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metrics for architectural, civil, mechanical drafting

THE CENTER FOR VOCATIONAL EDUCATION

TEACHING AND LEARNING THE METRIC SYSTEM

This metric instructional package was designed to meet job-related metric measurement needs of students. To use this package students should already know the occupational terminology, measurement terms, and tools currently in use. These materials were prepared with the help of experienced vocational teachers, reviewed by experts, tested in classrooms in different parts of the United States, and revised before distribution.

Each of the five units of instruction contains performance objectives, learning activities, and supporting information in the form of text, exercises, and tables. In addition, suggested teaching techniques are included. At the back of this package are objective-based evaluation items, a page of answers to the exercises and tests, a list of metric materials needed for the activities, references, and a list of suppliers.

Classroom experiences with this instructional package suggest the following teaching-learning strategies:

1. Let the first experiences be informal to make learning the metric system fun.
2. Students learn better when metric units are compared to familiar objects. Everyone should learn to "think metric." Comparing metric units to customary units can be confusing.
3. Students will learn quickly to estimate and measure in metric units by "doing."
4. Students should have experience with measuring activities before getting too much information.
5. Move through the units in an order which emphasizes the simplicity of the metric system (e.g., length to area to volume).
6. Teach one concept at a time to avoid overwhelming students with too much material.

Unit 1 is a general introduction to the metric system of measurement which provides informal, hands-on experiences for the students. This unit enables students to become familiar with the basic metric units, their symbols, and measurement instruments; and to develop a set of mental references for metric values. The metric system of notation also is explained.

Unit 2 provides the metric terms which are used in this occupation and gives experience with occupational measurement tasks.

Unit 3 focuses on job-related metric equivalents and their relationships.

Unit 4 provides experience with recognizing and using metric instruments and tools in occupational measurement tasks. It also provides experience in comparing metric and customary measurement instruments.

Unit 5 is designed to give students practice in converting customary and metric measurements. Students should learn to "think metric" and avoid comparing customary and metric units. However, skill with conversion tables will be useful during the transition to metric in each occupation.

Using These Instructional Materials

This package was designed to help students learn a core of knowledge about the metric system which they will use on the job. The exercises facilitate experiences with measurement instruments, tools, and devices used in this occupation and job-related tasks of estimating and measuring.

This instructional package also was designed to accommodate a variety of individual teaching and learning styles. Teachers are encouraged to adapt these materials to their own classes. For example, the information sheets may be given to students for self-study. References may be used as supplemental resources. Exercises may be used in independent study, small groups, or whole-class activities. All of the materials can be expanded by the teacher.

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Editors

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UNIT 1

SUGGESTED TEACHING SEQUENCE

1. These introductory exercises may require two or three teaching periods for all five areas of measurement.
2. Exercises should be followed in the order given to best show the relationship between length, area, and volume.
3. Assemble the metric measuring devices (rules, tapes, scales, thermometers, and measuring containers) and objects to be measured.*
4. Set up the equipment at work stations for use by the whole class or as individualized resource activities.
5. Have the students estimate, measure, and record using Exercises 1 through 5.
6. Present information on notation and make Table 1 available.
7. Follow up with group discussion of activities.

*Other school departments may have devices which can be used. Metric suppliers are listed in the reference section.

THE CENTER FOR VOCATIONAL EDUCATION

OBJECTIVES

The student will demonstrate these skills for the Linear, Area, Volume or Capacity, Mass, and Temperature Exercises, using the metric terms and measurement devices listed here.

SKILLS	EXERCISES				
	Linear (pp. 3 - 4)	Area (pp. 5 - 6)	Volume or Capacity (pp. 7 - 8)	Mass (pp. 9 - 10)	Temperature (p. 11)
1. Recognize and use the unit and its symbol for: 2. Select, use, and read the appropriate measuring instruments for: 3. State or show a physical reference for:	millimetre (mm) centimetre (cm) metre (m)	square centimetre (cm^2) square metre (m^2)	cubic centimetre (cm^3) cubic metre (m^3) litre (l) millilitre (ml)	gram (g) kilogram (kg)	degree Celsius (°C)
4. Estimate within 25% of the actual measure	height, width, or length of objects	the area of a given surface	capacity of containers	the mass of objects in grams and kilograms	the temperature of the air or a liquid
5. Read correctly	metre stick, metric tape measure, and metric rulers		measurements on graduated volume measuring devices	a kilogram scale and a gram scale	A Celsius thermometer

RULES OF NOTATION

1. Symbols are not capitalized unless the unit is a proper name (mm *not* MM).
2. Symbols are not followed by periods (m *not* m.).
3. Symbols are not followed by an *s* for plurals (25 g *not* 25 gs).
4. A space separates the numerals from the unit symbols (4 l *not* 4l).
5. Spaces, not commas, are used to separate large numbers into groups of three digits (45 271 km *not* 45,271 km).
6. A zero precedes the decimal point if the number is less than one (0.52 g *not* .52 g).
7. Litre and metre can be spelled either with an -re or -er ending.

METRIC UNITS, SYMBOLS, AND REFERENTS

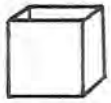
Quantity	Metric Unit	Symbol	Useful Referents
Length	millimetre	mm	Thickness of dime or paper clip wire
	centimetre	cm	Width of paper clip
	metre	m	Height of door about 2 m
	kilometre	km	12-minute walking distance
Area	square centimetre	cm^2	Area of this space 
	square metre	m^2	Area of card table top
	hectare	ha	Football field including sidelines and end zones
Volume and Capacity	millilitre	ml	Teaspoon is 5 ml
	litre	l	A little more than 1 quart
	cubic centimetre	cm^3	Volume of this container 
	cubic metre	m^3	A little more than a cubic yard
Mass	milligram	mg	Apple seed about 10 mg, grain of salt, 1 mg
	gram	g	Nickel about 5 g
	kilogram	kg	Webster's Collegiate Dictionary
	metric ton (1 000 kilograms)	t	Volkswagen Beetle

Table 1–a

METRIC PREFIXES

Multiples and Submultiples	Prefixes	Symbols
$1\,000\,000 = 10^6$	mega (mĕg′ȧ)	M
$1\,000 = 10^3$	kilo (kĭl′ō)	k
$100 = 10^2$	hecto (hĕk′tō)	h
$10 = 10^1$	deka (dĕk′ȧ)	da
Base Unit $1 = 10^0$		
$0.1 = 10^{-1}$	deci (dĕs′ĭ)	d
$0.01 = 10^{-2}$	centi (sĕn′tĭ)	c
$0.001 = 10^{-3}$	milli (mĭl′ĭ)	m
$0.000\,001 = 10^{-6}$	micro (mī′krō)	μ

Table 1–b

LINEAR MEASUREMENT ACTIVITIES

Metre, Centimetre, Millimetre

I. THE METRE (m)

A. DEVELOP A FEELING FOR THE SIZE OF A METRE

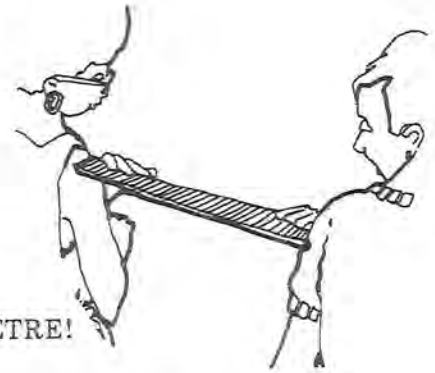
1. Pick up one of the metre sticks and stand it up on the floor. Hold it in place with one hand. Walk around the stick. Now stand next to the stick. With your other hand, touch yourself where the top of the metre stick comes on you.

THAT IS HOW HIGH A METRE IS!

2. Hold one arm out straight at shoulder height. Put the metre stick along this arm until the end hits the end of your fingers. Where is the other end of the metre stick? Touch yourself at that end.

THAT IS HOW LONG A METRE IS!

3. Choose a partner to stand at your side. Move apart so that you can put one end of a metre stick on your partner's shoulder and the other end on your shoulder. Look at the space between you.



THAT IS THE WIDTH OF A METRE!

B. DEVELOP YOUR ABILITY TO ESTIMATE IN METRES

Now you will improve your ability to estimate in metres. Remember where the length and height of a metre was on your body.

For each of the following items:

Estimate the size of the items and write your estimate in the ESTIMATE column. Measure the size with your metre stick and write the answer in the MEASUREMENT column.

Decide how close your estimate was to the actual measure. If your estimate was within 25% of the actual measure you are a "Metric Marvel."

		Estimate (m)	Measurement (m)	How Close Were You?
1.	Height of door knob from floor.	_____	_____	_____
2.	Height of door.	_____	_____	_____
3.	Length of table.	_____	_____	_____
4.	Width of table.	_____	_____	_____
5.	Length of wall of this room.	_____	_____	_____
6.	Distance from you to wall.	_____	_____	_____

Exercise 1

(continued on next page)

II. THE CENTIMETRE (cm)

There are 100 centimetres in one metre. If there are 4 metres and 3 centimetres, you write 403 cm [(4 x 100 cm) + 3 cm = 400 cm + 3 cm].

A. DEVELOP A FEELING FOR THE SIZE OF A CENTIMETRE

1. Hold the metric ruler against the width of your thumbnail. How wide is it? _____ cm
2. Measure your thumb from the first joint to the end. _____ cm
3. Use the metric ruler to find the width of your palm. _____ cm
4. Measure your index or pointing finger. How long is it? _____ cm
5. Measure your wrist with a tape measure. What is the distance around it? _____ cm
6. Use the tape measure to find your waist size. _____ cm

B. DEVELOP YOUR ABILITY TO ESTIMATE IN CENTIMETRES

You are now ready to estimate in centimetres. For each of the following items, follow the procedures used for estimating in metres.

