

Unit C: Measurement Technology

Half Course IV

HALF COURSE IV

Unit C: Measurement Technology

Hours: 12

General Learning Outcome:

Determine linear measurements in metric and imperial systems using different measuring devices

The intent of this section is to give students experience with linear measure in both metric and imperial systems so that they can use appropriate measuring devices, units of measure, and measurement strategies.

Specific Outcomes

- C-1 Develop linear estimation skills for at least two systems of measurement.
- C-2 Use various measuring devices to obtain linear measurements in both SI and imperial systems.
- C-3 Perform basic conversions within both the SI and imperial systems.
- C-4 Use measurement strategies to solve problems.

MEASUREMENT TECHNOLOGY

Instructional Materials

- Measuring devices—rulers, metre sticks, tape measures, micrometers (SI), vernier calipers (SI)
- *Essentials of Mathematics 11*

Connections with Problem Analysis and Analysis of Games and Numbers

Any of the Problem Analysis or Analysis of Games and Numbers activities may be interspersed with problems from the Measurement Technology unit.

**PRESCRIBED LEARNING
OUTCOMES**

General Outcome

Determine linear measurements in metric and imperial systems using different measuring devices.

Specific Outcome(s)

C-1 develop linear estimation skills for at least two systems of measurement

SUGGESTIONS FOR INSTRUCTION

Take time to discuss the development of measurement systems. Students should realize that there are more systems than the SI and imperial. However, this unit will focus on these two.

Emphasis should be placed on the rationale of the SI system (multiples of 10 to match our number system) and its advantages over other systems.

It may be necessary to review the basic units of linear measure in both systems. Line measurements to emphasize include:

1. SI: mm, cm, m, km
2. Imperial: inches, feet, yards, miles

Linear estimation skills in both SI and imperial systems should be practised.

Example 1

Identify suitable units of linear measure in the SI and imperial systems.

Item	Metric-SI	Imperial
a) distance from Winnipeg to Thompson		
b) length of a pen		
c) thickness of a coin		
d) diameter of a car tire		
e) dimensions of a duotang		

- ✓ Communications
- ✓ Connections
- ✓ Number Sense
- ✓ Organization and Structure
- Patterns
- ✓ Problem Solving
- ✓ Reasoning
- Technology
- ✓ Visualization

(continued)

SUGGESTIONS FOR ASSESSMENT

**SUGGESTED LEARNING
RESOURCES**

Print

Baron, C., et al. *Essentials of Mathematics 11*. Victoria, BC: British Columbia Ministry of Education, 2002.

**PRESCRIBED LEARNING
OUTCOMES**

C-1 develop linear estimation skills for at least two systems of measurement
– *continued*

SUGGESTIONS FOR INSTRUCTION

Example 1 (continued)

Suggested Answers

Item	Metric-SI	Imperial
a) distance from Winnipeg to Thompson	km	miles
b) length of a pen	cm	inches
c) thickness of a coin	mm	fraction of inch
d) diameter of a car tire	cm	inches
e) dimensions of a duotang	cm	inches

Example 2

Complete the following table with an appropriate estimate.

Item	Metric-SI	Imperial
a) distance from Winnipeg to Brandon		
b) length of ice surface in an arena		
c) width of a floor tile		
d) diameter of a loonie		
e) diameter of a human hair		

Suggested Answers

Item	Metric-SI	Imperial
a) distance from Winnipeg to Brandon	200 km	120 miles
b) length of ice surface in an arena	60 m	200 feet
c) width of a floor tile	30 cm	1 foot
d) diameter of a loonie	2.5 cm	1 inch
e) diameter of a human hair	1 mm	1/16th of inch

- ✓ Communications
- ✓ Connections
- ✓ Number Sense
- ✓ Organization and Structure
- Patterns
- ✓ Problem Solving
- ✓ Reasoning
- Technology
- ✓ Visualization

SUGGESTIONS FOR ASSESSMENT**SUGGESTED LEARNING
RESOURCES****Journal Entry**

A journal entry would be appropriate for this activity. Possible topics could include:

1. the advantages of the SI system (over the imperial)
2. the history or development of a particular unit of measure

Sample Questions

1. Estimate the height of a door in both SI and imperial units.
2. Identify an object that measures approximately:
 - a) 15 inches
 - b) 6 cm
3. Give three examples of where you use the imperial system of measurement in your daily life.

Sample Answers

1. 2 m; 6.5 ft.
2. a) length of a long file folder
b) diameter of a soft-drink can
3. a) height (e.g., 5' 8" tall)
b) weight (e.g., 125 pounds)
c) baking (2½ cups of flour)

**PRESCRIBED LEARNING
OUTCOMES**

C-2 use various measuring devices to obtain linear measurements in both SI and imperial systems

SUGGESTIONS FOR INSTRUCTION

Using rulers and tape measures, students should measure various objects to the nearest millimetre and to the nearest 1/16th inch. For some objects, it may be appropriate to use either one of the systems (SI or imperial), or both.

Example 3

Estimate, in both SI and imperial units, the length and width of each of the following objects. Use a metre stick, ruler, tape measure, or any other suitable device, to determine the actual measure of each object (rounded to the nearest mm or 1/16th of an inch).

Item	SI Estimate	Imperial Estimate	Actual SI	Actual Imperial
a) desktop				
b) textbook				
c) classroom				
d) window				
e) door				

Using vernier calipers, students should measure the width, length, diameter, and depth of various smaller objects.

Example 4

Estimate the following dimensions and then use a vernier caliper to measure

- the internal and external diameters of a small jar or can
- the depth of a small jar or can

Estimate the following dimensions and then use a micrometer to measure

- the thickness of a coin
- the thickness of a plastic ruler
- the thickness of a piece of paper (it may be easier to determine the thickness of 10 pieces of paper and then estimate the thickness of one)

General principles for using the devices and an understanding of the many varieties of calipers and micrometers are to be emphasized over mastery of usage.

Note: Any problems where vernier calipers and micrometers are used deal with SI units only.

