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ABSTRACT

Designed to meet the job-related metric measurement needs of students interested in wastewater technology, this instructional package is part of a set of 55 packages for metric instruction in different occupations. The package is intended for students who already know the occupational terminology, measurement terms, and tools currently in use. Each of the five units in this instructional package 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 the 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. The material is designed to accommodate a variety of individual teaching and learning styles, e.g., independent study, small group, or whole-class activity. Exercises are intended to facilitate experiences with measurement instruments, tools, and devices used in this occupation and job-related tasks of estimating and measuring. Unit I, a general introduction to the metric system of measurement, 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, a skill considered useful during the transition to metric in each occupation. (HD)

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metrics for wastewater technology

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ERIC

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 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 gives students experience with using the compound metric units particular to this occupation.

Unit 6 is designed to give students practice in converting Customary and metric measurements. 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.

Gloria S. Cooper
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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.

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:	millimetre (mm) centimetre (cm)	square centimetre (cm^2)	cubic centimetre (cm^3)	gram (g)	degree Celsius (°C)
2. Select, use, and read the appropriate measuring instruments for:	metre (m)	square metre (m^2)	cubic metre (m^3) litre (l)	kilogram (kg)	
3. State or show a physical reference for:			millilitre (ml)		
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

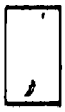
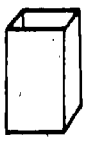
Quantity	Metric Unit	Symbol	Useful Referents
Length	millimetre	mm	Thickness of dime or paper clip wire
	centimetre	cm	Width of paper clip
	metre	m	Height of door about 2 m
	kilometre	km	12-minute walking distance
Area	square centimetre	cm^2	Area of this space 
	square metre	m^2	Area of card table top
	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 (měg'ă)	M
$1\,000 = 10^3$	kilo (kĭl'ō)	k
$100 = 10^2$	hecto (hĕk'tō)	h
$10 = 10^1$	deka (dĕk'ă)	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

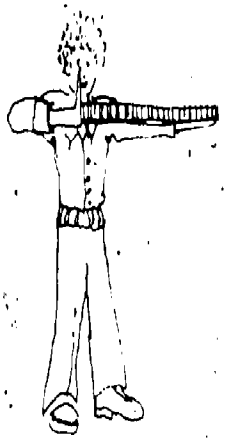
I. THE METRE (m)

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!

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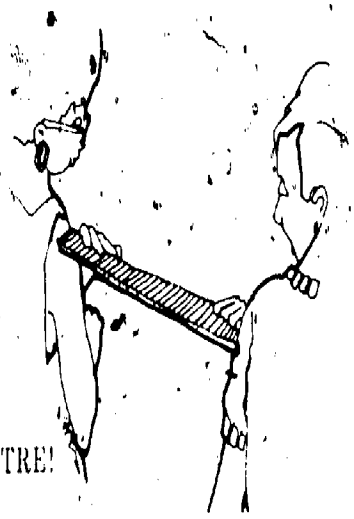
3. Choose a partner to stand at your side. Move apart so that you can put one end of a metre stick on your partner's shoulder and the other end on your shoulder. Look at the space between you.



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 1 metres and 3 centimetres, you write 103 cm [(1 x 100 cm) + 3 cm = 100 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!