	Estimate (cm)	Measurement (cm)	How Close Were You?
1. Length of a paper clip.	_____	_____	_____
2. Diameter (width) of a coin.	_____	_____	_____
3. Width of a postage stamp.	_____	_____	_____
4. Length of a pencil.	_____	_____	_____
5. Width of a sheet of paper.	_____	_____	_____

III. THE MILLIMETRE (mm)

There are 10 millimetres in one centimetre. When a measurement is 2 centimetres and 5 millimetres, you write 25 mm [(2 x 10 mm) + 5 mm = 20 mm + 5 mm]. There are 1 000 mm in 1 m.

A. DEVELOP A FEELING FOR THE SIZE OF A MILLIMETRE

Using a ruler marked in millimetres, measure:

1. Thickness of a paper clip wire. _____ mm
2. Thickness of your fingernail. _____ mm
3. Width of your fingernail. _____ mm
4. Diameter (width)of a coin. _____ mm
5. Diameter (thickness) of your pencil. _____ mm
6. Width of a postage stamp. _____ mm

B. DEVELOP YOUR ABILITY TO ESTIMATE IN MILLIMETRES

You are now ready to estimate in millimetres. For each of the following items, follow the procedures used for estimating in metres.

	Estimate (mm)	Measurement (mm)	How Close Were You?
1. Thickness of a nickel.	_____	_____	_____
2. Diameter (thickness) of a bolt.	_____	_____	_____
3. Length of a bolt.	_____	_____	_____
4. Width of a sheet of paper.	_____	_____	_____
5. Thickness of a board or desk top.	_____	_____	_____
6. Thickness of a button.	_____	_____	_____

AREA MEASUREMENT ACTIVITIES

Square Centimetre, Square Metre

WHEN YOU DESCRIBE THE AREA OF SOMETHING, YOU ARE SAYING HOW MANY SQUARES OF A GIVEN SIZE IT TAKES TO COVER THE SURFACE.

I. THE SQUARE CENTIMETRE (cm^2)

A. DEVELOP A FEELING FOR A SQUARE CENTIMETRE

1. Take a clear plastic grid, or use the grid on page 6.
2. Measure the length and width of one of these small squares with a centimetre ruler.

   THAT IS ONE SQUARE CENTIMETRE!

3. Place your fingernail over the grid. About how many squares does it take to cover your fingernail?
   _____cm^2
4. Place a coin over the grid. About how many squares does it take to cover the coin? _____cm^2
5. Place a postage stamp over the grid. About how many squares does it take to cover the postage stamp?
   _____cm^2
6. Place an envelope over the grid. About how many squares does it take to cover the envelope?
   _____cm^2
7. Measure the length and width of the envelope in centimetres. Length _____ cm; width _____ cm. Multiply to find the area in square centimetres. _____ cm x _____ cm = _____ cm^2. How close are the answers you have in 6. and in 7.?

B. DEVELOP YOUR ABILITY TO ESTIMATE IN SQUARE CENTIMETRES

You are now ready to develop your ability to estimate in square centimetres.

Remember the size of a square centimetre. For each of the following items, follow the procedures used for estimating in metres.

		Estimate (cm^2)	Measurement (cm^2)	How Close Were You?
1.	Index card.	_____	_____	_____
2.	Book cover.	_____	_____	_____
3.	Photograph.	_____	_____	_____
4.	Window pane or desk top.	_____	_____	_____

II. THE SQUARE METRE (m^2)

A. DEVELOP A FEELING FOR A SQUARE METRE

1. Tape four metre sticks together to make a square which is one metre long and one metre wide.
2. Hold the square up with one side on the floor to see how big it is.
3. Place the square on the floor in a corner. Step back and look. See how much floor space it covers.
4. Place the square over a table top or desk to see how much space it covers.
5. Place the square against the bottom of a door. See how much of the door it covers. How many squares would it take to cover the door? _____m^2

   THIS IS HOW BIG A SQUARE METRE IS!

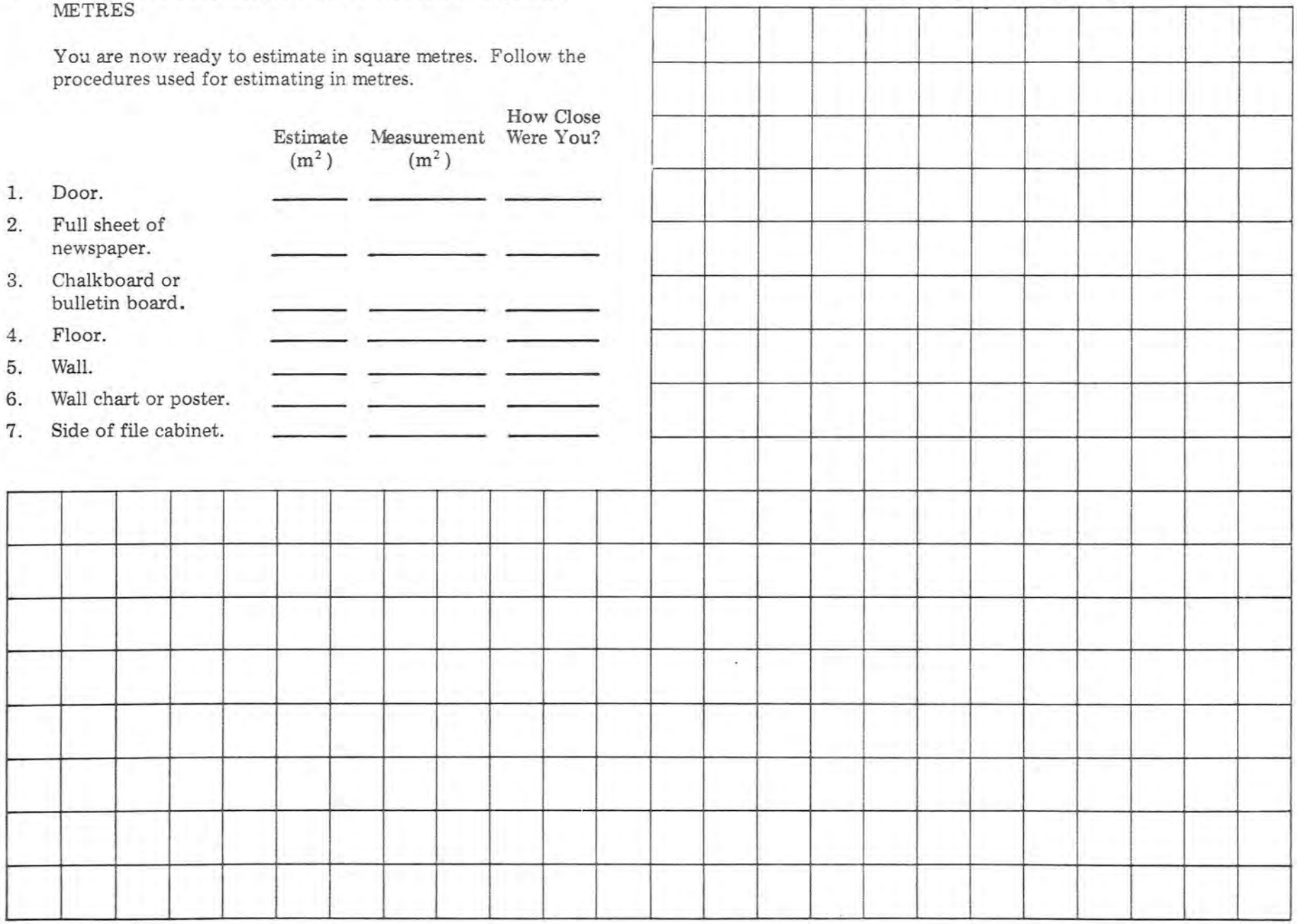
(continued on next page)

B. DEVELOP YOUR ABILITY TO ESTIMATE IN SQUARE METRES

You are now ready to estimate in square metres. Follow the procedures used for estimating in metres.

		Estimate (m^2)	Measurement (m^2)	How Close Were You?
1.	Door.	_____	_____	_____
2.	Full sheet of newspaper.	_____	_____	_____
3.	Chalkboard or bulletin board.	_____	_____	_____
4.	Floor.	_____	_____	_____
5.	Wall.	_____	_____	_____
6.	Wall chart or poster.	_____	_____	_____
7.	Side of file cabinet.	_____	_____	_____

CENTIMETRE GRID



VOLUME MEASUREMENT ACTIVITIES

Cubic Centimetre, Litre, Millilitre, Cubic Metre

I. THE CUBIC CENTIMETRE (cm^3)

A. DEVELOP A FEELING FOR THE CUBIC CENTIMETRE

1. Pick up a colored plastic cube. Measure its length, height, and width in centimetres.

   THAT IS ONE CUBIC CENTIMETRE!

2. Find the volume of a plastic litre box.

   a. Place a ROW of cubes against the bottom of one side of the box. How many cubes fit in the row?_____

   b. Place another ROW of cubes against an adjoining side of the box. How many rows fit inside the box to make one layer of cubes?_____

   How many cubes in each row?_____

   How many cubes in the layer in the bottom of the box?_____

   c. Stand a ROW of cubes up against the side of the box. How many LAYERS would fit in the box?_____

   How many cubes in each layer?_____

   How many cubes fit in the box altogether?_____

   THE VOLUME OF THE BOX IS _____CUBIC CENTIMETRES.

   d. Measure the length, width, and height of the box in centimetres. Length _____cm; width _____cm; height _____cm. Multiply these numbers to find the volume in cubic centimetres.

   _____cm x _____cm x _____cm = _____cm^3.
   Are the answers the same in c. and d.?

B. DEVELOP YOUR ABILITY TO ESTIMATE IN CUBIC CENTIMETRES

You are now ready to develop your ability to estimate in cubic centimetres.

Remember the size of a cubic centimetre. For each of the following items, use the procedures for estimating in metres.