- ✓ Communications
- ✓ Connections
- ✓ Organization and Structure
- ✓ Patterns
- ✓ Problem Solving
- ✓ Reasoning
- ✓ Technology
- ✓ Visualization

SUGGESTIONS FOR ASSESSMENT

**SUGGESTED LEARNING
RESOURCES**

Internet

Micrometer and vernier
caliper applets

<[http://members.shaw.ca/
ron.blond/](http://members.shaw.ca/ron.blond/)>

Vernier caliper applet

<[http://webphysics.davidson.
edu/Applets/TaiwanUniv/
ruler/vernier.html](http://webphysics.davidson.edu/Applets/TaiwanUniv/ruler/vernier.html)>

**PRESCRIBED LEARNING
OUTCOMES**

C-3 perform basic conversions within both the SI and imperial systems

SUGGESTIONS FOR INSTRUCTION

Conversions between SI and imperial or vice versa are not required as part of *Senior 3 Consumer Mathematics*.

Example 5

Convert each of the following units of linear measure as indicated.

- | | |
|----------------------|----------------------|
| a) 3m = _____ cm | b) 53 cm = _____ mm |
| c) 25 mm = _____ cm | d) 450 cm = _____ m |
| e) 0.65 m = _____ mm | f) 7.4 mm = _____ cm |
| g) 3.5 km = _____ m | h) 560 m = _____ km |

Solutions

- | | |
|-----------|-------------|
| a) 300 cm | b) 530 mm |
| c) 2.5 cm | d) 4.50 m |
| e) 650 mm | f) 0.74 cm |
| g) 3500 m | h) 0.560 km |

Example 6

Convert each of the following units of linear measure as indicated.

- | | |
|-----------------------------------|--------------------------------------|
| a) 5 ft. = _____ in. | b) 3 yd. = _____ ft. |
| c) $2\frac{1}{2}$ ft. = _____ in. | d) 36 in. = _____ ft. |
| e) 18 in. = _____ ft. | f) 27 in. = _____ ft. +
_____ in. |
| g) 4 ft. 4 in. = _____ in. | h) 2 yd. 8 in. = _____ in. |

Solutions

- | | |
|------------|------------------|
| a) 60 in. | b) 9 ft. |
| c) 30 in. | d) 3 ft. |
| e) 1.5 ft. | f) 2 ft. + 3 in. |
| g) 52 in. | h) 80 in. |

- | | |
|-------------------------------------|------------------------|
| ✓ Communications | Patterns |
| Connections | Problem Solving |
| Number Sense | ✓ Reasoning |
| ✓ Organization and Structure | Technology |
| | ✓ Visualization |

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SUGGESTIONS FOR ASSESSMENT

**SUGGESTED LEARNING
RESOURCES**

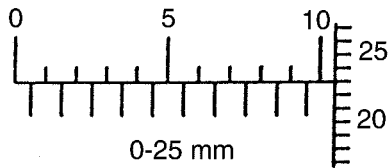
Journal Entries

1. Give a situation in which using a ruler would be preferable to using a vernier caliper and vice versa.
2. Give examples of situations in which the most appropriate device for measurement is:
 - a) a micrometer
 - b) vernier caliper
 - c) a ruler

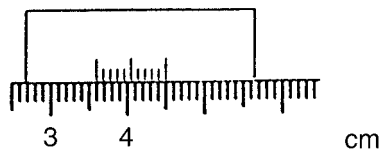
Justify your choice.

Sample Questions

1. State the following micrometer measurement. Be sure to include the units.



2. State the following vernier caliper measurement. Be sure to include the units.



Solutions

1. 10.23 mm
2. 3.6 cm or 36 mm

**PRESCRIBED LEARNING
OUTCOMES**

C-3 perform basic conversions within both the SI and imperial systems
– *continued*

SUGGESTIONS FOR INSTRUCTION

Example 7

Complete the following operations as indicated.

- a) $2.7 \text{ m} + 45 \text{ cm} =$
- b) $3.9 \text{ cm} + 71 \text{ mm} =$
- c) $2.1 \text{ km} + 520 \text{ m} =$
- d) $2.8 \text{ cm} - 15 \text{ mm} =$
- e) $3.5 \text{ m} - 185 \text{ cm} =$
- f) $1.45 \text{ km} - 650 \text{ m} =$

Solutions

- a) 3.15 m or 315 cm
- b) 11 cm or 110 mm
- c) 2.62 km or 2620 m
- d) 1.3 cm or 13 mm
- e) 1.65 m or 165 cm
- f) 0.8 km or 800 m

Example 8

Complete the following operations as indicated.

- a) $3 \text{ ft.} + 15 \text{ in.} =$
- b) $2 \text{ ft. } 8 \text{ in.} + 1 \text{ ft. } 3 \text{ in.} =$
- c) $3 \text{ ft. } 7 \text{ in.} + 8 \text{ ft. } 9 \text{ in.} =$
- d) $1 \text{ yd. } 2 \text{ ft.} + 5 \text{ ft.} =$
- e) $2 \text{ ft. } 9 \text{ in.} - 1 \text{ ft. } 7 \text{ in.} =$
- f) $4 \text{ ft. } 10 \text{ in.} + 2 \text{ ft. } 6 \text{ in.} - 18 \text{ in.} =$

Solutions

- a) 4 ft. + 3 in. or 51 inches
- b) 3 ft. + 11 in. or 47 inches
- c) 12 ft. + 4 in. or 148 inches
- d) 3 yd. + 1 ft. or 10 feet
- e) 1 ft. + 2 in. or 14 inches
- f) 5 ft. + 10 in. or 70 inches

- | | |
|-------------------------------------|------------------------|
| ✓ Communications | Patterns |
| Connections | Problem Solving |
| Number Sense | ✓ Reasoning |
| ✓ Organization and Structure | Technology |
| | ✓ Visualization |

SUGGESTIONS FOR ASSESSMENT**SUGGESTED LEARNING
RESOURCES****Mental Math**

Change the following units of linear measure as indicated:

- a) 3 m = _____ cm
- b) 2 ft. = _____ in.
- c) 2 miles = _____ feet
- d) 12.4 m = _____ mm
- e) 28 ft. = _____ yds.

Solutions

- a) 300 cm
- b) 24 in.
- c) 10560 feet
- d) 12,400 mm
- e) $9\frac{1}{3}$ yds.