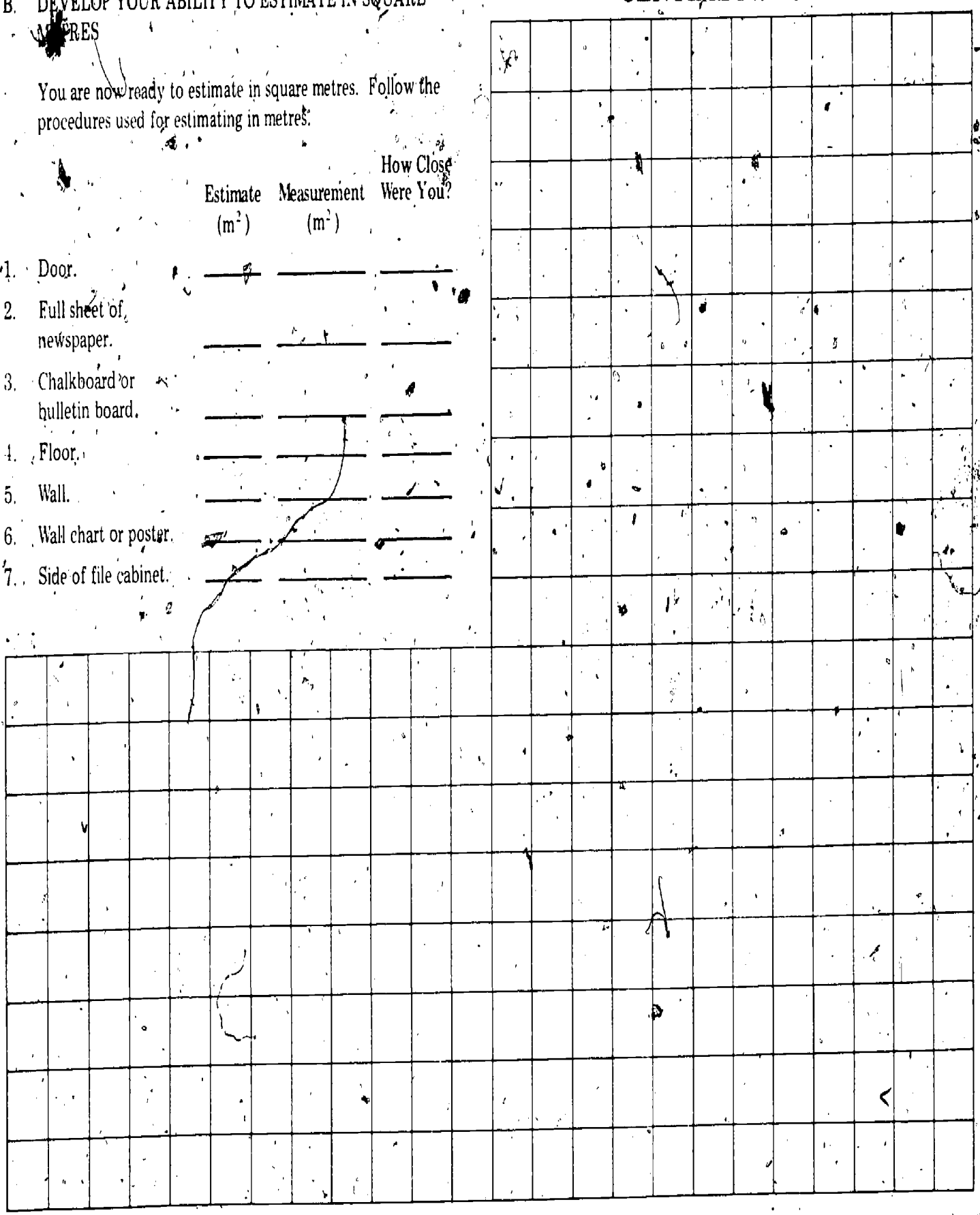
Exercise 2
(continued on next page)

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.			

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.