		Estimate (cm^3)	Measurement (cm^3)	How Close Were You?
1.	Index card file box.	_____	_____	_____
2.	Freezer container.	_____	_____	_____
3.	Paper clip box.	_____	_____	_____
4.	Box of staples.	_____	_____	_____

II. THE LITRE (l)

A. DEVELOP A FEELING FOR A LITRE

1. Take a one litre beaker and fill it with water.
2. Pour the water into paper cups, filling each as full as you usually do. How many cups do you fill?

   THAT IS HOW MUCH IS IN ONE LITRE!
3. Fill the litre container with rice.

   THAT IS HOW MUCH IT TAKES TO FILL A ONE LITRE CONTAINER!

(continued on next page)

B. DEVELOP YOUR ABILITY TO ESTIMATE IN LITRES

You are now ready to develop your ability to estimate in litres. To write two and one-half litres, you write 2.5 l, or 2.5 litres. To write one-half litre, you write 0.5 l, or 0.5 litre. To write two and three-fourths litres, you write 2.75 l, or 2.75 litres.

For each of the following items, use the procedures for estimating in metres.

		Estimate (l)	Measurement (l)	How Close Were You?
1.	Medium-size freezer container.	_____	_____	_____
2.	Large freezer container.	_____	_____	_____
3.	Small freezer container.	_____	_____	_____
4.	Bottle or jug.	_____	_____	_____

III. THE MILLILITRE (ml)

There are 1 000 millilitres in one litre. 1 000 ml = 1 litre. Half a litre is 500 millilitres, or 0.5 litre = 500 ml.

A. DEVELOP A FEELING FOR A MILLILITRE

1. Examine a centimetre cube. Anything which holds 1 cm^3 holds 1 ml.
2. Fill a 1 millilitre measuring spoon with rice. Empty the spoon into your hand. Carefully pour the rice into a small pile on a sheet of paper.

   THAT IS HOW MUCH ONE MILLILITRE IS!
3. Fill the 5 ml spoon with rice. Pour the rice into another pile on the sheet of paper.

   THAT IS 5 MILLILITRES, OR ONE TEASPOON!
4. Fill the 15 ml spoon with rice. Pour the rice into a third pile on the paper.

   THAT IS 15 MILLILITRES, OR ONE TABLESPOON!

B. DEVELOP YOUR ABILITY TO ESTIMATE IN MILLILITRES

You are now ready to estimate in millilitres. Follow the procedures used for estimating metres.

		Estimate (ml)	Measurement (ml)	How Close Were You?
1.	Small juice can.	_____	_____	_____
2.	Paper cup or tea cup.	_____	_____	_____
3.	Soft drink can.	_____	_____	_____
4.	Bottle.	_____	_____	_____

IV. THE CUBIC METRE (m^3)

A. DEVELOP A FEELING FOR A CUBIC METRE

1. Place a one metre square on the floor next to the wall.
2. Measure a metre UP the wall.
3. Picture a box that would fit into that space.

   THAT IS THE VOLUME OF ONE CUBIC METRE!

B. DEVELOP YOUR ABILITY TO ESTIMATE IN CUBIC METRES

For each of the following items, follow the estimating procedures used before.

		Estimate (m^3)	Measurement (m^3)	How Close Were You?
1.	Office desk.	_____	_____	_____
2.	File cabinet.	_____	_____	_____
3.	Small room.	_____	_____	_____

MASS (WEIGHT) MEASUREMENT ACTIVITIES

Kilogram, Gram

The mass of an object is a measure of the amount of matter in the object. This amount is always the same unless you add or subtract some matter from the object. Weight is the term that most people use when they mean mass. The weight of an object is affected by gravity; the mass of an object is not. For example, the weight of a person on earth might be 120 pounds; that same person's weight on the moon would be 20 pounds. This difference is because the pull of gravity on the moon is less than the pull of gravity on earth. A person's mass on the earth and on the moon would be the same. The metric system does not measure weight--it measures mass. We will use the term mass here.

The symbol for gram is g.

The symbol for kilogram is kg.

There are 1 000 grams in one kilogram, or 1 000 g = 1 kg.

Half a kilogram can be written as 500 g,or 0.5 kg.

A quarter of a kilogram can be written as 250 g,or 0.25 kg.

Two and three-fourths kilograms is written as 2.75 kg.

I. THE KILOGRAM (kg)

DEVELOP A FEELING FOR THE MASS OF A KILOGRAM

Using a balance or scale, find the mass of the items on the table. Before you find the mass, notice how heavy the object "feels" and compare it to the reading on the scale or balance.

		Mass (kg)
1.	1 kilogram box.	_____
2.	Textbook.	_____
3.	Bag of sugar.	_____
4.	Package of paper.	_____
5.	Your own mass.	_____

B. DEVELOP YOUR ABILITY TO ESTIMATE IN KILOGRAMS

For the following items ESTIMATE the mass of the object in kilograms, then use the scale or balance to find the exact mass of the object. Write the exact mass in the MEASUREMENT column. Determine how close your estimate is:

		Estimate (kg)	Measurement (kg)	How Close Were You?
1.	Bag of rice.	_____	_____	_____
2.	Bag of nails.	_____	_____	_____
3.	Large purse or briefcase.	_____	_____	_____
4.	Another person.	_____	_____	_____
5.	A few books.	_____	_____	_____

(continued on next page)

II. THE GRAM (g)

A. DEVELOP A FEELING FOR A GRAM

1. Take a colored plastic cube. Hold it in your hand. Shake the cube in your palm as if shaking dice. Feel the pressure on your hand when the cube is in motion, then when it is not in motion.

   THAT IS HOW HEAVY A GRAM IS!

2. Take a second cube and attach it to the first. Shake the cubes in first one hand and then the other hand; rest the cubes near the tips of your fingers, moving your hand up and down.

   THAT IS THE MASS OF TWO GRAMS!

3. Take five cubes in one hand and shake them around.

   THAT IS THE MASS OF FIVE GRAMS!

B. DEVELOP YOUR ABILITY TO ESTIMATE IN GRAMS

You are now ready to improve your ability to estimate in grams. Remember how heavy the 1 gram cube is, how heavy the two gram cubes are, and how heavy the five gram cubes are. For each of the following items, follow the procedures used for estimating in kilograms.

		Estimate (g)	Measurement (g)	How Close Were You?
1.	Two thumbtacks.	_____	_____	_____
2.	Pencil.	_____	_____	_____
3.	Two-page letter and envelope.	_____	_____	_____
4.	Nickel.	_____	_____	_____
5.	Apple.	_____	_____	_____
6.	Package of margarine.	_____	_____	_____

TEMPERATURE MEASUREMENT ACTIVITIES

Degree Celsius

I. DEGREE CELSIUS (°C)

Degree Celsius (°C) is the metric measure for temperature.

A. DEVELOP A FEELING FOR DEGREE CELSIUS

Take a Celsius thermometer. Look at the marks on it.

1. Find 0 degrees.

   WATER FREEZES AT ZERO DEGREES CELSIUS (0°C)

   WATER BOILS AT 100 DEGREES CELSIUS (100°C)

2. Find the temperature of the room. _____ °C. Is the room cool, warm, or about right?
3. Put some hot water from the faucet into a container. Find the temperature. _____ °C. Dip your finger quickly in and out of the water. Is the water very hot, hot, or just warm?
4. Put some cold water in a container with a thermometer. Find the temperature. _____ °C. Dip your finger into the water. Is it cool, cold, or very cold?
5. Bend your arm with the inside of your elbow around the bottom of the thermometer. After about three minutes find the temperature. _____ °C. Your skin temperature is not as high as your body temperature.

   NORMAL BODY TEMPERATURE IS 37 DEGREES CELSIUS (37°C).

   A FEVER IS 39°C.

   A VERY HIGH FEVER IS 40°C.

B. DEVELOP YOUR ABILITY TO ESTIMATE IN DEGREES CELSIUS

For each item, ESTIMATE and write down how many degrees Celsius you think it is. Then measure and write the MEASUREMENT. See how close your estimates and actual measurements are.

		Estimate (°C)	Measurement (°C)	How Close Were You?
1.	Mix some hot and cold water in a container. Dip your finger into the water.	_____	_____	_____
2.	Pour out some of the water. Add some hot water. Dip your finger quickly into the water.	_____	_____	_____
3.	Outdoor temperature.	_____	_____	_____
4.	Sunny window sill.	_____	_____	_____
5.	Mix of ice and water.	_____	_____	_____
6.	Temperature at floor.	_____	_____	_____
7.	Temperature at ceiling.	_____	_____	_____

UNIT 2

OBJECTIVES

The student will recognize and use the metric terms, units, and symbols used in this occupation.

- Given a metric unit, state its use in this occupation.
- Given a measurement task in this occupation, select the appropriate metric unit and measurement tool.

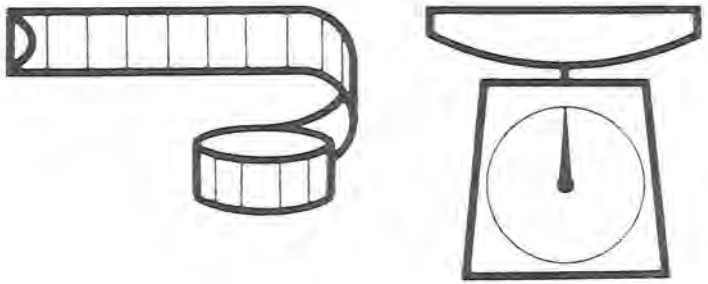
SUGGESTED TEACHING SEQUENCE

1. Assemble metric measurement tools (rules, tapes, scales, thermometers, etc.) and objects related to this occupation.
2. Discuss with students how to read the tools.
3. Present and have students discuss Information Sheet 2 and Table 2.
4. Have students learn occupationally-related metric measurements by completing Exercises 6 and 7.
5. Test performance by using Section A of "Testing Metric Abilities."