**PRESCRIBED LEARNING
OUTCOMES**

C-4 use measurement strategies to solve problems

SUGGESTIONS FOR INSTRUCTION

Briefly discuss “accuracy” and “precision” with regard to measurement.

The accuracy of the measurement refers to how close the measured value is to the true or accepted value. For example, if you use a micrometer to find the thickness of an object with a known thickness of 11.25 mm, and you get a reading of 10.24 mm, your measurement is not very accurate. The accuracy of a measurement instrument can be determined with only one measurement.

Precision refers to how close together a group of measurements actually are. Precision has nothing to do with the true or accepted value of a measurement, so it is quite possible to be very precise and totally inaccurate. For example, an object has a known length of 5.75 cm. You measure the object five times using a vernier caliper and record the following lengths: 5.45 cm, 5.46 cm, 5.43 cm, 5.44 cm, and 5.45 cm. The caliper would be considered precise. In this case, however, the precision is high and accuracy is low. The fault often lies with the instrument. The precision of an instrument can only be determined with multiple measurements.

Students should strive for both accuracy and precision in the measurements that they make, whether they are using a ruler, a micrometer, or a vernier caliper.

Note: It may be necessary for the teacher to occasionally recalibrate the micrometers, as they tend to lose accuracy after repeated use.

We can never guarantee that two measures of the same item will be exactly the same. The variability of instruments and procedures will cause differences in the measures.

- To say that an item measures 3 cm is less precise than to say it measures 3.1 cm.
- To report that an item measures 5.3 cm does not guarantee that a person repeating the procedure, even with the same instrument, would also report 5.3 cm.
- Take as much care as possible when taking measurements and report results with as much precision as seems reasonable.

- | | |
|------------------------------|-------------------|
| ✓ Communications | Patterns |
| ✓ Connections | ✓ Problem Solving |
| Number Sense | ✓ Reasoning |
| ✓ Organization and Structure | Technology |
| | ✓ Visualization |

(continued)

SUGGESTIONS FOR ASSESSMENT

**SUGGESTED LEARNING
RESOURCES**

PRESCRIBED LEARNING OUTCOMES

C-4 use measurement strategies to solve problems
– *continued*

SUGGESTIONS FOR INSTRUCTION

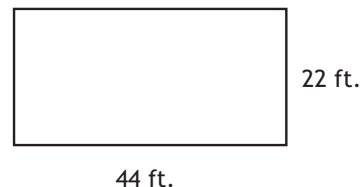
Example 1

A gable roof composed of two rectangles is to be covered with asphalt shingles. Each rectangle is 44 ft. by 22 ft. A bundle of shingles contains 27 shingles and will cover $33\frac{1}{3}$ sq.ft.

- a) Find the area of the roof.
- b) How many complete bundles of shingles are needed to cover the roof?

Solution

a) total square footage of roof
 = $2(44 \text{ ft.})(22 \text{ ft.})$
 = 1936 square feet



b) one bundle covers $33\frac{1}{3}$ square feet

total # bundles needed

= $1936 \div 33\frac{1}{3}$
 = 58.08

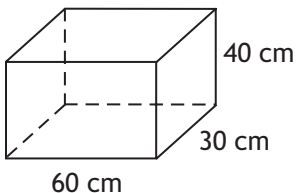
→ 59 bundles are needed

Example 2

The inside dimensions of an aquarium are: 60-cm long, 30-cm wide, and 40-cm deep.

- a) Find the volume of the aquarium in cubic centimetres.
- b) If 1 cubic centimetre equals 1 millilitre, find the volume of the tank in millilitres and litres.
- c) If 1 litre of water has a mass of 1 kilogram, what is the mass of the water in the filled aquarium?

Solution

a) 
volume = $(60 \text{ cm})(30 \text{ cm})(40 \text{ cm})$
 = $72\,000 \text{ cm}^3$

b) volume in mL = 72 000 mL
 volume in L = $72\,000 \div 1000 = 72 \text{ L}$

c) mass of water = 72 kg

(continued)

- ✓ Communications
- ✓ Connections
- ✓ Organization and Structure
- Patterns
- ✓ Problem Solving
- ✓ Reasoning
- Technology
- ✓ Visualization

SUGGESTIONS FOR ASSESSMENT

**SUGGESTED LEARNING
RESOURCES**

PRESCRIBED LEARNING OUTCOMES

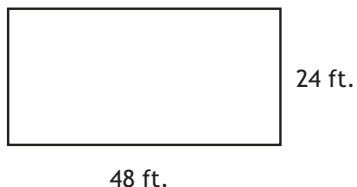
C-4 use measurement strategies to solve problems
– *continued*

SUGGESTIONS FOR INSTRUCTION

Example 3

A contractor intends to pour a concrete pad for a shed that measures 24 feet by 48 feet. If the floor is to be 6 inches thick, find the number of cubic yards of concrete that are required.

Solution



volume = $l \times w \times h$

24 ft. = 8 yds.

48 ft. = 16 yds.

6 in. = 0.5 ft. = $\frac{1}{6}$ yd.

so volume = $(8)(16)\left(\frac{1}{6}\right)$
= $21\frac{1}{3}$ cubic yards

OR

volume = $24 \times 48 \times 0.5$

= 576 ft^3

$1 \text{ yd}^3 = 27 \text{ ft}^3$

$\therefore \frac{576}{27} = 21\frac{1}{3} \text{ yd}^3$

Example 4

A room measures 12' 6" by 15' and has a ceiling height of 96".

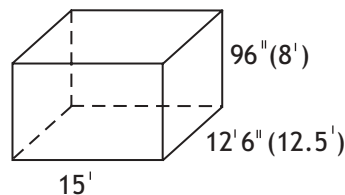
- a) Ignoring any openings such as doors or windows, find the total square footage of wall area to be painted.
- b) If the ceiling area is to be tiled, how many tiles measuring 12" by 12" will it take to tile the ceiling?

Solution

- a) total square footage of wall = ?

