## Part 2: Cone and Cylinder

4. a) Fill the cone with water.

   b) Pour the water into the large cylinder.

   c) Repeat parts a) and b) until the cylinder is full.

   d) Record how many times you had to pour from the cone into the cylinder to fill it.

5. **Reflect**

   a) The capacity of the cylinder is how many times as large as the capacity of the cone?

   b) The capacity of the cone is what fraction of the capacity of the cylinder?

6. **Extend Your Understanding** The formula for the volume or capacity of a cylinder is
   $V = \pi r^2 h$, where $r$ is the radius
   $h$ is the height
   Write a formula for the volume or capacity of a cone.

## On the Job 1

### Using a Formula for the Volume of a Cone

Many businesses purchase cone-shaped cups because they are less expensive than other shapes.

**a)** Calculate the capacity of a conical paper cup with a diameter of 5 cm and a height of 9 cm, to the nearest cubic centimetre.

**b)** Calculate the height of a conical paper cup that has a diameter of 7 cm and a capacity of 130 $cm^3$, to the nearest tenth of a centimetre.

### Solution

**a)** The capacity of a cone can be determined using the formula $V = \frac{1}{3}\pi r^2 h$, where $r$ is the radius of the circle and $h$ is the height of the cone

The radius equals half the diameter.

$$V = \frac{1}{3} \times \pi \times (2.5)^2 \times 9$$

$$V = 58.904\ldots$$


The volume of the paper cup is about 59 $cm^3$.

**b)** The capacity is 120 $cm^3$. The radius is 3.5 cm.

$$V = \frac{1}{3}\pi r^2 h$$

$$130 = \frac{1}{3}\pi(3.5)^2 h$$

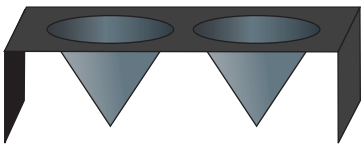
$$130 = (12.828\ldots)h \qquad \text{Divide both sides of the equal sign by } 12.828\ldots.$$

$$10.133\ldots = h$$

The height of the paper cup is about 10.1 cm.

### Your Turn

A company manufactures conical metal moulds.



**a)** Calculate the capacity of one mould with a diameter of 2 in. and a height of $1\frac{1}{2}$ in., to the nearest tenth of a cubic inch.

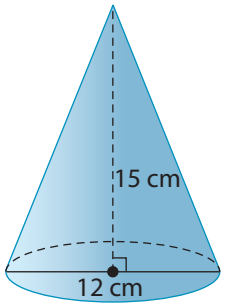
**b)** Calculate the height of one mould that has a diameter of $2\frac{1}{2}$ in. and a capacity of 2 $in.^3$, to the nearest tenth of an inch.

## Check Your Understanding

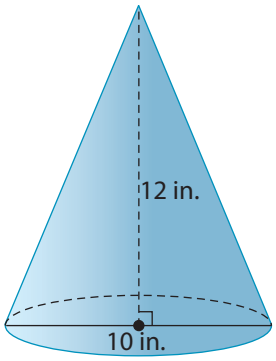
### Try It

**1.** To the nearest cubic unit, calculate the volume of each cone.

**a)**




**b)**




**2.** For each cone in #1, determine the volume of a cylinder that has the same diameter and the same height.

**3. a)** For the cone in #1a), determine the volume of a cone that has the same diameter and twice the height.

**b)** How many times greater is the volume of the larger cone than the volume of the smaller cone?

**4. a)** For the cone in #1b), determine the volume of a cone that has the same height and twice the diameter.

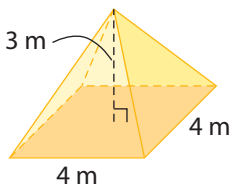
**b)** How many times greater is the volume of the larger cone than the volume of the smaller cone?

**5. a)** A cone has the same volume as the cone in #1a) but has a diameter of 10 cm. What is the height of the cone, to the nearest centimetre?

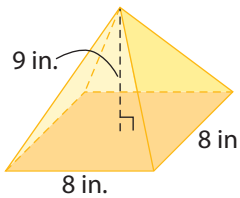
**b)** A cone has the same volume as the cone in #1b) but has a diameter of 8 in. What is the height of the cone, to the nearest inch?