METRICS IN THIS OCCUPATION

Changeover to the metric system is under way. Large corporations are already using metric measurement to compete in the world market. The metric system has been used in various parts of industrial and scientific communities for years. Legislation, passed in 1975, authorizes an orderly transition to use of the metric system. As businesses and industries make this metric changeover, employees will need to use metric measurement in job-related tasks.

Table 2 lists those metric terms which are most commonly used in this occupation. These terms are replacing the measurement units used currently. What kinds of job-related tasks use measurement? Think of the many different kinds of measurements you now make and use Table 2 to discuss the metric terms which replace them. See if you can add to the list of uses beside each metric term.



METRIC UNITS FOR ARCHITECTURAL, CIVIL, AND MECHANICAL DRAFTING

Quantity	Unit	Symbol	Use
Length	micrometre	μm	Surface finishes.*
	millimetre	mm	Chamfer; length and diameter of screws and bolts; tolerances; drill hole size; tool sizes; length of a metric drafting scale; pencil lead diameter; bolt radius; length and width of drafting paper; fixture dimensions.
	centimetre	cm	Length of drafting table; radius; length of a T-square; panel and pavement thickness.
	metre	m	Length of bar stock, wire, and rolls of white print paper; road width; curve radius; house plan; wall and floor length, wall height.
	kilometre	km	Plat; surveys; landscaping; hauling distance; road construction.
Area	square millimetre	mm^2	Cross-sectional area of wire, reinforcing rod and pipe.
	square centimetre	cm^2	Area of drafting paper; size of openings; cross sections.
	square metre	m^2	Floor area; sidewalk; driveways; ventilating systems.
	hectare	ha	Survey; plats.
	square kilometre	km^2	
Volume/Capacity	cubic millimetre	mm^3	Metal removal.
	cubic centimetre	cm^3	Volume of hydraulic cylinder engine displacement; capacity of small tanks and containers.**
	cubic metre	m^3	Concrete; earth excavation; landfill; backfill; sand and gravel; tack coat.
	millilitre	ml	Ink; rubber cement; thinner; tanks and containers; measuring granular substance by volume; bottle of ammonia; spray marking paint.
	litre	l	Water heater; liquid or gas tanks**; pool specifications.
Mass	gram	g	Powdered plastic; small finished products; erasing compound; soil samples; concrete coloring.
	kilogram	kg	Steel; structural materials; furnishings and equipment.
	metric ton	t	Steel; machinery; equipment; concrete; sand; gravel; fill; asphalt.
Pressure	kilopascal	kPa	Pressure in auto tires; air, gas, plumbing or hydraulic systems; pressure for air brush.

*Surface finish is given in micrometres.

Example: $\overset{0.1}{\checkmark}$ is a super finish similar to a very fine buff, lap, burnish, or bright polish. Suitable for raceways, ball bearings, and rollers of antifriction bearings.

Note: The roughness values are the average deviation in micrometres. 1 micrometre = .001 mm.

**Tank and container capacities, and engine displacement can be given either in millilitres and litres or in cubic centimetres and cubic metres.

TRYING OUT METRIC UNITS

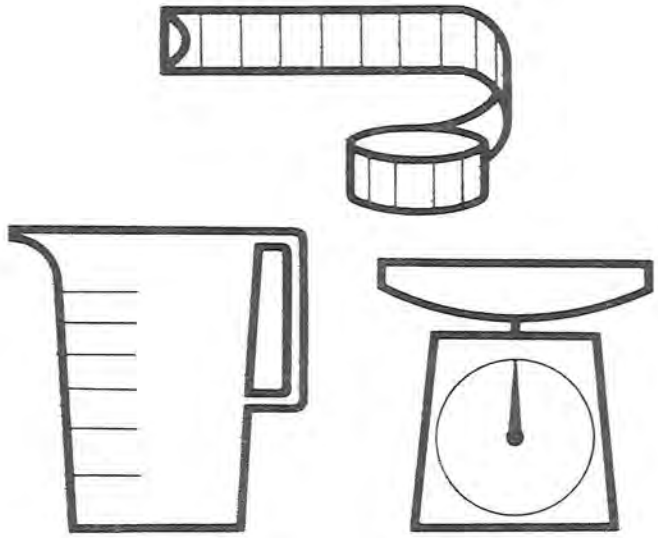
To give you practice with metric units, first estimate the measurements of the items below. Write down your best guess next to the item. Then actually measure the item and write down your answers using the correct metric symbols. The more you practice, the easier it will be.

	Estimate	Actual
Length		
1. Palm width		
2. Hand span		
3. Your height		
4. Wall height		
5. Pavement width		
6. Tree diameter		
7. Brick		
8. Room width		
9. Ceiling height		
10. Sidewalk width		
11. Shrub height		
12. Window length		
13. Length of a city block		
14. Door height		
15. Door opening width		
Area		
16. Desk top		
17. Floor		
18. Pavement surface between two points		
19. Parking lot		
20. Sidewalk between two points		
21. Wall		
22. Lawn		
23. Ceiling		
24. Window pane		
25. Sheet of drafting paper		
Volume/Capacity		
26. Small bottle		
27. Desk drawer		
28. Length of pipe		
29. Cylinder		
30. Cabinet		
31. Bathtub		
32. Dump truck bed		
33. Bucket		
34. Small box or package		
35. Room		
Mass		
36. Textbook		
37. Nickel		
38. Yourself		
39. Brick		
40. A quantity of dirt		
41. A litre of water (net)		
42. Paper clip		
43. Piece of steel		
44. Sheet of plywood		
45. Wall stud		
Temperature		
46. Room		
47. Outside		
48. Hot tap water		
49. Ice water		

BUILDING WITH METRICS

It is important to know what metric measurement to use. Show what measurement to use in the following situations.

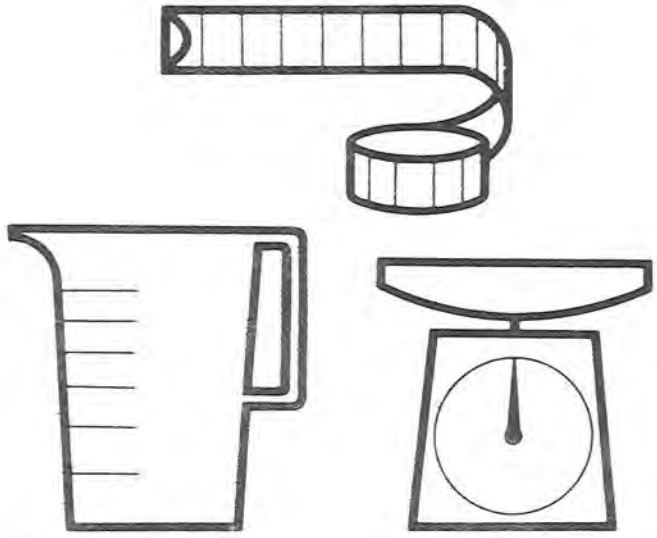
1. Height of wall	
2. Width of door opening	
3. Dimensions of window	
4. Length of wall stud	
5. Dimensions of plywood	
6. Capacity of pipe	
7. Capacity of heating duct	
8. Area of floor	
9. Area of wall	
10. Mass of plywood sheet	
11. Thickness of brick ledge	
12. Height of foundation	
13. Area of living space	
14. Volume of living space	
15. Window glass area	
16. Wall stud spacing	
17. Water pressure	
18. Soil percolation	
19. Foundation depth	
20. Length of brick	
21. Width of mortar joint	



DRAFTING WITH METRICS

It is important to know what metric measurement to use. Show what measurement to use in the following situations.

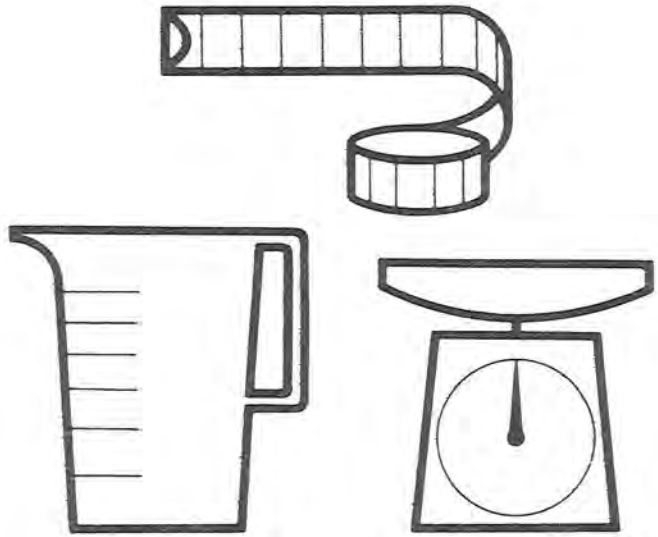
1. Length and width of table top	
2. Length and width of drafting paper	
3. Area of table top	
4. Area of drafting paper	
5. Volume of classroom	
6. Mass of yourself	
7. Mass of contents of room	
8. Area of walls of the room	
9. Span of compass	
10. Span of beam compass	
11. Temperature of room	
12. Mass of sand	
13. Mass of water	
14. Height of concrete slump	
15. Depth of beam flex	
16. Melting point of steel	
17. Swimming pool capacity	
18. Mass of water in swimming pool	
19. Capacity of dump truck box	
20. Pressure in water pipe	
21. Angle of highway curve	
22. Distance between two towns	



DRAWING WITH METRICS

It is important to know what metric measurement to use. Show what measurement to use in the following situations.