$12' 6" = 12.5'$

$96" = 8'$



two narrower walls = $2(12.5 \text{ ft.})(8) = 200$ square feet

two longer walls = $2(15 \text{ ft.})(8) = 240$ square feet

total = $200 + 240 = 440$ square feet

- b) area of ceiling = $15' \times 12.5' = 187.5 \text{ ft}^2$

minimum number of tiles = 188

- ✓ Communications
- ✓ Connections
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SUGGESTIONS FOR ASSESSMENT

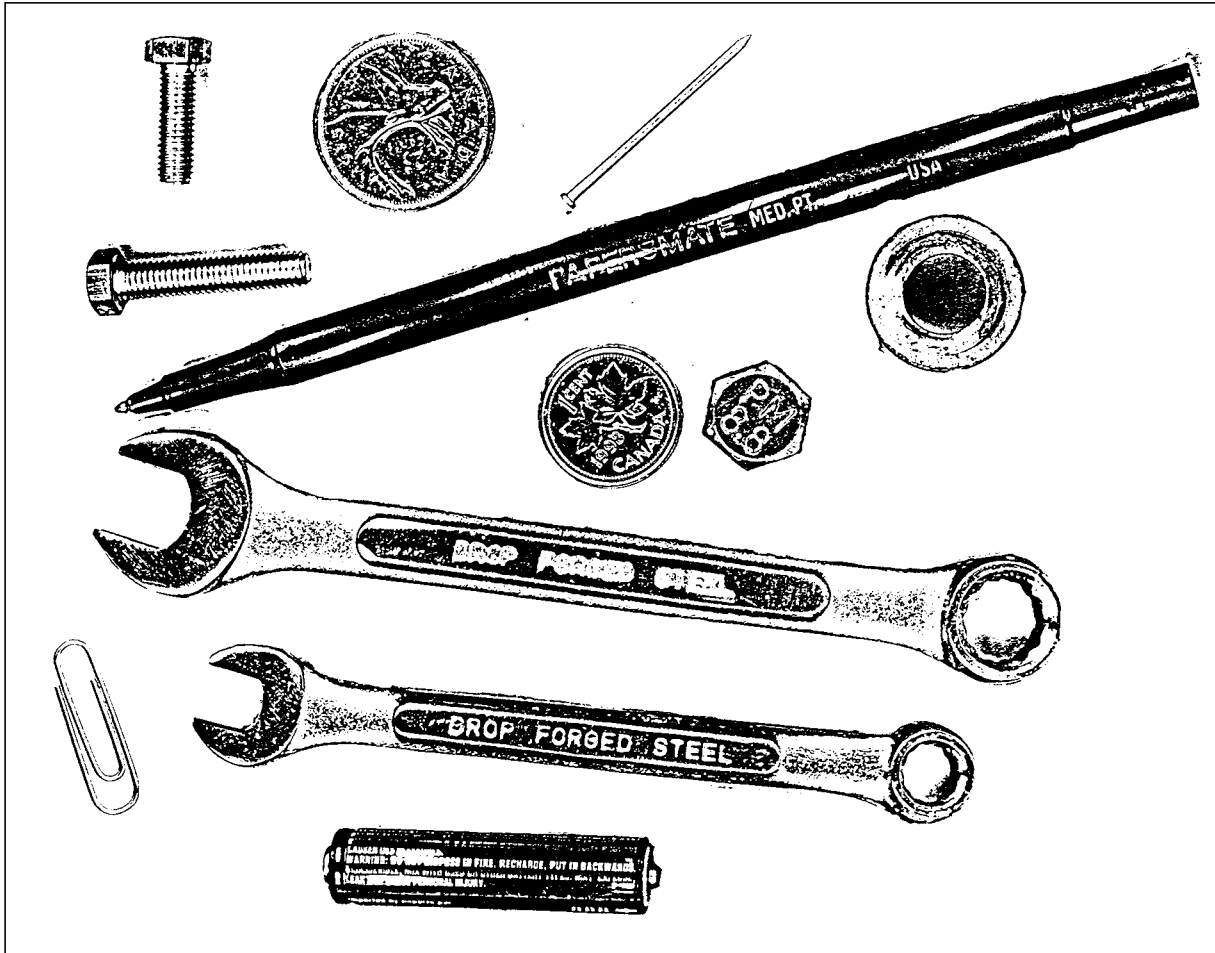
**SUGGESTED LEARNING
RESOURCES**

Appendix

Blackline Master 1

SI Measure

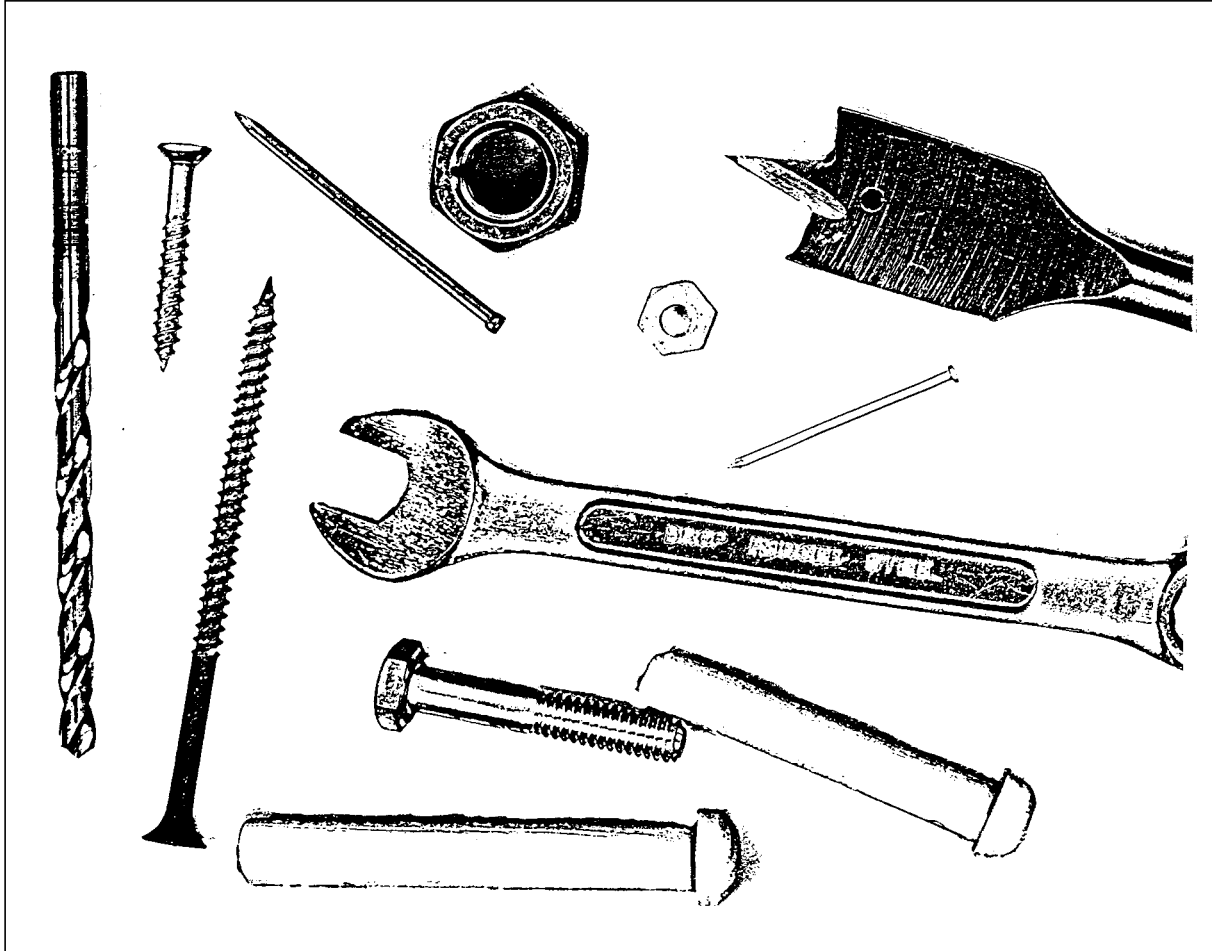
Measure each of the following items to the nearest millimetre.