**6.** Calculate the volume of each square-based pyramid.

**a)**

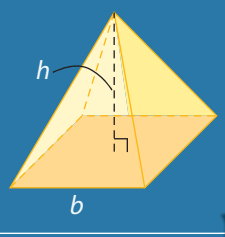



**b)**




**F.Y.I.**

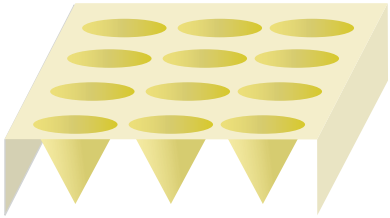
The formula for the volume of a square-based pyramid is $V = \frac{1}{3}b^2h$, where $b$ is the length of base and $h$ is the height of the pyramid.



## Apply It

7. Salt or sand for melting the snow and ice on Canadian roads is piled for storage in the shape of a cone. Calculate the approximate volume of a salt cone that is 20 metres in diameter and 16 metres high. Round your answer to the nearest cubic metre.

8. A manufacturer of chef's supplies makes cone mould trays. Each mould has a height of 3.5 inches and a diameter of 2 inches. What is the total capacity of the entire tray, to the nearest cubic inch?



9. The icemaker at the local fish plant has broken. The ice room currently has a cone-shaped stack of ice with a diameter of 12 ft and a height of 6 ft. Four boats need 8 cubic yards of ice. Does the plant have enough ice on hand for all four boats?

10. A glass sculpture is in the shape of a square-based pyramid. The base length of the sculpture is 4 ft. The height of the sculpture is 6 ft. What volume of glass did the artist use to create the sculpture?

11. The Muttart Conservatory in Edmonton, Alberta, is made up of four square-based pyramids. The two large pyramids are 24 m high and have a base length of 26 m. The two small pyramids are 18 m high and have a base length of 19.5 m. What is the total volume of all four pyramids?

## On the Job 2

### Volume of a Composite Figure


The amount of venting required for a garage depends on its size. The shape of the garage shown is a **composite figure**. Calculate the volume of the garage.

**composite figure**
- a 3-D figure made up of two or more regular figures

**Strategy**

**Simplify the Original Problem**

**Tools of the Trade**

A garage or shed can get extremely hot during summer days and can hold moisture during wet days. Ventilation is important to prevent the buildup of heat and moisture. For more information on venting a garage or shed, go to www.mcgrawhill.ca/school/learningcentres and follow the links.

### Solution

The garage is a triangular prism on top of a rectangular prism.

Rectangular prism:

The length is 15 ft, the width is 12 ft, and the height is 9 ft.

$V_1 = lwh$
$V_1 = 15 \times 12 \times 9$
$V_1 = 1620$

The volume of the rectangular prism is 1620 ft$^3$.

Triangular prism:

The length is 15 ft, the width is 12 ft, and the height is 4 ft.

$V_2 = \frac{1}{2}lwh$

13 ft − 9 ft = 4 ft

$V_2 = \frac{1}{2} \times 15 \times 12 \times 4$
$V_2 = 360$

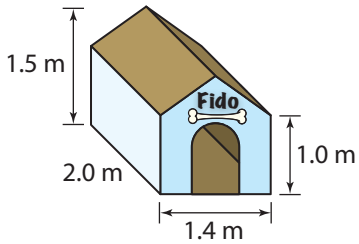
The volume of the roof part of the garage is 360 ft$^3$.

$V = V_1 + V_2$
$V = 1620 + 360$
$V = 1980$

The total volume of the garage is 1980 ft$^3$.

### Your Turn

Determine the volume of Fido's doghouse.