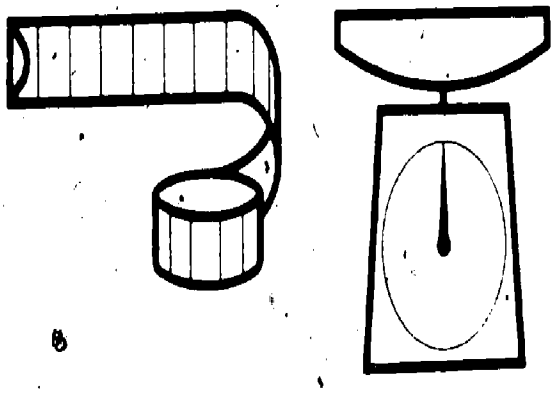
SUGGESTED TEACHING SEQUENCE

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 WASTEWATER

Quantity	Unit	Symbol	Use
Linear dimensions	millimetre	mm	Manometer tube; U-tube.
	centimetre	cm	Diameter of a pipe; tubing.
	metre	m	Length of a channel or sewer.
Area	square centimetre	cm^2	Area of the nappe over weir.
	square metre	m^2	Area of a clarifier; trucking filter.
	hectare	ha	Area of a lagoon (100 m x 100 m).
	square kilometre	km^2	Area of a collection system.
Volume/Capacity	cubic centimetre	cm^3	Capacity of a cylinder.
	cubic metre	m^3	Capacity of an aeration tank.
	millilitre	ml	Volume of thiosulfate for a DO titration.
	litre	l	A lab sample.
Mass	gram	g	Mass of a dry reagent.
	kilogram	kg	Sludge.
	metric ton	t	Truck loads of sludge.
Temperature	degree Celsius	°C	Water temperature.
Pressure	kilopascal	kPa	Pump pressure.
Flow Rates	cubic metres per second	m^3/s	Flow over a weir.
	cubic metres per minute	m^3/min	Flow through a channel.
	cubic metres per day	m^3/d	Flow through a wastewater plant.
	litres per second	l/s	Flow through a pipe.
Application Rate	grams per cubic metre	g/m^3	Amount of chlorine used per m^3 of water.
	kilograms per day	kg/d	Chlorinator setting.
	cubic metres per cubic megametre	m^3/Mm^3	Grit removed per flow unit.
Power	kilowatt	kW	Electric motor.
	Watt	W	Rating of a motor.
Energy	Joule	J	Energy required to pump water.

Table 2

TRYING OUT METRIC UNITS

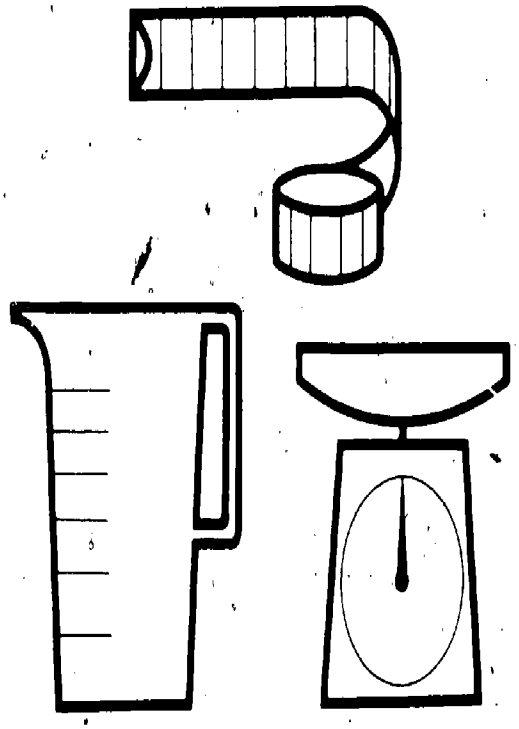
To give you practice with metric units, first estimate the measurements of the items below. Write down your best guess next to the item. Then actually measure the item and write down your answers using the correct metric symbols. The more you practice, the easier it will be.

	Estimate	Actual
Length		
1. Palm width		
2. Hand span		
3. Ceiling height of this room		
4. Width of paper clip		
5. Thickness of nickel		
6. Width of this room		
7. Diameter of U-tube		
8. Length of a fish tank		
9. Diameter of a manometer tube		
Area		
10. Desk top		
11. Classroom floor		
12. Workbench		
13. Sheet of paper		
14. Pipe cross section		
Volume/Capacity		
15. Small bottle		
16. Measuring cup (metric)		
17. Milk container		
18. Bucket		
19. Small box		
20. Tool box		
21. Aeration tank		
22. Cylinder		
Mass		
23. Textbook		
24. Nickel		
25. Paper clip		
26. A litre of water (net)		
27. Roll of 50/50 solder		
28. A quantity of dry reagent		
Temperature		
29. Room temperature		
30. Outside temperature		
31. Hot-tap water		
32. Ice water		

WASTEWATER METRICS

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

1. Volume of an aeration tank	
2. Length of a channel	
3. Area of a trickling filter	
4. Amount of sludge incinerated each day	
5. Capacity of a motor	
6. Depth of sludge placed on a drying bed per filling	
7. Flow of water through a pipe	
8. Size of waste treatment plant	
9. Amount of water evaporated each hour	
10. Depth of a channel	
11. A sedimentation tank:	
a. length	
b. width	
12. Diameter of a pipe	
13. Area of a sludge bed	
14. Cross sectional area of a grit chamber	
15. Volume of a fish tank	
16. Volume of a clarifier	
17. Mass of a wheelbarrow	
18. Mass of a set screw	
19. Truck load of sludge	
20. Temperature of a stream	
21. Area of a lagoon or pond	
22. Volume of a grab sample	



UNIT 3

OBJECTIVE

The student will recognize and use metric equivalents.