1. Length and width of table top	
2. Length and width of drafting paper	
3. Area of table top	
4. Area of drafting paper	
5. Volume of ink bottle	
6. Volume of inking pen	
7. Thickness of sheet of paper	
8. Thickness of a ream of paper	
9. Pencil thickness	
10. Pencil lead diameter	
11. Area of cross section of pencil lead	
12. Span of compass	
13. Span of beam compass	
14. Area of triangle	
15. Angles of a triangle	
16. Length of a piece of bar stock	
17. Thickness of a drawing template	
18. Dimension of arrow heads	
19. Surface finish on a machined surface	
20. Length of roll of blueprint or white print paper	
21. Bolt dimensions	
22. Tolerance dimensions	



UNIT 3

OBJECTIVE

The student will recognize and use metric equivalents.

- Given a metric unit, state an equivalent in a larger or smaller metric unit.

SUGGESTED TEACHING SEQUENCE

1. Make available the Information Sheets (3 - 8) and the associated Exercises (8 - 14), one at a time.
2. As soon as you have presented the Information, have the students complete each Exercise.
3. Check their answers on the page titled ANSWERS TO EXERCISES AND TEST.
4. Test performance by using Section B of "Testing Metric Abilities."

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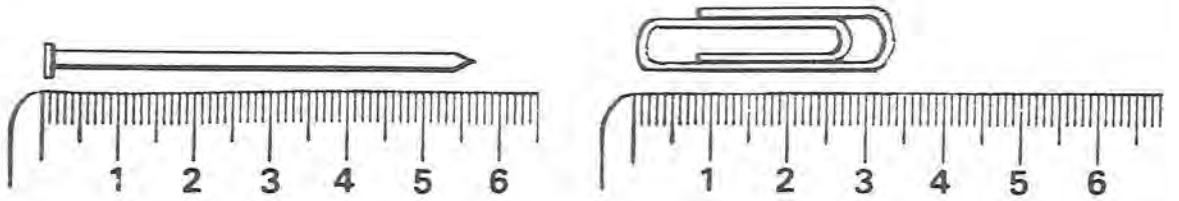
METRIC-METRIC EQUIVALENTS

Centimetres and Millimetres



Look at the picture of the nail next to the ruler. The nail is 57 mm long. This is 5 cm + 7 mm. There are 10 mm in each cm, so 1 mm = 0.1 cm (one-tenth of a centimetre). This means that 7 mm = 0.7 cm, so 57 mm = 5 cm + 7 mm
= 5 cm + 0.7 cm
= 5.7 cm. Therefore 57 mm is the same as 5.7 cm.

Now measure the paper clip. It is 34 mm. This is the same as 3 cm + _____mm. Since each millimetre is 0.1 cm (one-tenth of a centimetre), 4 mm = _____cm. So, the paper clip is 34 mm = 3 cm + 4 mm
= 3 cm + 0.4 cm
= 3.4 cm. This means that 34 mm is the same as 3.4 cm.

Information Sheet 3

Now you try some.

a) 26 mm = _____ cm
b) 583 mm = _____ cm
c) 94 mm = _____ cm
d) 680 mm = _____ cm
e) 132 mm = _____ cm
f) 802 mm = _____ cm
g) 1 400 mm = _____ cm
h) 2 307 mm = _____ cm

Exercise 8

Metres, Centimetres, and Millimetres

There are 100 centimetres in one metre. Thus,

2 m = 2 x 100 cm = 200 cm,
3 m = 3 x 100 cm = 300 cm,
8 m = 8 x 100 cm = 800 cm,
36 m = 36 x 100 cm = 3 600 cm.

There are 1 000 millimetres in one metre, so

2 m = 2 x 1 000 mm = 2 000 mm,
3 m = 3 x 1 000 mm = 3 000 mm,
6 m = 6 x 1 000 mm = 6 000 mm,
24 m = 24 x 1 000 mm = 24 000 mm.

From your work with decimals you should know that

one-half of a metre can be written 0.5 m (five-tenths of a metre),
one-fourth of a centimetre can be written 0.25 cm
(twenty-five hundredths of a centimetre).

This means that if you want to change three-fourths of a metre to millimetres, you would multiply by 1 000. So

$0.75 \text{ m} = 0.75 \times 1\,000 \text{ mm}$

$= \frac{75}{100} \times 1\,000 \text{ mm}$

$= 75 \times \frac{1\,000}{100} \text{ mm}$

$= 75 \times 10 \text{ mm}$

= 750 mm. This means that 0.75 m = 750 mm.

Information Sheet 4

Fill in the following chart.

metre m	centimetre cm	millimetre mm
1	100	1 000
2	200	
3		
9		
		5 000
74		
0.8	80	
0.6		600
	2.5	25
		148
	639	

Exercise 9

Millilitres to Litres

There are 1 000 millilitres in one litre. This means that

2 000 millilitres is the same as 2 litres,
3 000 ml is the same as 3 litres,
4 000 ml is the same as 4 litres,
12 000 ml is the same as 12 litres.

Since there are 1 000 millilitres in each litre, one way to change millilitres to litres is to divide by 1 000. For example,

Or $1\,000 \text{ ml} = \frac{1\,000}{1\,000} \text{ litre} = 1 \text{ litre}.$

$2\,000 \text{ ml} = \frac{2\,000}{1\,000} \text{ litres} = 2 \text{ litres}.$

And, as a final example,

$28\,000 \text{ ml} = \frac{28\,000}{1\,000} \text{ litres} = 28 \text{ litres}.$

What if something holds 500 ml? How many litres is this? This is worked the same way.

$500 \text{ ml} = \frac{500}{1\,000}$ litre = 0.5 litre (five-tenths of a litre). So 500 ml is the same as one-half (0.5) of a litre.

Change 57 millilitres to litres.

$57 \text{ ml} = \frac{57}{1\,000}$ litre = 0.057 litre (fifty-seven thousandths of a litre).

Information Sheet 5

Now you try some. Complete the following chart.

millilitres (ml)	litres (l)
3 000	3
6 000	
	8
14 000	
	23
300	0.3
700	
	0.9
250	
	0.47
275	

Exercise 10

Litres to Millilitres

What do you do if you need to change litres to millilitres? Remember, there are 1 000 millilitres in one litre, or 1 litre = 1 000 ml.

So,

2 litres = 2 x 1 000 ml = 2 000 ml,
7 litres = 7 x 1 000 ml = 7 000 ml,
13 litres = 13 x 1 000 ml = 13 000 ml,
0.65 litre = 0.65 x 1 000 ml = 650 ml.

Information Sheet 6

Now you try some. Complete the following chart.

litres l	millilitres ml
8	8 000
5	
46	
	32 000
0.4	
0.53	
	480

Exercise 11

Grams to Kilograms

There are 1 000 grams in one kilogram. This means that

2 000 grams is the same as 2 kilograms,

5 000 g is the same as 5 kg,

700 g is the same as 0.7 kg, and so on.

To change from grams to kilograms, you use the same procedure for changing from millilitres to litres.

Information Sheet 7

Try the following ones.

grams g	kilograms kg
4 000	4
9 000	
23 000	
	8
300	
275	

Exercise 12

Kilograms to Grams

To change kilograms to grams, you multiply by 1 000.

4 kg = 4 x 1 000 g = 4 000 g,
23 kg = 23 x 1 000 g = 23 000 g,
0.75 kg = 0.75 x 1 000 g = 750 g.

Information Sheet 8

Complete the following chart.

kilograms kg	grams g
7	7 000
11	
	25 000
0.4	
0.63	
	175

Exercise 13

Changing Units at Work

Some of the things you use in this occupation may be measured in different metric units. Practice changing each of the following to

a) 5 cm diameter pipe is _____ mm
b) 2 500 kg of soil is _____ t
c) 50 x 800 mm board is _____ cm
d) 0.25 litre of solvent is _____ ml
e) 240 cm of rope is _____ m
f) 65 cm stud spacing is _____ m
g) 0.5 t of copper is _____ kg
h) 2 m board is _____ mm
i) 500 g of nails is _____ kg
j) 120 x 240 cm sheet is _____ mm
k) 250 ml of solution is _____ l
l) 10 m of wire is _____ cm
m) 1 cm mortar joint is _____ mm
n) 2 kg of brick is _____ g
o) 1 m x 2.1 m door is _____ mm
p) 500 ml of oil is _____ l
q) 3 cm nail is _____ mm
r) 50 m wall length is _____ cm
s) 2 500 g of cement is _____ kg
t) 120 mm diameter tree is _____ cm
u) 0.5 litre of dye is _____ ml
v) 2 400 mm wall panel is _____ cm

Exercise 14

UNIT 4

OBJECTIVE

The student will recognize and use instruments, tools, and devices for measurement tasks in this occupation.

- Given metric and Customary tools, instruments, or devices, differentiate between metric and Customary.
- Given a measurement task, select and use an appropriate tool, instrument or device.
- Given a metric measurement task, judge the metric quantity within 25% and measure within 1% accuracy.

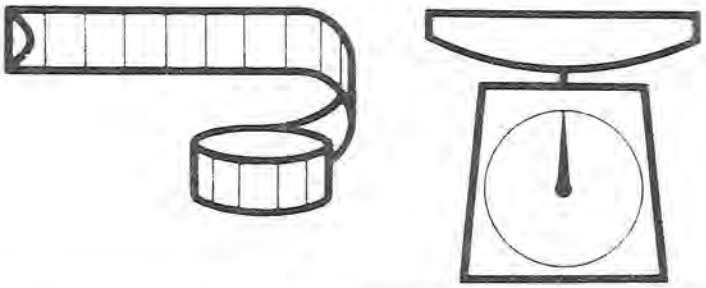
SUGGESTED TEACHING SEQUENCE

1. Assemble metric and Customary measuring tools and devices (rules, scales, °C thermometer, micrometer, drafting scales, templates, measuring tapes, gages) and display in separate groups at learning stations.
2. Have students examine metric tools and instruments for distinguishing characteristics and compare them with Customary tools and instruments.
3. Have students verbally describe characteristics.
4. Present or make available Information Sheet 9.
5. Mix metric and Customary tools or equipment at learning station. Give students appropriate Exercises 15 and 16.
6. Test performance by using Section C of "Testing Metric Abilities."