- | | | | |
|--------------------------|-------|--|-------|
| a) size of large wrench | _____ | g) length of large bolt | _____ |
| b) size of small wrench | _____ | h) length of small bolt | _____ |
| c) length of AAA battery | _____ | i) length of nail | _____ |
| d) diameter of quarter | _____ | j) diameter of bolt head | _____ |
| e) diameter of penny | _____ | k) length of paper clip | _____ |
| f) length of pen | _____ | l) inside and outside diameter of washer | _____ |

Imperial Measure

Measure each of the following items to the nearest 1/16 of an inch.

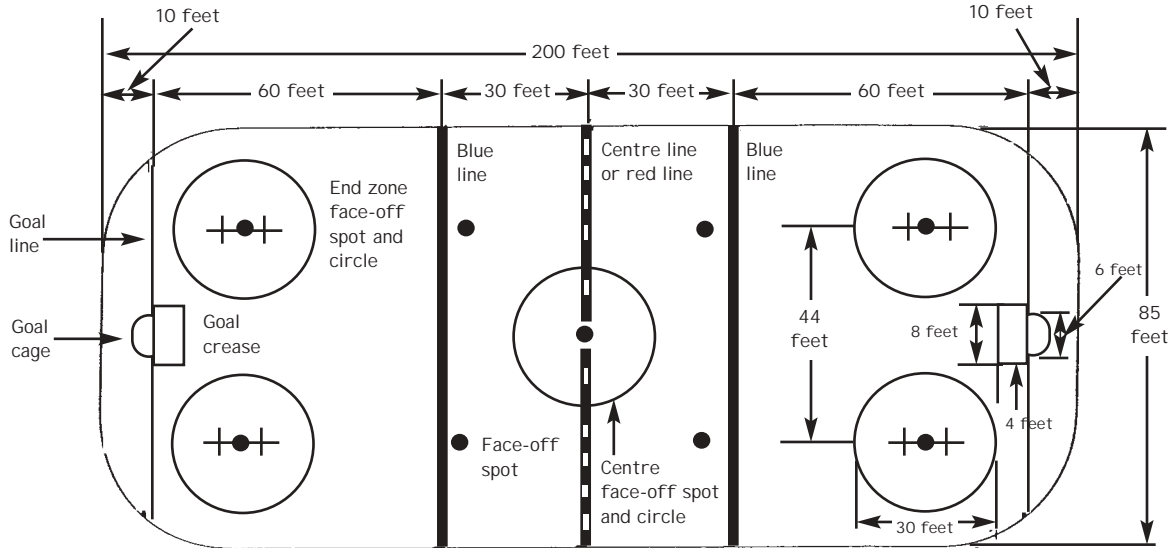


- | | | | |
|----------------------------------|-------|---|-------|
| a) diameter of small nut | _____ | g) length of small nail | _____ |
| b) diameter of large nut | _____ | h) length of large nail | _____ |
| c) length of gyproc screw (long) | _____ | i) length of large dowel (exclude head) | _____ |
| d) length of wood screw (short) | _____ | j) length of small dowel (exclude head) | _____ |
| e) diameter of steel drill bit | _____ | k) size of wrench | _____ |
| f) size of wood bit | _____ | l) length of bolt (exclude head) | _____ |

Blackline Master 3

The Rink

Use the diagram of the hockey arena to answer the following questions.

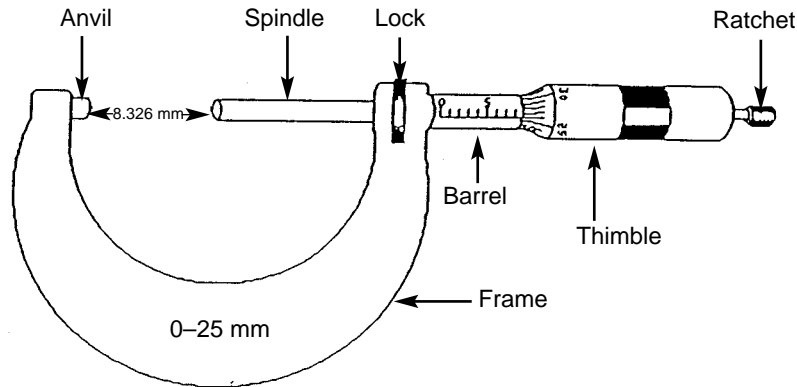


1. Tina wants to skate three miles as a part of her exercise program. If she skates laps of the ice surface going behind the goals each time, approximately how many laps must she skate to complete her workout (1 mile = 5280 feet)?
2. John wanted to approximate the distance he skated in a hockey game. In a typical two-minute shift someone counted that he skated from one end to the other nine different times. If he played 24 minutes during the game, approximate the minimum distance he skated in miles.
3. Is the diagram drawn accurately to scale? Complete a minimum of three measurement comparisons to show that the diagram is or is not drawn to scale.