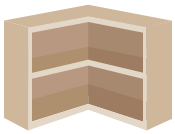


## Check Your Understanding

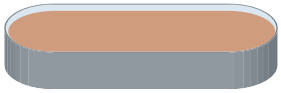
### Try It

**1.** Identify the individual figures that make up each composite figure.

**a)** shelves

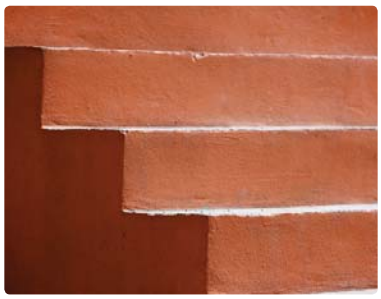


**b)** planter

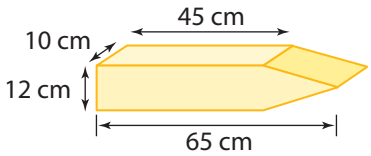


**c)** shed

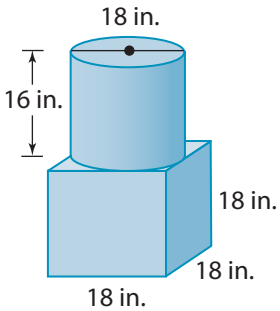
**d)** stairs



**2.** What is the volume of the composite figure?

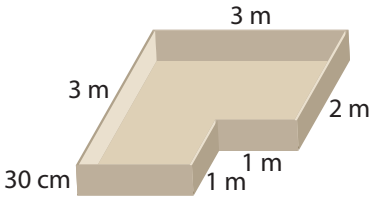



**3.** Determine the volume of the composite figure, to the nearest tenth of a cubic inch.



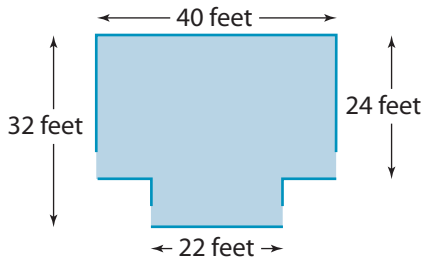

### Apply It

**4. a)** Calculate the capacity of this L-shaped sandbox.

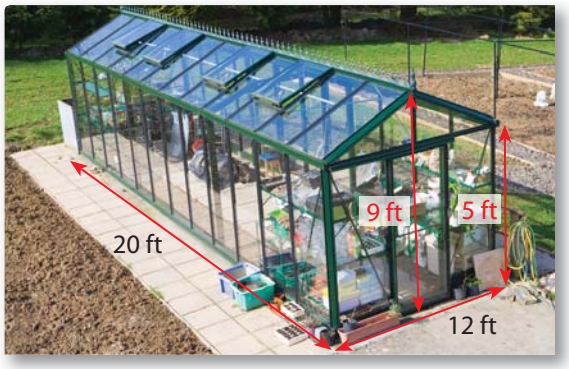



**b)** The sandbox is filled with sand to an average depth of 20 cm. Calculate the volume of the sand in the sandbox.

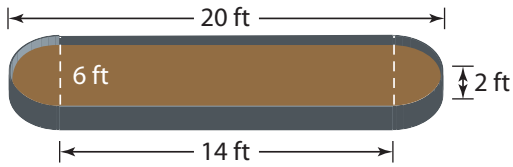
5. The dining area of a restaurant has a T shape. The owners need to replace the air-conditioning system. Calculate the volume of the air in the dining area. The ceiling is 12 feet high.




6. Calculate the volume of the greenhouse.




7. A planter is in the shape of a composite figure. It is made up of a rectangular prism and two half-cylinders.




a) What is the volume of the planter? Round your answer to the nearest cubic foot.

b) Brittney says that the planter is just a rectangular prism with rounded corners. Approximate the capacity of the planter by considering it to be a rectangular prism.

c) Calculate the difference between the answers in parts a) and b).

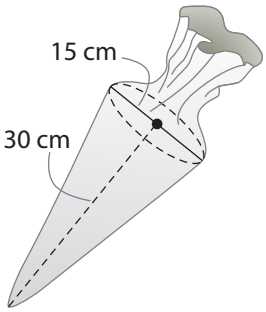
## Work With It

1. a) A snow cone cup has a diameter of 8 cm and a height of 11 cm. Calculate the capacity of the cup, to the nearest cubic centimetre.

   b) Is your answer in part a) a good estimate of the volume of the flavoured ice shown in the picture? Explain.

2. Some grain silos are in the shape of cylinders with conical tops. The inside diameter of a silo is 90 feet. The height inside the cylinder is 50 feet. The height inside the cone is 30 feet. Determine the capacity of the silo. Round your answer to the nearest cubic foot.

3. A cake-decorating bag has the shape of a cone. The diameter of the bag is 15 cm and the height is 30 cm. How much frosting will fit in the bag, to the nearest cubic centimetre?