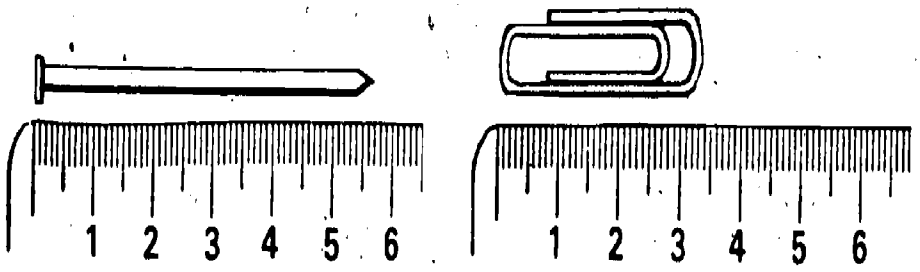
- Given a metric unit, state an equivalent in a larger or smaller metric unit.

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."

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
		118
	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,

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

Or

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

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.

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

Change 57 millilitres to litres.

$57 \text{ ml} = \frac{57}{1\,000} \text{ litre} = 0.057 \text{ litre}$ (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
11 000	
	23
300	0.3
700	
	0.9
250	
	0.47
275	

Exercise 10

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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	
	180

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
1 000	1
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 metric equivalents by completing these statements.

a) 340 ml of water is _____ l
b) 23 g of water is _____ kg
c) 2 300 g of solids is _____ kg
d) 3 400 kg of sludge is _____ t
e) 120 mm pipe diameter is _____ cm
f) 1 300 cm of pipe is _____ m
g) 29 litres of water is _____ ml
h) 5 cm diameter tube is _____ mm
i) 250 ml of solution is _____ l
j) 0.25 litre of liquid is _____ ml
k) 250 mm diameter pipe is _____ cm
l) 0.75 kg of dry reagent is _____ g
m) 2.4 t of sludge is _____ kg
n) 40 litre tank is _____ ml

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.

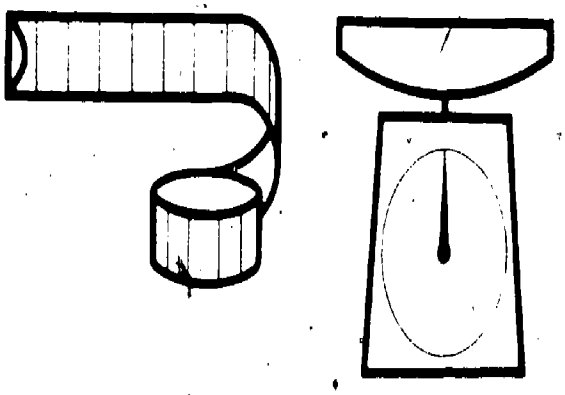
SUGGESTED TEACHING SEQUENCE

1. Assemble metric and Customary measuring tools and devices (rules, scales, ^{o}C thermometer, wrenches, micrometer, gages, meters, and glassware) and display in separate groups at learning stations.
2. Present or make available Information Sheet 9.
3. Have students examine metric tools and instruments for distinguishing characteristics and compare them with Customary tools and instruments.
4. Have students verbally describe characteristics.
5. Mix metric and Customary tools or equipment at learning station. Give each student a metric assignment.
6. Evaluate performance from 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 improper dosages, damaged materials, or injury to self or fellow workers. For example, putting 25 pounds per day of chlorine into a treated flow requiring 25 kilograms will not sterilize the outflow. 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, hundreds 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 drill bits, feeler gages.
6. Some products may have a special metric symbol such as a block M to show they are metric.
7. Don't force bolts, wrenches, or other devices which are not fitting properly.
8. Practice selecting and using tools, instruments, and devices.
9. Note that a 3/8 in. ratchet for a socket wrench set, 1 cm by 1 cm or 1 cm^2, fits Customary or metric sockets.



UNIT 5

OBJECTIVE

The student will recognize and use appropriate metric compound expressions used in wastewater treatment.

- Given the event to be measured, recognize the correct metric expression.
- Given the event to be measured, select and use the correct metric expression.

SUGGESTED TEACHING SEQUENCE

1. Present or make available Information Sheet 10.
2. Have students complete Exercise 15 and Exercise 16.
3. Test performance with Section D of "Testing Metric Abilities."

METRIC COMPOUND EXPRESSIONS FOR WASTEWATER TREATMENT

Metric units are combined in series to describe specific events. The rate of flow through a pipe is stated as cubic metres per second, m^3/s. This expression measures the amount of water (m^3) that passes a certain point each second (s).