SELECTING AND USING METRIC INSTRUMENTS , TOOLS AND DEVICES

Selecting an improper tool or misreading a scale can result in an improper plan, damaged materials, or injury to workers. For example, if the design flexing moment of a steel beam is 0.5 mm, but was misread as 0.5 cm, the longer flexing moment would cause undue stress and the beam would collapse; measuring a road bed width in yards by using a measuring tape dimensioned in metres would result in an improper survey or plan; and when the design tolerance of an axle bearing shaft is 0.001 m and the shaft is machined to 0.01 m, it will have too tight a fit and break. Here are some suggestions:

1. Find out in advance whether Customary or metric units, tools, instruments, or products are needed for a given task.
2. Examine the tool or instrument before using it.
3. The metric system is a decimal system. Look for units marked off in whole numbers, tens or tenths, hundred or hundredths.
4. Look for metric symbols on the tools or gages such as m, mm, kg, g, kPa.
5. Look for decimal fractions (0.25) or decimal mixed fractions (2.50) rather than common fractions (3/8) on tools and devices.
6. Some products may have a special metric symbol such as a block M to show they are metric.
7. Don't force devices which are not fitting properly.
8. Practice selecting and using tools, instruments, and devices.



WHICH TOOLS FOR THE JOB?

Practice and prepare to demonstrate your ability to *identify, select, and use* metric-scaled tools and instruments for the tasks given below. You should be able to use the measurement tools to the appropriate precision of the tool, instrument, or task.

Select and demonstrate or describe use of tools, instruments, or devices to:

1. Measure length of board.
2. Determine mass of a brick.
3. Measure height of a wall.
4. Measure width of a window.
5. Find width and height of a door.
6. Find capacity of a room.
7. Calculate area of floor space.
8. Find ceiling dimensions.
9. Find paneling dimensions.
10. Select lettering size on blueprint.
11. Calculate wall weight.
12. Measure panel thickness.
13. Find beam flex.
14. Check nail length.
15. Find compression strength.

MEASURING UP IN ARCHITECTURAL DRAFTING

For the tasks below, estimate the metric measurement to within 25% of actual measurement, and verify the estimation by measuring to within 1% of actual measurement.

	Estimate	Verify
1. Length of table		
2. Width of table		
3. Length of paneling		
4. Width of paneling		
5. Wall height		
6. Window dimensions		
7. Doorway opening: a. length		
b. width		
8. Hall width		
9. Floor space		
10. Room capacity		
11. Stud dimension		
12. Heat register dimensions: a. length		
b. width		
13. Wall length		
14. Dimensions of drafting paper: a. length		
b. width		
15. Width of white print paper		
16. Angle of rafter slope		
17. Volume of ammonia in partly-filled jug		

WHICH TOOLS FOR THE JOB?

Practice and prepare to demonstrate your ability to *identify, select, and use* metric-scaled tools and instruments for the tasks given below. You should be able to use the measurement tools to the appropriate precision of the tool, instrument, or task.

Select and demonstrate or describe use of tools, instruments, or devices to:

1. Adjust a compass to draw a circle.
2. Adjust a beam compass to draw an arc.
3. Calculate the scale of the drawing to fit on a sheet of paper.
4. Calculate the area of an irregularly shaped plot of land.
5. Survey a plot to determine area.
6. Survey a project and figure the grade.
7. Calculate the cut and fill on a project.
8. Calculate the quantity of asphalt paving needed for a project.
9. Calculate the amount of fill sand needed for a project.
10. Calculate the amount of tack coat needed for a project.
11. Test a core sample of concrete.
12. Measure the percolation rate of the soil.
13. Measure the overall length of a bolt.

MEASURING UP IN CIVIL DRAFTING

For the tasks below, estimate the metric measurement to within 25% of actual measurement, and verify the estimation by measuring to within 5% of actual measurement.

	Estimate	Verify
1. Length of a city block		
2. Mass of a concrete building block		
3. Cubic volume of sand		
4. Area of water main pipe		
5. Length of building		
6. Angle between three points		
7. Distance between two points		
8. Percolation rate of soil		
9. Slope of angle		
10. Radius of curbing		
11. Width of sidewalk		
12. Diameter of tree		
13. Tire air pressure		
14. Mass of ingredients of concrete prepared for a slump test:		
a. sand		
b. gravel		
c. cement		
d. water		

WHICH TOOLS FOR THE JOB?

Practice and prepare to demonstrate your ability to *identify, select, and use* metric-scaled tools and instruments for the tasks given below. You should be able to use the measurement tools to the appropriate precision of the tool, instrument, or task.

Select and demonstrate or describe use of tools, instruments, or devices to:

1. Adjust the compass to draw a circle.
2. Adjust the beam compass to draw an arc.
3. Center a view on a piece of paper.
4. Scale down a bookcase to fit a piece of drafting paper.
5. Draw two tangents to a circle so that they intersect at 90°.
6. Draw two tangents to a circle so that they intersect at 45°.
7. Determine the cross hatch spacing on a cut away view.
8. Draw a 24 mm circle in an isometric view.
9. Measure a styrofoam cup.
10. Measure the overall length of a bolt.
11. Measure the angle of screw threads.
12. Measure a root thread diameter.
13. Measure the number of threads per mm.
14. Order a drawing pen point by size.

MEASURING UP IN MECHANICAL DRAFTING

For the tasks below, estimate the metric measurement to within 25% of actual measurement, and verify the estimation by measuring to within 1% of actual measurement.

	Estimate	Verify
1. Length of table		
2. Width of table		
3. Length of a sheet of drafting paper		
4. Width of a sheet of drafting paper		
5. Temperature of the drafting room		
6. Height of table top		
7. Angle of slant of drawing board		
8. Bolt dimension (length and thread size)		
9. Extension of lead from mechanical pencil		
10. Size of pen point		
11. Angles of a triangle		
12. Degree of chamfer on a machined product		
13. Thread pitch of a bolt		
14. Hole diameter		
15. Diameter across flats of bolt head		

UNIT 5

OBJECTIVE

The student will recognize and use metric and Customary units interchangeably in ordering, selling, and using products and supplies in this occupation.

- Given a Customary (or metric) measurement, find the metric (or Customary) equivalent on a conversion table.
- Given a Customary unit, state the replacement unit.

SUGGESTED TEACHING SEQUENCE

1. Assemble packages and containers of materials.
2. Present or make available Information Sheet 10 and Table 3.
3. Have students find approximate metric-Customary equivalents by using Exercise 17.
4. Test performance by using Section D of "Testing Metric Abilities."

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METRIC-CUSTOMARY EQUIVALENTS

During the transition period there will be a need for finding equivalents between systems. Conversion tables list calculated equivalents between the two systems. When a close equivalent is needed, a conversion table can be used to find it. Follow these steps:

1. Determine which conversion table is needed.
2. Look up the known number in the appropriate column; if not listed, find numbers you can add together to make the total of the known number.
3. Read the equivalent(s) from the next column.

Table 3 on the next page gives an example of a metric-Customary conversion table which you can use for practice in finding approximate equivalents. Table 3 can be used with Exercise 17, Part 2 and Part 3.

Below is a table of metric-Customary equivalents which tells you what the metric replacements for Customary units are.* This table can be used with Exercise 17, Part 1 and Part 3. The symbol ≈ means "nearly equal to."

1 cm ≈ 0.39 inch	1 inch ≈ 2.54 cm	1 ml ≈ 0.2 tsp	1 tsp ≈ 5 ml
1 m ≈ 3.28 feet	1 foot ≈ 0.305 m	1 ml ≈ 0.07 tbsp	1 tbsp ≈ 15 ml
1 m ≈ 1.09 yards	1 yard ≈ 0.91 m	1 l ≈ 33.8 fl oz	1 fl oz ≈ 29.6 ml
1 km ≈ 0.62 mile	1 mile ≈ 1.61 km	1 l ≈ 4.2 cups	1 cup ≈ 237 ml
1 cm^2 ≈ 0.16 sq in	1 sq in ≈ 6.5 cm^2	1 l ≈ 2.1 pts	1 pt ≈ 0.47 l
1 m^2 ≈ 10.8 sq ft	1 sq ft ≈ 0.09 m^2	1 l ≈ 1.06 qt	1 qt ≈ 0.95 l
1 m^2 ≈ 1.2 sq yd	1 sq yd ≈ 0.8 m^2	1 l ≈ 0.26 gal	1 gal ≈ 3.79 l
1 hectare ≈ 2.5 acres	1 acre ≈ 0.4 hectare	1 gram ≈ 0.035 oz	1 oz ≈ 28.3 g
1 cm^3 ≈ 0.06 cu in	1 cu in ≈ 16.4 cm^3	1 kg ≈ 2.2 lb	1 lb ≈ 0.45 kg
1 m^3 ≈ 35.3 cu ft	1 cu ft ≈ 0.03 m^3	1 metric ton ≈ 2205 lb	1 ton ≈ 907.2 kg
1 m^3 ≈ 1.3 cu yd	1 cu yd ≈ 0.8 m^3	1 kPa ≈ 0.145 psi	1 psi ≈ 6.895 kPa

*Adapted from *Let's Measure Metric. A Teacher's Introduction to Metric Measurement.* Division of Educational Redesign and Renewal, Ohio Department of Education, 65 S. Front Street, Columbus, OH 43215, 1975.