## Discuss It

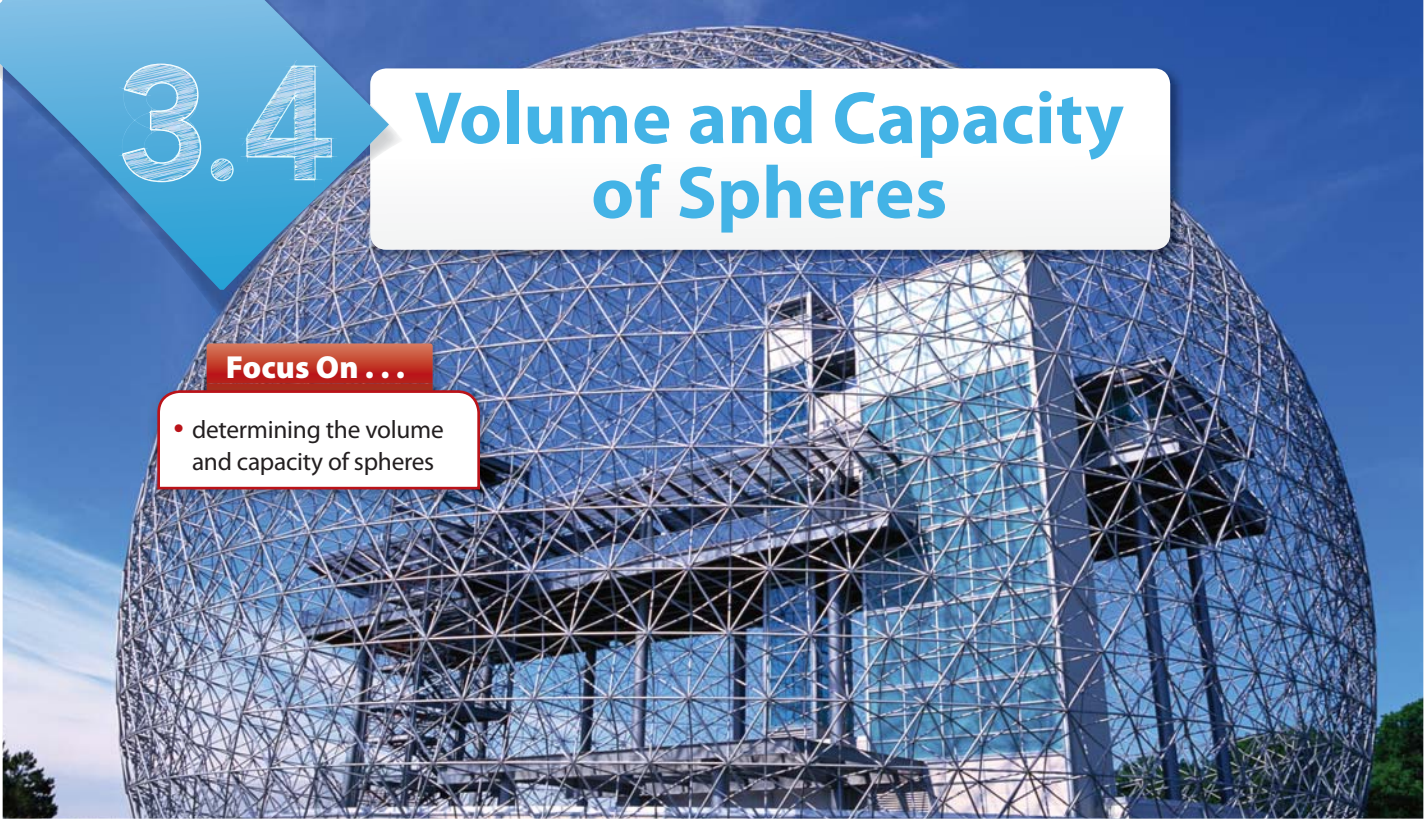
4. a) Explain why #3 refers to the inside diameter and inside height of the silo.

   b) What measurement would you calculate if you used the outside dimensions?

5. Brittney says that a planter is just a rectangular prism with rounded corners. So, you can approximate the capacity of the planter by considering it to be a rectangular prism. Do you agree with Brittney's strategy in for estimating the capacity of the planter? Explain why or why not.

6. Explain why doubling the height of a cone doubles the volume but doubling the diameter makes the volume four times as great.

# 3.4 Volume and Capacity of Spheres



**Focus On . . .**

- determining the volume and capacity of spheres

*The Biosphère is a museum in Montréal dedicated to the environment. The diameter of the sphere is about 76 metres.*

## Explore the Volume of a Sphere

**Materials**

- 500-mL measuring cup (or larger)
- water
- sphere (such as a golf ball)
- ruler

**Strategy**

**Guess and Check**

One way to measure the volume of an object is to measure how much water it displaces.

1. **a)** Fill a measuring cup with 250 mL of water.
   **b)** Completely submerge a sphere in the measuring cup.
   **c)** Read the volume of the water plus the ball. The difference is the volume of the sphere.