Extension: Assume the diagram is drawn to scale. Use the length of 200 feet to calculate the scale factor of the drawing.

Precision Measurement: The Micrometer

A micrometer measures small lengths, such as the diameters of pipes, rods, wires, bolts, and washers. The following diagram depicts the key parts of a micrometer.



Note the following parts of the instrument:

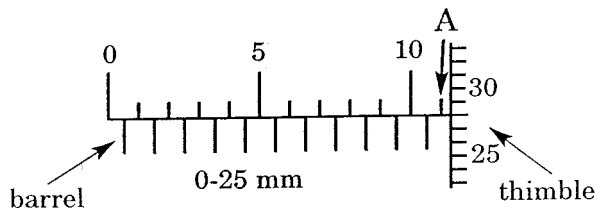
- a) where measuring occurs
 - jaws: anvil and spindle — to measure small lengths
- b) two measurement scales
 - a scale on the barrel (fixed scale)
 - a scale on the thimble (moving scale)

The micrometer will either measure in metric or imperial units. Questions focus solely on metric units.

In the micrometer examples used, one complete rotation of the thimble advances the thimble 0.5 mm on the fixed scale. Since the thimble is marked with 50 divisions, each division represents

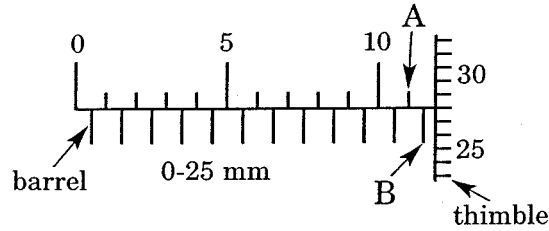
$$\left(\frac{1}{50}\right) \times (0.5 \text{ mm}) = 0.01 \text{ mm}.$$

Example 1



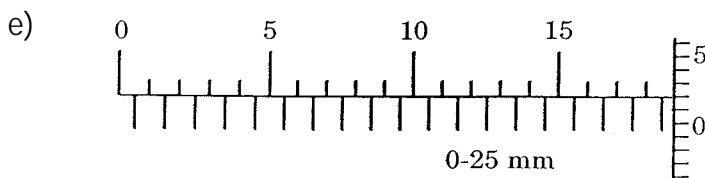
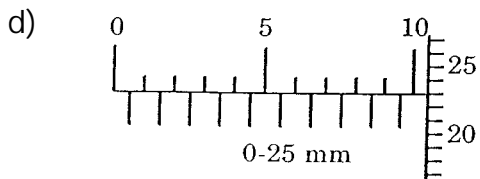
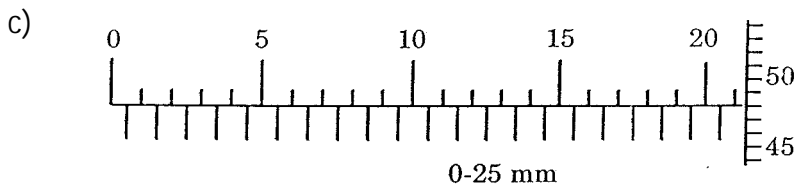
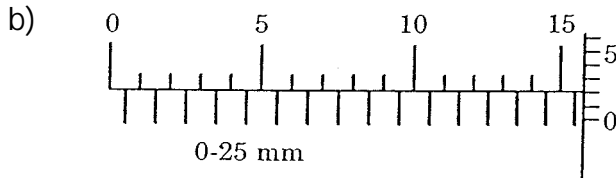
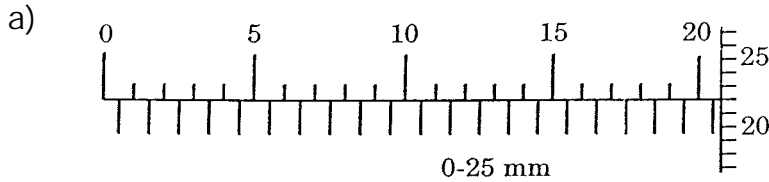
- The measure of the last marking on the barrel or fixed scale is 11 mm. (Arrow A)
- The thimble or moving scale reading is 0.28 mm.
- The sum gives the final measurement: 11 mm + 0.28 mm = 11.28 mm.