The amount of water evaporated each hour is stated as kilograms per hour—kg/h. Various other combinations will be used to describe other conditions. For example, the amount of water flow each day (m^3/d) compared to the sand filter surface area (m^2), provides the compound expression $m^3/d/m^2$.

A compound may consist of 2 combined units or 3 combined units. Below is a chart showing combinatorial possibilities. This chart is not exhaustive.

In a two-unit expression, any line item in Column A may be combined with any line item from Column B or C.

In a three-unit expression, any line item in Column A may be followed by any line item from Column B plus any line item from Column C.

Examples:

From:		
	Column A	m^3
	Column A and B	m^3/s
	Column A and B and C	$m^3/h/m^3$
	Column A and C	m^3/m^2

METRIC COMPOUND EXPRESSION CHART

Column A	Column B	Column C
1. m	s	m
2. m^2	min	m^2
3. m^3	hr	m^3
4. mg	d	mg
5. g	wk	g
6. kg	mo	kg
7. t	a	t
8. l	yr	l

MEASURING UP IN WASTEWATER TREATMENT

List the appropriate metric expression for the description given.

1. Flow over weirs	
2. Amount of wet solids disposed of each year	
3. Amount of air compared to the amount of wastewater treated	
4. Surface area weir length ratio	
5. Amount of solids per day per surface area	
6. Mass each day of volatile solids compared to digester volume	
7. Heat required per amount of water evaporated	
8. Mass of BOD applied each day compared to the volatile solids under aeration	
9. Flow each day per weir length	
10. Mass of wet sludge each hour per unit of hearth area	
11. Amount of chlorine per the amount of wastewater	
12. Rate of water evaporated each hour	
13. Depth of wet sludge placed on a drying bed per year	

Exercise 15

What metric expression is required in the following statements?

1. A waste treatment plant receives 68 000 _____ of domestic sewage and 15 000 _____ of industrial waste.
2. A 20 l sample of wastewater contains 2 000 _____ of solids.
3. A 1.5 _____ motor is used to drive a sump pump.
4. Influent BOD to a series of ponds is 200 _____.
5. There is a flow of 3 800 _____ containing 120 _____ BOD primary effluent and 2 600 _____ air is used.
6. The DO in a receiving stream was 10.3 mg/l when the temperature was 11 _____.
7. 110 _____ of chlorine are used to treat 3 785 m^3 of water.
8. A litre sample of wastewater contains 1.2 _____ of a solid.
9. Suspended solids removal at a plant yields 2 838 _____ of dry weight suspended solids.
10. A digester produced 27 000 _____ each day of gas when loaded.
11. The average temperature of a stream based on the following measurements is _____.

Time	Temperature °C
12 noon	12.7
6 P.M.	13.3
12 midnight	11.6
6 A.M.	10.4

Exercise 16

UNIT 6

OBJECTIVE

The student will recognize and use metric and Customary units interchangeably 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.
- Given a metric (or Customary) amount, state the approximate Customary (or metric) amount.

SUGGESTED TEACHING SEQUENCE

1. Assemble part, pumps and gages of wastewater treatment facility.
2. Present or make available Information Sheet 11 and Table 3.
3. Have students find approximate metric-Customary equivalents by using Exercise 17.
4. Test performance by using Section E of "Testing Metric Abilities."

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

GALLONS TO LITRES						LITRES TO GALLONS					
gal.	l	gal.	l	gal.	l	l	gal.	l	gal.	l	gal.
100	378.5	10	37.9	1	3.8	100	26.41	10	2.64	1	0.26
200	757.1	20	75.7	2	7.6	200	52.84	20	5.28	2	0.53
300	1 135.6	30	113.6	3	11.4	300	79.25	30	7.92	3	0.79
400	1 514.1	40	151.4	4	15.1	400	105.67	40	10.57	4	1.06
500	1 892.7	50	189.2	5	18.9	500	132.09	50	13.21	5	1.32
600	2 271.2	60	227.1	6	22.7	600	158.51	60	15.85	6	1.59
700	2 649.7	70	264.9	7	26.5	700	184.92	70	18.49	7	1.85
800	3 028.3	80	302.8	8	30.2	800	211.34	80	21.13	8	2.11
900	3 406.8	90	340.7	9	34.1	900	237.76	90	23.78	9	2.38