2. **Reflect** Millilitres are used to measure the volume of liquids. Estimate the volume of the sphere in an SI unit that is used for solids.

3. **Extend Your Understanding**
   **a)** Measure the diameter of the sphere in centimetres.
   **b)** Use $V = \frac{4}{3}\pi r^3$ to calculate the volume of the sphere, to the nearest tenth of a cubic centimetre
   **c)** Compare the answer in Step 3b) to your estimate in Step 2).

## On the Job 1

### Determine the Volume of a Sphere

A company supplies accessories for the game of pool. Pool balls today are generally made of plastic resins. The balls are numbered 1 through 15. Each has a diameter of 5.8 cm.

**a)** What is the volume of the material used to make one ball? Express your answer in cubic centimetres.

**b)** In a standard game of pool, you use 15 balls. What is the total volume of 15 balls, to the nearest hundredth of a cubic metre?

### Solution

**a)** The volume of a sphere can be determined using the formula

$V = \frac{4}{3}\pi r^3$, where $r$ is the radius of the sphere

$V = \frac{4}{3} \times \pi \times (2.9)^3$

$V = 102.160\ldots$

$5.8 \div 2 = 2.9$

C 4 A b/c 3 × π × ( 2.9 ^ 3 ) =

102.1604043

The volume of one pool ball is about 102 cubic centimetres.

**b)** $102 \times 15 = 1530$

The volume of 15 pool balls is about 1530 cubic centimetres.

$1530 \div 1\,000\,000 = 0.00153$

The volume of 15 pool balls is about 0.00153 cubic metres.

**F.Y.I.**

$1\ m^3 = 1\,000\,000\ cm^3$

**F.Y.I.**

An armillary sphere is a navigational device used in the early 14th and 15th centuries for travellers by sea. The sphere pictured here is located at Merton College, Oxford, England. An armillary sphere can also be found on Memorial University's campus in St John's, NL.

**F.Y.I.**

$1\ ft^3 = 1728\ in.^3$

## Your Turn

A sports equipment supplier sells softballs for pitching machines.

**a)** What is the volume of a softball that has a radius of 2 in.? Express your answer to the nearest cubic inch.

**b)** The softballs are sold in a case of 6 dozen. What is the total volume of the softballs in a case, to the nearest tenth of a cubic foot?

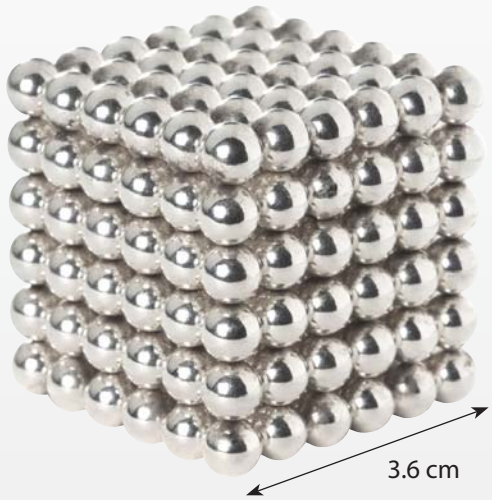
**Puzzler**

A puzzle is made up of magnetic balls.