CONVERSION TABLES

MILLIMETRES TO CENTIMETRES TO INCHES

mm	cm	in.	mm	cm	in.	mm	cm	in.
100	10	3.93	10	1	0.39	1	0.1	0.04
200	20	7.87	20	2	0.79	2	0.2	0.08
300	30	11.81	30	3	1.18	3	0.3	0.12
400	40	15.74	40	4	1.57	4	0.4	0.16
500	50	19.68	50	5	1.97	5	0.5	0.20
600	60	23.62	60	6	2.36	6	0.6	0.24
700	70	27.56	70	7	2.76	7	0.7	0.28
800	80	31.50	80	8	3.15	8	0.8	0.31
900	90	35.43	90	9	3.54	9	0.9	0.35

1000 mm or 1 metre = 39.37 inches

INCHES TO CENTIMETRES TO MILLIMETRES

in.	cm	mm	in.	cm	mm
1	2.54	25.4	1/8	0.32	3.2
2	5.08	50.8	1/4	0.64	6.4
3	7.62	76.2	1/2	1.27	12.7
4	10.16	101.6	3/4	1.91	19.1
5	12.70	127.0			
6	15.24	152.4			
7	17.78	177.8			
8	20.32	203.2			
9	22.86	228.6			
10	25.40	254.0			

12 in. or 1 ft. = 30.48 cm or 304.8 mm

SQUARE FEET TO SQUARE METRES

ft^2	m^2	ft^2	m^2	ft^2	m^2	ft^2	m^2
1000	92.90	100	9.29	10	0.93	1	0.09
2000	185.81	200	18.58	20	1.82	2	0.19
3000	278.81	300	27.88	30	2.79	3	0.28
4000	371.61	400	37.16	40	3.72	4	0.37
5000	464.52	500	46.45	50	4.65	5	0.46
6000	557.42	600	55.74	60	5.57	6	0.56
7000	650.32	700	65.03	70	6.50	7	0.65
8000	743.22	800	74.32	80	7.43	8	0.74
9000	836.13	900	83.61	90	8.36	9	0.84

SQUARE METRES TO SQUARE FEET

m^2	ft^2	m^2	ft^2	m^2	ft^2	m^2	ft^2
100	1076.39	10	107.64	1	10.76	0.1	1.08
200	2152.78	20	215.28	2	21.53	0.2	2.15
300	3229.17	30	322.92	3	32.29	0.3	3.23
400	4305.56	40	430.56	4	43.06	0.4	4.31
500	5381.96	50	538.20	5	53.82	0.5	5.38
600	6458.35	60	645.83	6	64.58	0.6	6.46
700	7534.74	70	753.47	7	75.35	0.7	7.53
800	8611.13	80	861.11	8	86.11	0.8	8.61
900	9687.52	90	968.75	9	96.87	0.9	9.69

ANY WAY YOU WANT IT

1. You are working in a drafting firm. With the change to metric measurement some of the things you order, sell or use are marked only in metric units. You will need to be familiar with appropriate Customary equivalents in order to communicate with customers and suppliers who use Customary units. To develop your skill use the Table on Information Sheet 10 and give the approximate metric quantity (both number and unit) for each of the following Customary quantities.

	Customary Quantity	Metric Quantity
a)	2 lbs. of grass seed	
b)	4 qts. of ammonia	
c)	3/4 in. pipe	
d)	10 acres	
e)	1000 lbs. of aluminum	
f)	18 in. diameter tree	
g)	two-gallon can	
h)	6 ft. tape measurer	
i)	1 fl. oz. of spray paint	
j)	3 miles	
k)	8 in. pipe	
l)	2 in. x 4 in. x 8 ft. stud	
m)	2 ft. sidewalk	
n)	6 in. stake	
o)	1/4 in. bolt	
p)	16 oz. can of epoxy	
q)	4 ft. x 2 ft. window	
r)	5 gals. of paint	

2. Use the conversion tables from Table 3 to convert the following:

a)	1 3/4 in.	=	mm	f)	0.4 cm	=	in.
b)	13 mm	=	in.	g)	19 in.	=	mm
c)	1241 ft.^{2}	=	m^2	h)	331.7 m^2	=	ft.^{2}
d)	11.3 cm	=	in.	i)	442 mm	=	in.
e)	39.37 in.	=	mm	j)	1 ft.	=	cm

3. Complete the Requisition Form using the items listed. Convert the Customary quantities to metric before filling out the form. Complete all the information (Date, For, No., etc.).
Order the following civil engineering or drafting materials:

a) 1200 lbs. of sand
b) 5 gals. of white print fluid in 1 gal. containers
c) 50 yd. roll of white print paper
d) 1000 sq. ft. of paneling
e) 1 pt. of rubber cement thinnker
f) 6 ft. metal tape measure
g) 6 - 4 in. paint brushes

REQUISITION

Date _____

For _____

_____

No. _____ Date Wanted _____

Deliver to _____

QTY	UNIT	ITEM

Requested by _____

Approved by _____

SECTION A

1. One kilogram is about the mass of a:
   - [A] nickel
   - [B] apple seed
   - [C] basketball
   - [D] Volkswagen "Beetle"

2. A square metre is about the area of:
   - [A] this sheet of paper
   - [B] a card table top
   - [C] a bedspread
   - [D] a postage stamp

3. The length of screws and bolts is measured in:
   - [A] millilitres
   - [B] micrometres
   - [C] millimetres
   - [D] kilograms

4. The mass of steel is measured in:
   - [A] millilitres
   - [B] centimetres
   - [C] kilograms
   - [D] cubic metres

5. Road width is normally given in:
   - [A] kilograms
   - [B] metres
   - [C] grams
   - [D] centimetres

6. The correct way to write twenty grams is:
   - [A] 20 gms
   - [B] 20 Gm.
   - [C] 20 g.
   - [D] 20 g

7. The correct way to write twelve thousand millimetres is:
   - [A] 12.000 mm.
   - [B] 12.000 mm
   - [C] 12 000mm
   - [D] 12 000 mm

SECTION B

8. A board 20 centimetres wide also has a width of:
   - [A] 0.2 millimetre
   - [B] 2 000 millimetres
   - [C] 2 millimetres
   - [D] 200 millimetres

9. A 750 gram drafting set is the same as:
   - [A] 7.5 kilograms
   - [B] 75.0 kilograms
   - [C] 750 kilograms
   - [D] 0.75 kilogram

SECTION C

10. For measuring kilograms you would use a:
    - [A] scale
    - [B] pressure gage
    - [C] ruler
    - [D] container

11. For measuring millilitres you would use a:
    - [A] tape
    - [B] container
    - [C] ruler
    - [D] pressure gage

12. For measuring in centimetres and millimetres you would use a:

    [A] thermometer

    [B] ruler

    [C] scale

    [D] measuring cup or graduate

13. For measuring in Celsius you would use a:

    [A] ruler

    [B] measuring cup or graduate

    [C] thermometer

    [D] scale

14. Estimate the length of the line segment below:

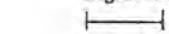
    [A] 23 grams

    [B] 6 centimetres

    [C] 40 millimetres

    [D] 14 pascals

15. Estimate the length of the line segment below:



    [A] 10 millimetres

    [B] 4 centimetres

    [C] 4 pascals

    [D] 23 milligrams

SECTION D

16. The metric unit for liquid measure which replaces the fluid ounce is:

    [A] millilitre

    [B] hectare

    [C] litre

    [D] gram

17. The metric unit for area which replaces the acre is:

    [A] litre

    [B] kilometre

    [C] square metre

    [D] hectare

18. The metric unit for pressure which replaces pounds per square inch (psi) is:

    [A] cubic centimetre

    [B] kilopascal

    [C] cubic metre

    [D] Celsius

19. The metric unit for liquid measure which replaces the gallon is:

    [A] litre

    [B] pascal

    [C] metre

    [D] kilogram

Use this conversion table to answer questions 20 and 21.

mm	in.	mm	in.
1	0.04	0.1	0.004
2	0.08	0.2	0.008
3	0.12	0.3	0.012
4	0.16	0.4	0.016
5	0.20	0.5	0.020
6	0.24	0.6	0.024
7	0.28	0.7	0.028
8	0.31	0.8	0.031
9	0.35	0.9	0.035

20. The equivalent of 5.5 mm is:

    [A] 0.220 in.

    [B] 0.55 in.

    [C] 2.20 in.

    [D] 0.055 in.

21. The equivalent of 6.2 mm is:

    [A] 0.62 in.

    [B] 0.062 in.

    [C] 0.248 in.

    [D] 0.2408 in.

ANSWERS TO EXERCISES AND TEST

EXERCISES 1 THRU 6

The answers depend on the items used for the activities.

EXERCISE 7

Currently accepted metric units of measurement for each question are shown in Table 2. Standards in each occupation are being established now, so answers may vary.

EXERCISE 8

a)	2.6 cm	e)	13.2 cm
b)	58.3 cm	f)	80.2 cm
c)	9.4 cm	g)	140.0 cm
d)	68.0 cm	h)	230.7 cm

EXERCISES 9 THRU 13

Tables are reproduced in total. Answers are in parentheses.

Exercise 9

metre m	centimetre cm	millimetre mm
1	100	1 000
2	200	(2 000)
3	(300)	(3 000)
9	(900)	(9 000)
(5)	(500)	5 000
74	(7 400)	(74 000)
0.8	80	(800)
0.6	(60)	600
(0.025)	2.5	25
(0.148)	(14.8)	148
(6.39)	639	(6 390)

Exercise 10

millilitres ml	litres l
3 000	3
6 000	(6)
(8 000)	8
(14 000)	(14)
(23 000)	23
300	0.3
700	(0.7)
(900)	0.9
250	(0.25)
(470)	0.47
275	(0.275)

Exercise 11

litres l	millilitres ml
8	8 000
5	(5 000)
46	(46 000)
(32)	32 000
0.4	(400)
0.53	(530)
(0.48)	480

Exercise 12

grams g	kilograms kg
4 000	4
9 000	(9)
23 000	(23)
(8 000)	8
300	(0.3)
275	(0.275)

Exercise 13

kilograms kg	grams g
7	7 000
11	(11 000)
(25)	25 000
0.4	(400)
0.63	(630)
(0.175)	175

Exercise 14

a)	50 mm	l)	1 000 cm
b)	2.5 t	m)	10 mm
c)	5 cm x 80 cm	n)	2 000 g
d)	250 ml	o)	1 000 mm x 2 100 mm
e)	2.4 m	p)	0.5 litre
f)	0.65 m	q)	30 mm
g)	500 kg	r)	5 000 cm
h)	2 000 mm	s)	2.5 kg
i)	0.5 kg	t)	12 cm
j)	1 200 mm x 2 400 cm	u)	500 ml
k)	0.25 litre	v)	240 cm

EXERCISES 15 AND 16

The answers depend on the items used for the activities.