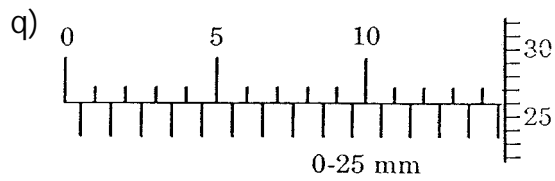
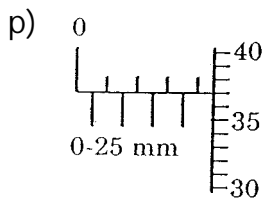
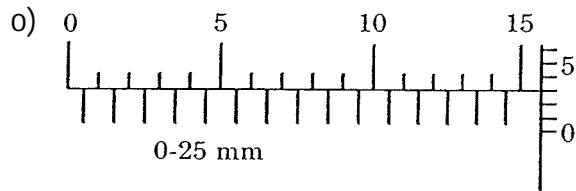
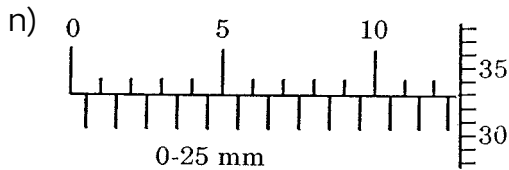
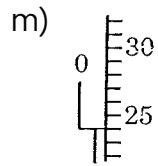
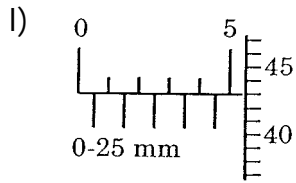
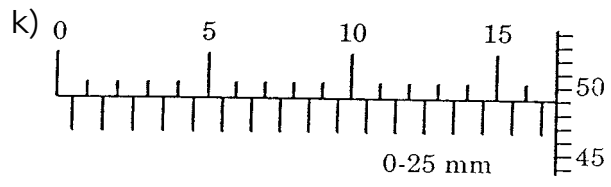
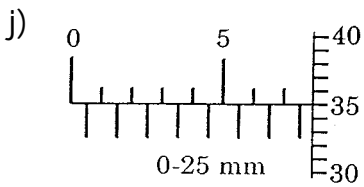
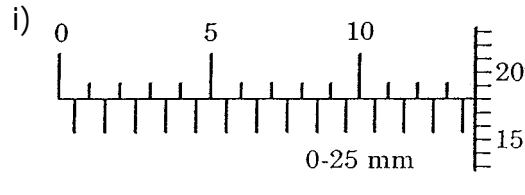
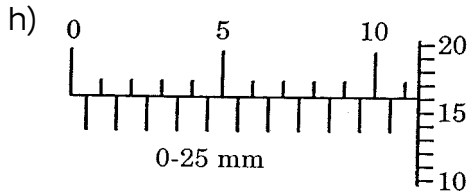
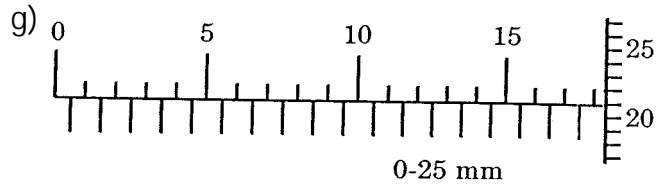
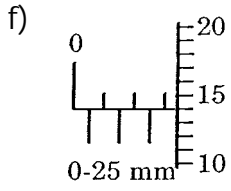
Example 2



- The fixed scale is 11.5 mm. (Arrow B indicates the last mark showing.)
- The moving scale yields 0.28 mm.
- The resulting measure is $11.5 \text{ mm} + 0.28 \text{ mm} = 11.78 \text{ mm}$.

1. Read the following micrometer measurements. Be sure to include the units.

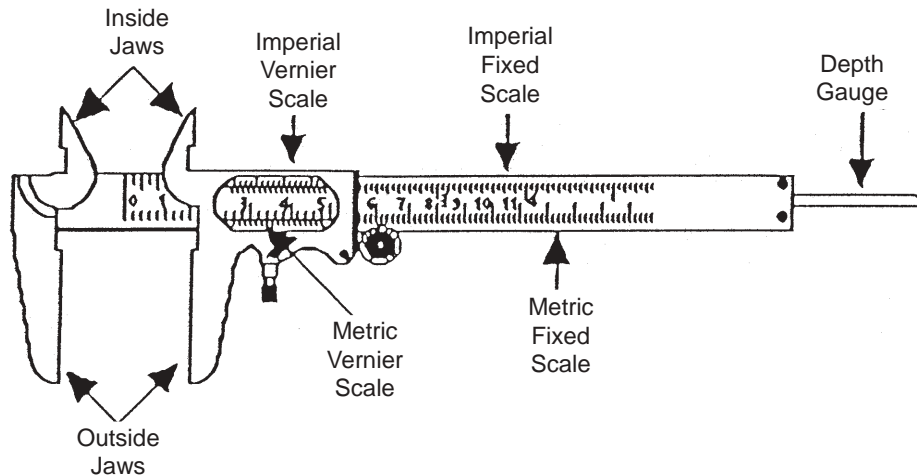




Blackline Master 5

Precision Measurement: The Vernier Caliper

The vernier caliper is another instrument used in precision measurement. While most calipers will measure in both metric and imperial units, this section will deal only with metric measurement.



This instrument has three devices for measuring:

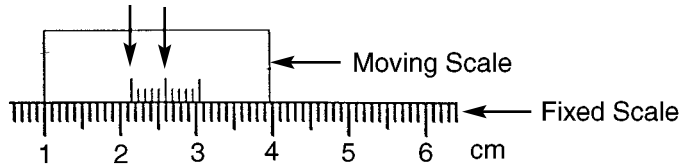
- **outside jaws** — to measure outer dimensions of objects such as the diameter of a shaft
- **inside jaws** — to measure with the jaws on the inside such as the inner diameter of a pipe
- **stem or depth gauge** — to measure the inside depth such as a small cylinder

The instrument also has:

- a fixed measuring scale
- a moving or sliding scale called a vernier

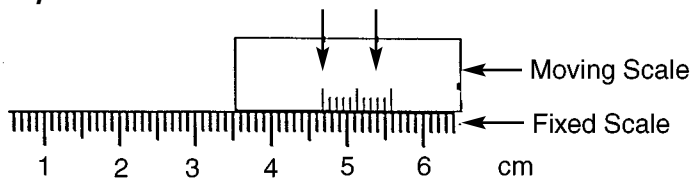
The Metric Scale: The fixed scale is divided into millimetres. Each millimetre can be further subdivided into smaller units (the same amount as indicated on the vernier). In the following examples, the vernier is broken into 10 units. Each represents $1/10$ of 1 mm or 0.1 mm. If the vernier has 20 units, the caliper is capable of measuring to $1/20$ of 1 mm or 0.05 mm (each division on the vernier represents 0.05 mm).