**a)** What is the total volume of all of the balls in the cube shown?

**b)** The same number of balls are rearranged into a sphere. Does the total volume of the balls change? Explain.

**c)** Are the volume of the cube and the volume of the sphere the same if they are made of the same number of balls?

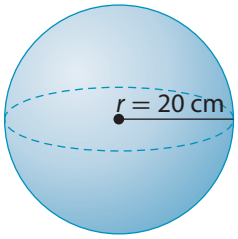


## Check Your Understanding

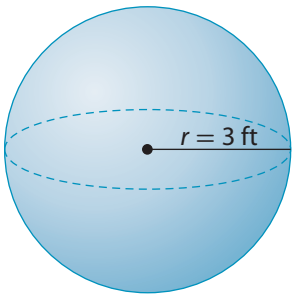
### Try It

**1.** To the nearest cubic unit, what is the volume of each sphere?

**a)**

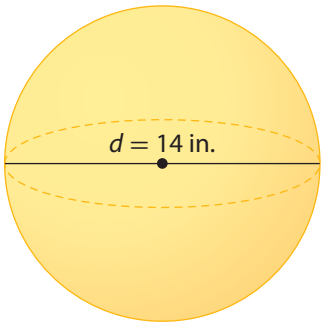



**b)**

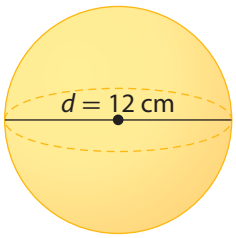



**2.** To the nearest cubic unit, what is the volume of each sphere?

**a)**




**b)**



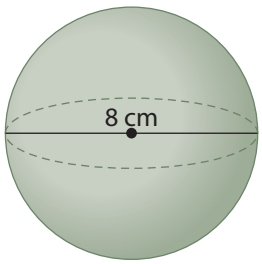

**3.** What is the volume in #1a) in cubic metres?

**4.** What is the volume in #2a) in cubic feet?

## Apply It

**5.** La Géode is a theatre in Paris, France, that is in the shape of a sphere. The sphere has a diameter of 36 metres and consists of 6433 steel triangles. What is the approximate volume of La Géode, to the nearest cubic metre?

**6.** Florists use a foam-like material for flower arranging. Foam balls come in a variety of sizes.




**a)** What is the volume of a foam ball with an 8-cm diameter?

**b)** Predict the volume of a foam ball with a 16-cm diameter. Explain your reasoning.

**c)** Calculate the volume of a ball with a 16-cm diameter. Compare your calculation with your estimate.

**d)** How many times greater is the volume of the larger ball than the volume of the smaller ball? Explain why.

**7.** The sphere shown is a unique type of accommodation in the trees that you can rent on a property on Vancouver Island, B.C. The outside diameter of each sphere is 3150 mm. The sphere is made of fibreglass and a wooden frame that have a total thickness of about 2.5 mm.

**a)** What is the inside diameter of the sphere?

**b)** What is the capacity of the sphere, to the nearest cubic centimetre?

## Work With It

1. Calculate the approximate capacity of a spherical fishbowl with an inside diameter of 9 inches.

2. The basketballs used by the National Basketball Association (NBA) have a circumference of 75 cm.
   a) Determine the radius of an NBA basketball. Round your answer to the nearest tenth of a centimetre. **Hint:** The formula for the circumference of a circle is $C = \pi d$ or $C = 2\pi r$.
   b) Calculate the volume of a basketball. Round your answer to the nearest tenth of a cubic centimetre.
   c) A basketball is generally made of leather that is 1.5 mm thick. Determine the interior diameter of a basketball, to the nearest tenth of a centimetre.
   d) Calculate the capacity of the inside of a basketball. Round your answer to the nearest tenth of a cubic centimetre.

3. A manufacturer makes steel balls that have a radius of 2.5 cm.
   a) Calculate the surface area of one ball, to the nearest tenth of a square centimetre.
   b) Calculate the volume of the ball, to the nearest tenth of a cubic centimetre.
   c) Another steel ball they make has half the radius. Estimate the surface area and volume of a ball with a radius of 1.25 cm.
   d) Calculate the surface area and volume of the smaller ball, to the nearest tenth of a unit.
   e) By how much did the surface area decrease? By how much did the volume decrease?
   f) Explain why the surface area and volume decreased by a different amount.

4. A scoop of ice cream has a diameter of 2.5 inches.
   a) What is the approximate volume of a three-scoop serving?
   b) Why can this calculation only be approximate?

## Discuss It

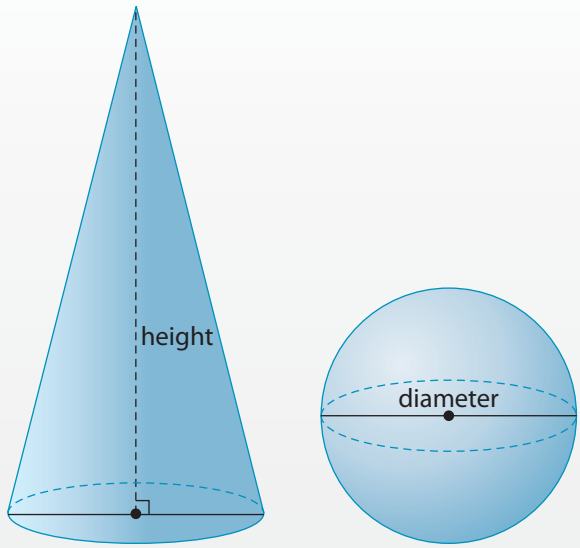
5. Explain why the capacity of the fishbowl in #1 must be less than your calculation.