EXERCISE 17

Part 1.

a)	0.9 kg	l)	5.08 cm x 10.16 cm x 2.44 m
b)	3.8 litres	m)	0.61 m
c)	1.905 cm	n)	15.24 cm
d)	4 ha	o)	0.635 cm
e)	450 kg	p)	452.8 g
f)	45.72 cm	q)	1.22 m x 0.61 m
g)	7.58 litres	r)	18.95 litres
h)	1.83 m		
i)	29.6 ml		
j)	4.83 km		
k)	20.32 cm		

Part 2.

a)	44.5 mm	f)	0.16 in.
b)	0.51 in.	g)	482.6 mm
c)	115.29 m^2	h)	3,570.38 $ft.^2$
d)	4.44 in.	i)	17.39 in.
e)	1 000 mm	j)	30.48 cm

Part 3.

a)	540 kg
b)	5 - 3.79 litres
c)	45.5 m
d)	90 m^2
e)	0.47 litre
f)	1.83 m
g)	6 - 10.16 cm

TESTING METRIC ABILITIES

1.	C	8.	D	15.	A
2.	B	9.	D	16.	A
3.	C	10.	A	17.	D
4.	C	11.	B	18.	B
5.	B	12.	B	19.	A
6.	D	13.	C	20.	A
7.	D	14.	B	21.	C

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SUGGESTED METRIC TOOLS AND DEVICES NEEDED TO COMPLETE MEASUREMENT TASKS IN EXERCISES 1 THROUGH 5

(* Optional)

LINEAR

- Metre Sticks
- Rules, 30 cm
- Measuring Tapes, 150 cm
- *Height Measure
- *Metre Tape, 10 m
- *Trundle Wheel
- *Area Measuring Grid

VOLUME/CAPACITY

- *Nesting Measures, set of 5, 50 ml - 1 000 ml
- Economy Beaker, set of 6, 50 ml - 1 000 ml
- Metric Spoon, set of 5, 1 ml - 25 ml
- Dry Measure, set of 3, 50, 125, 250 ml
- Plastic Litre Box
- Centimetre Cubes

MASS

- Bathroom Scale
- *Kilogram Scale
- *Platform Spring Scale
  - 5 kg Capacity
  - 10 kg Capacity
- Balance Scale with 8-piece mass set
- *Spring Scale, 6 kg Capacity

TEMPERATURE

- Celsius Thermometer

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SUGGESTED METRIC TOOLS AND DEVICES NEEDED TO COMPLETE OCCUPATIONAL MEASUREMENT TASKS

In this occupation the tools needed to complete Exercises 6, 15, and 16 are indicated by "★."

★	A.	Assorted Metric Hardware—Hex nuts, washers, screws, cotter pins, etc.
	B.	Drill Bits—Individual bits or sets, 1 mm to 13 mm range
★	C.	Vernier Caliper—Pocket slide type, 120 mm range
★	D.	Micrometer—Outside micrometer caliper, 0 mm to 25 mm range
	E.	Feeler Gage—13 blades, 0.05 mm to 1 mm range
★	F.	Metre Tape—50 or 100 m tape
★	G.	Thermometers—Special purpose types such as a clinical thermometer
	H.	[1] Temperature Devices—Indicators used for ovens, freezing/cooling systems, etc.
	I.	Tools—Metric open end or box wrench sets, socket sets, hex key sets
	J.	Weather Devices—Rain gage, barometer, humidity, wind velocity indicators
★	K.	[1] Pressure Gages—Tire pressure, air, oxygen, hydraulic, fuel, etc.
	L.	[1] Velocity—Direct reading or vane type meter
	M.	Road Map—State and city road maps
★	N.	Containers—Buckets, plastic containers, etc., for mixing and storing liquids
★	O.	Containers—Boxes, buckets, cans, etc., for mixing and storing dry ingredients

Most of the above items may be obtained from local industrial, hardware, and school suppliers. Also, check with your school district's math and science departments and/or local industries for loan of their metric measurement devices.

[1] Measuring devices currently are not available. Substitute devices (i.e., thermometer) may be used to complete the measurement task.

REFERENCES

Going Metric in Drafting. Center for Metric Education, Western Michigan University, Kalamazoo, MI 49001, 1974, (available through the industrial education departments of teacher education instutions in each of the states), 51 transparency masters, Notes and Comments (12 pages).

Set of transparency masters and teacher's script for metrication of drafting in construction and manufacturing. Includes various scale comparisons, rounding-off rules and tolerancing, preferred metric linear sizes for engineering design, comparisons of first- and third-angle orthographic metric drawings, ISO metric thread sizes, and reading metric micrometers and calipers.

Let's Measure Metric. A Teacher's Introduction to Metric Measurement. Division of Educational Redesign and Renewal, Ohio Department of Education, 65 S. Front Street, Columbus, OH 43215, 1975, 80 pages; $1.50, must include check to state treasurer.

Activity-oriented introduction to the metric system designed for independent or group inservice education study. Introductory information about metric measurement; reproducible exercises apply metric concepts to common measurement situations; laboratory activities for individuals or groups. Templates for making metre tape, litre box, square centimetre grid.

Measuring with Meters, or, How to Weigh a Gold Brick with a Meter-Stick. Metrication Institute of America, P.O. Box 236, Northfield, IL 60093, 1974, 23 min., 16 mm, sound, color; $310.00 purchase, $31.00 rental.

Film presents units for length, area, volume and mass, relating each unit to many common objects. Screen overprints show correct use of metric symbols and ease of metric calculations. Relationships among metric measures of length, area, volume, and mass are illustrated in interesting and unforgettable ways.

Metric Education, An Annotated Bibliography for Vocational, Technical and Adult Education. Product Utilization, The Center for Vocational Education, The Ohio State University, Columbus, OH 43210, 1974, 149 pages; $10.00.

Comprehensive bibliography of instructional materials, reference materials and resource list for secondary, post-secondary, teacher education, and adult basic education. Instructional materials indexed by 15 occupational clusters, types of materials, and educational level.

Metric Education, A Position Paper for Vocational, Technical and Adult Education. Product Utilization, The Center for Vocational Education, The Ohio State University, Columbus, OH 43210, 1975, 46 pages; $3.00.

Paper for teachers, curriculum developers, and administrators in vocational, technical and adult education. Covers issues in metric education, the metric system, the impact of metrication on vocational and technical education, implications of metric instruction for adult basic education, and curriculum and instructional strategies.

Metric Supplement to Technical Drawing. Mark Henschel, 3123 N. Seminary, Chicago, IL 60657, 1975, 48 pages, $1.50; 40% discount to schools and non-profit institutions.

Introduction to reading metric drawings based on the practices of American industries going metric. Describes basic metric units and prefixes, international metric paper sizes, converting inch drawings to metric, making tolerance conversions, dual-dimensioning practices, first-angle projections, special symbols, and thread designations. Includes drawings from industries—International Harvester, ITT Gilfillan, Caterpillar Tractor, Clarke Equipment, General Motors—and on ISO Metric Screw Threads. Sets of questions with drawings, answers appended. Conversion charts appended for tap and drill sizes.

Metrics in Career Education. Lindbeck, John R., Charles A. Bennett Company, Inc., 809 W. Detweiller Drive, Peoria, IL 61614, 1975, 103 pages, $3.60, paper; $2.70 quantity school purchase.

Presents metric units and notation in a well-illustrated manner. Individual chapters on metrics in drafting, metalworking, woodworking, power and energy, graphic arts, and home economics. Chapters followed by several learning activities for student use. Appendix includes conversion tables and charts.

Taking the Tricks Out of Metrics. Metric Training Department, Creative Universal, Inc., Tower 14, 21700 Northwestern Highway, Southfield, MI 48975, 1976, 4 booklets; $3.00 each, $12.00 set, discounts.

Series of booklets presents step-by-step directions, questions, answers on how to read metric measurement tools: micrometers, vernies calipers, rules, dial indicators.

METRIC SUPPLIERS

Brown & Sharpe Manufacturing Co., Precision Park, North Kingstown, RI 02852

Industrial quality micrometers, steel rules, screw pitch and thickness gages, squares, depth gages, calipers, dial indicators, conversion charts and guides.

Central Instrument Company, 900 Riverside Drive, New York, NY 10032.

Drafting rules and scales for drafting, engineering, architecture, conversion tables and slides, posters, teaching aids, drafting templates.

Dick Blick Company, P.O. Box 1267, Galesburg, IL 61401.

Instructional quality rules, tapes, metre sticks, cubes, height measures, trundle wheels, measuring cups and spoons, personal scales, gram/kilogram scales, feeler and depth gages, beakers, thermometers, kits and other aids.

Regal-Beloit Corporation, P.O. Box 38, South Beloit, IL 61080.

Audio-cassettes, books, charts and posters, films, filmstrips, industrial measuring instruments and metric fasteners, kits, periodicals, reports and pamphlets, slides and transparencies.

INFORMATION SOURCES

American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, DC 20036.

Charts, posters, reports and pamphlets, *Metric Reporter* newsletter. National metric coordinating council representing industry, government, education, professional and trade organizations.

National Bureau of Standards, Office of Information Activities, U.S. Department of Commerce, Washington, DC 20234.

Free and inexpensive metric charts and publications, also lends films and displays.