Example 1



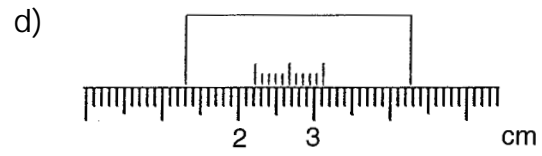
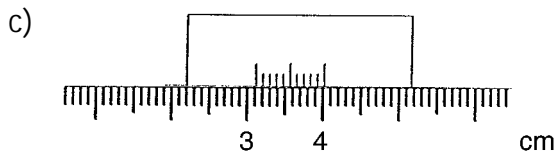
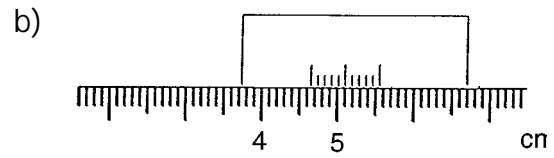
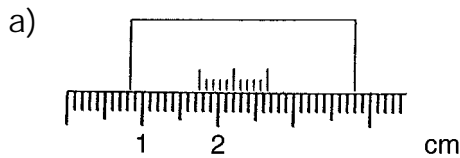
- from the fixed scale: 21 mm or 2.1 cm
- the **fifth line** on the vernier is best matched to the fixed scale. This represents 0.5 mm or 0.05 cm. The reading of the caliper is 21 mm + 0.5 mm = 21.5 mm or 2.1 cm + 0.05 cm = 2.15 cm.

Example 2

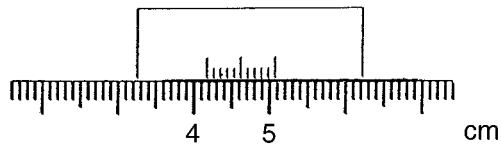


- from the fixed scale: 46 mm or 4.6 cm
- the eighth line on the vernier is best matched to the fixed scale. This represents 0.8 mm or 0.08 cm. The reading of the caliper is 46 mm + 0.8 mm = 46.8 mm or 4.6 cm + 0.08 cm = 4.68 cm.

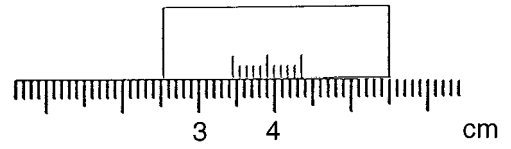
1. Read the following vernier caliper measurements. Be sure to include the units.



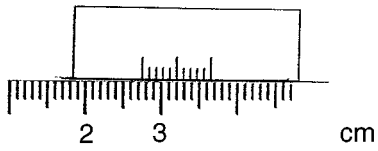
g)



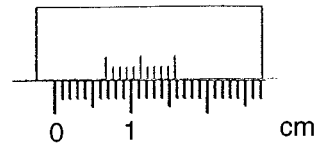
h)



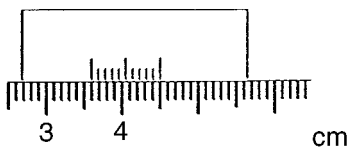
i)



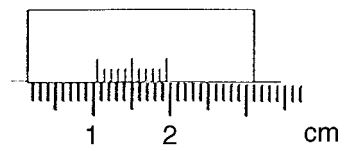
j)



k)



l)



Measuring with a Vernier Caliper

The following table can be used for measurement results using a vernier caliper with some items found in the classroom. Include some additional items.

2. a)

Item	Actual Measurement
thickness of a book	
inside diameter of a marker cap	
diameter of a pencil	
diameter of a quarter	
inside depth of a marker cap	

b) Compare your answers with those of another student. What are some possible reasons for variations in your answers?

Blackline Master 7

Measurement Activity—The Volume of Money

When considering volume, do 2.5 dimes equal 1 quarter?

Which is thicker, a quarter or a nickel?

- Using a vernier caliper or a micrometer, find the thickness and diameter of each of the listed coins so that you can complete the following table.

Coin	Thickness	Diameter	Volume
Penny			
Nickel			
Dime			
Quarter			
Toonie			

Each of the coins is a cylinder, with the thickness representing the height (assuming coins are of uniform thickness).

For a cylinder, the formula for volume is: $V = \left(\frac{d}{2}\right)^2 \pi h$ or $\frac{\pi d^2 h}{4}$ or $\pi r^2 h$

If you have access to a computer, this table can be completed as a spreadsheet assignment.

- After answering the two questions at the top of the page, write two more questions that could be answered from the information in your table.

Answer Key

Blackline Master 1: SI Measure

- | | | | |
|----------|-----------|----------|-----------------|
| a) 10 mm | d) 25 mm | g) 30 mm | h) 14 mm |
| b) 8 mm | e) 20 mm | h) 20 mm | k) 24 mm |
| c) 25 mm | f) 152 mm | i) 34 mm | l) 11 mm, 22 mm |

Blackline Master 2: Imperial Measure

- | | | | |
|---------|------------|-------------|-----------|
| a) 3/8" | d) 1 3/16" | g) 1 5/16" | j) 2" |
| b) 3/4" | e) 3 5/8" | h) 1 13/16" | k) 3/8" |
| c) 3" | f) 7/8" | i) 2 3/8" | l) 1 1/2" |

Note: The teacher may need to explain what is meant by "size" of a wood bit or "size" of a wrench.

Blackline Master 3: The Rink

- One possible answer: approx. 28 laps
- One possible answer: approx. 3.7 miles
- Answers vary.

Blackline Master 4: Precision Measurement: The Micrometer

- | | | | |
|-------------|-------------|-------------|-------------|
| a) 20.72 mm | f) 3.14 mm | j) 7.85 mm | n) 12.83 mm |
| b) 15.52 mm | g) 18.21 mm | k) 16.99 mm | o) 15.03 mm |
| c) 21.48 mm | h) 11.16 mm | l) 5.43 mm | p) 4.37 mm |
| d) 10.23 mm | i) 13.68 mm | m) 0.24 mm | q) 14.76 mm |
| e) 18.52 mm | | | |

Blackline Master 5: Precision Measurement: The Vernier Caliper

- | | | |
|------------|------------|------------|
| a) 17.5 mm | e) 9.7 mm | i) 27.5 mm |
| b) 46.5 mm | f) 13.6 mm | j) 6.7 mm |
| c) 31.2 mm | g) 41.7 mm | k) 36.0 mm |
| d) 22.2 mm | h) 34.5 mm | l) 10.5 mm |
- Answers will vary.
- Using an electronic digital caliper and $\pi = 3.14$:

Penny: 407.22 mm ³	Quarter: 694.83 mm ³
Nickel: 635.06 mm ³	Toonie: 993.46 mm ³
Dime: 301.32 mm ³	
- Answers will vary.