6. Explain why doubling the radius of a sphere makes its volume 8 times as great.

7. Explain how to determine the radius of a sphere when you know the volume. Provide an example.

### Puzzler

A cone and a sphere have the same volume and the same radius. What is the ratio of the height of the cone to the diameter of the sphere?



# 3 Skill Check

## What You Need to Know

| Section | After this section, I know how to . . . |
|---|---|
| 3.1 | ■ estimate the volume of cylinders and of rectangular and triangular prisms<br>■ calculate the volume of cylinders and of rectangular and triangular prisms |
| 3.2 | ■ compare capacity and volume<br>■ convert between units of capacity<br>■ estimate capacity or volume using a reference |
| 3.3 | ■ use formulas to determine the volume or capacity of 3-D figures<br>■ use formulas to determine the volume or capacity of composite figures |
| 3.4 | ■ determine the volume and capacity of spheres |

*If you are unsure about any of these questions, review the appropriate section or sections of this chapter.*

### 3.1 Volume, pages 106–117


**1.** Determine the volume of a metal can with a diameter of 10 cm and a height of 14 cm. Round your answer to the nearest cubic centimetre.

**2.** Air-conditioning installers frequently need to calculate the volume of spaces. An indoor soccer facility has the dimensions 200 feet by 100 feet, and it is 22 feet high.

**a)** What is the volume of air in the facility, in cubic feet?

**b)** Express your answer to the nearest cubic yard.

### 3.2 Volume and Capacity, pages 118–127

**3.** Complete the following conversions.

**a)** 1 gallon = ■ quarts

**b)** 1 quart = ■ pints

**c)** 1 pint = ■ cups

**d)** 1 cup = ■ fluid ounces

**e)** 1 gallon = ■ fluid ounces

4. A recipe for lobster bisque on a U.S. web site includes 4 cups of cream.
   a) Convert 4 cups to fluid ounces.
   b) Convert 4 cups to an approximate equivalent in litres.

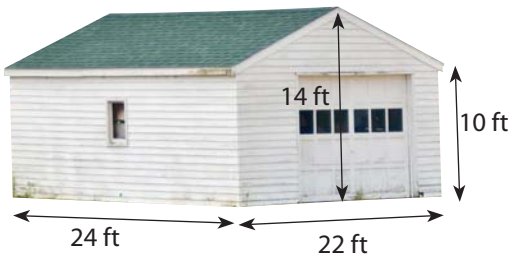
5. The bottle of cleaning fluid shown has a capacity of 2 L.
   a) Estimate the amount of cleaning fluid that remains in the bottle, in millilitres.
   b) Approximately how much cleaning fluid has been used, in litres?

## 3.3 Using Formulas for Volume and Capacity, pages 128–136

6. Vera made a candle in the shape of a square-based pyramid. The height of the candle is 5 in., and the base length is 4 inches. What is the volume of wax she used to make the candle?

7. A cone has a height of 22 cm and a radius of 15 cm. To the nearest cubic centimetre, calculate the volume of the cone.

8. What is the volume of the garage, to the nearest cubic foot?




## 3.4 Volume and Capacity of Spheres, pages 137–143

9. Each summer, David works as a tennis coach. He uses balls that have a diameter of 6.7 cm. What is the volume of one of these tennis balls, to the nearest cubic centimetre?

10. Keesha teaches fitness classes that include working out with an exercise ball. Exercise balls have an average diameter of 65 cm.
    a) What is the capacity of the ball?
    b) Do you think the volume of air in the ball is the same as your answer in part a)? Explain.

# 3 Test Yourself

*For #1 to #7, select the best answer.*

**1.** Which is *not* a three-dimensional figure?

**A** cone
**B** cylinder
**C** prism
**D** rhombus

**2.** Which item might have a capacity of 1 U.S. gallon?

**A** bathtub
**B** plastic gas can
**C** swimming pool
**D** teacup

**3.** Which imperial volume is equivalent to 1 pint?

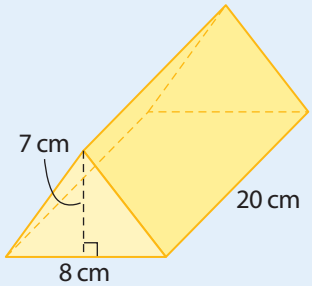
**A** 8 ounces
**B** 1 cup
**C** 2 cups
**D** $\frac{1}{4}$ quart

**4.** What is the approximate volume of this book?

**A** 80 $in^3$
**B** 65 $cm^3$
**C** 1 $ft^3$
**D** 0.1 $m^3$

**5.** What is the volume of the triangular prism?

**A** 1120 $cm^3$
**B** 560 $cm^3$
**C** 148 $cm^3$
**D** 35 $cm^3$




**6.** What is the capacity of the cooler?

**A** the same as its volume
**B** greater than its volume
**C** less than its volume
**D** it depends how full it is

**7.** What is a reasonable estimate for the volume of a sphere that has a radius of 10 inches?

**A** 40 cubic inches
**B** 400 cubic inches
**C** 4000 cubic inches
**D** 40 000 cubic inches

**8.** **a)** Determine the volume of the steel drum. Round your answer to the nearest cubic inch.

**b)** The capacity of a typical steel drum is 55 U.S. gallons. What is the capacity in quarts?


**9.** A recipe for a salad dressing calls for $\frac{1}{4}$ cup vinegar. Convert $\frac{1}{4}$ cup to ounces.

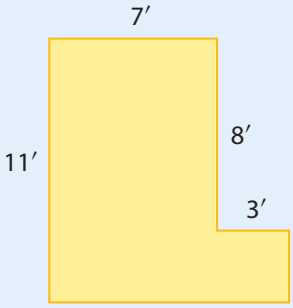
**10.** A children's sorting toy is in the shape of a cone. The height is 16 cm, and the diameter of the base is 15 cm. What volume of solid wood is needed to make the toy? Round your answer to the nearest tenth of a cubic centimetre.

**11.** Estimate the volume of sand needed to fill a cylindrical sandbox that has a diameter of about 3 m. The depth of the sand is about 20 cm. Round your answer to the nearest tenth of a cubic metre.

**12.** A washroom in a school is L-shaped. The ceiling is 10 ft high.

**a)** Determine the capacity of the room.

**b)** An exhaust fan draws air at a rate of 80 $ft^3$/min. To the nearest minute, how long does it take for the fan to exchange the air in the washroom?



# 3 Chapter Project

Project

## Build a 3-D Object

1. Design and build an object that is a composite 3-D figure.

   It could be something for inside, such as a candleholder or a water feature.

   It could be a container, such as a vase or an instrument case.

   It could be something for outside, such as a birdhouse or a fountain.

   Decide how big it will be and what it will be made of. It could be the actual size or it could be a scale model.

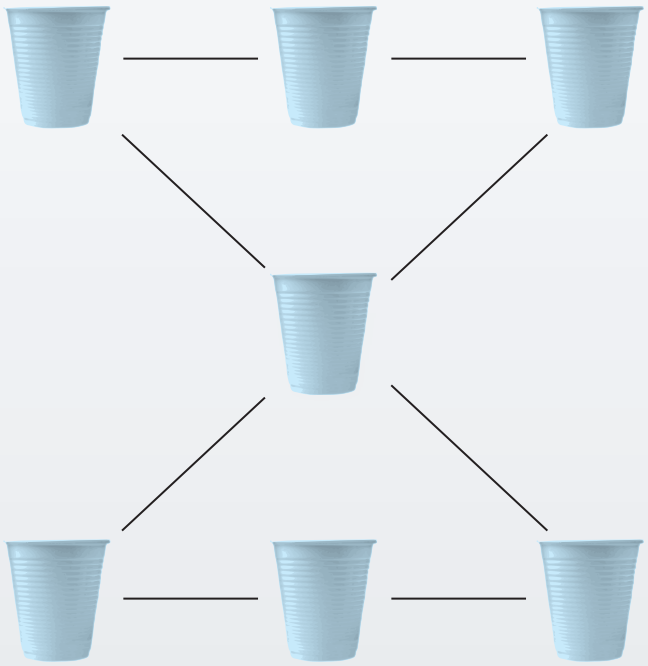
2. Calculate the surface area and volume of your 3-D object.

# 3 GAMES AND PUZZLES

## Fill Up the Cups

**Materials**
- Fill Up the Cups BLM

1. Each cup can hold a volume of 1 mL, 2 mL, 3 mL, 4 mL, 5 mL, 6 mL, or 7 mL. Place the cups in the pattern shown so that the sum of the three volumes along each straight path is 12 mL. Use each of the seven volumes only once.



2. Compare your solution to those of your classmates.
3. How do the solutions differ?
4. What one condition must exist to make all of the solutions possible?