GALLONS TO CUBIC METRES								CUBIC METRES TO GALLONS					
gal.	m^3	gal.	m^3	gal.	m^3	gal.	m^3	m^3	gal.	m^3	gal.	m^3	gal.
1,000,000	3 785	100,000	378.5	10,000	37.9	1,000	3.8	100 000	26,417,200	10 000	2,641,720	1 000	264,172
2,000,000	7 570	200,000	757.0	20,000	75.7	2,000	7.6	200 000	52,834,410	20 000	5,283,441	2 000	528,344
3,000,000	11 355	300,000	1 135.5	30,000	113.6	3,000	11.4	300 000	79,251,610	30 000	7,925,161	3 000	792,516
4,000,000	15 140	400,000	1 514.0	40,000	151.4	4,000	15.1	400 000	105,668,800	40 000	10,566,880	4 000	1,056,688
5,000,000	18 927	500,000	1 892.7	50,000	189.3	5,000	18.9	500 000	132,086,000	50 000	13,208,600	5 000	1,320,860
6,000,000	22 712	600,000	2 271.2	60,000	227.1	6,000	22.7	600 000	158,503,200	60 000	15,850,320	6 000	1,585,032
7,000,000	26 498	700,000	2 649.8	70,000	265.0	7,000	26.5	700 000	184,920,400	70 000	18,492,040	7 000	1,849,204
8,000,000	30 028	800,000	3 002.8	80,000	300.3	8,000	30.0	800 000	211,337,600	80 000	21,133,760	8 000	2,113,376
9,000,000	34 069	900,000	3 406.9	90,000	340.7	9,000	34.1	900 000	237,754,800	90 000	23,775,480	9 000	2,377,548

ANY WAY YOU WANT IT

You are working in a wastewater treatment plant. With the change to metric measurement some of the devices you measure are marked only in metric units. You will need to be familiar with appropriate Customary equivalents in order to communicate. To develop your skill use Table 3 to do the following exercises.

1. A flow measuring meter at a wastewater treatment plant recorded the following flow data. Convert it to the appropriate metric equivalents:

	Customary	Metric
a) Monday	8,000,000 gals.	_____
b) Tuesday	7,500,000 gals.	_____
c) Wednesday	8,140,000 gals.	_____
d) Thursday	8,737,000 gals.	_____
e) Friday	10,000,000 gals.	_____
f) Saturday	9,660,000 gals.	_____
g) Sunday	7,122,000 gals.	_____

2. A series of new wastewater treatment plants along the Racoon River have the following daily flow rate. Convert to gallons for reporting purposes.

Plant	Metric Flow	Customary Quantity
A	40 000 m^3	_____
B	24 000 m^3	_____
C	59 000 m^3	_____

3. The water consumption of a home for a week was read in litres. Convert the data to gallons.

	Metric	Customary
a) Monday	900 litres	_____
b) Tuesday	850 litres	_____
c) Wednesday	797 litres	_____
d) Thursday	958 litres	_____
e) Friday	699 litres	_____
f) Saturday	910 litres	_____
g) Sunday	785 litres	_____

4. The flow thru four channels was as follows. Convert to litres.

	Customary	Metric
A	900 gals.	_____
B	780 gals.	_____
C	835 gals.	_____
D	698 gals.	_____

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 mass of sludge is measured in:

   [A] litres per second

   [B] kilograms

   [C] cubic metres

   [D] hectares

4. Application rates of chlorine used in water treatment are normally given in:

   [A] grams per kilogram

   [B] millilitres per litre

   [C] cubic metres per day

   [D] grams per cubic metre

5. The correct way to write twenty grams is:

   [A] 20 gms

   [B] 20 Gm.

   [C] 20 g.

   [D] 20 g

6. 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

7. A pipe 100 mm in diameter is equal to:

   [A] 10 centimetres

   [B] 1 000 centimetres

   [C] 0.1 centimetre

   [D] 100 centimetres

8. Two metric tons of sludge has a mass of:

   [A] 2 000 kilograms

   [B] 10 000 kilograms

   [C] 20 000 kilograms

   [D] 1 000 kilograms

SECTION C

9. To measure millilitres, use a:

   [A] scale

   [B] graduated cylinder

   [C] pressure gage

   [D] rule

10. To measure grams, use a:

    [A] pressure gage

    [B] graduated cylinder

    [C] scale

    [D] rule

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SECTION D

11. Flow over a weir can be expressed as:

    [A] m^3/day/g

    [B] m^3/day/km

    [C] m^3/day/m

    [D] m^3/day/litre

12. The amount of dry sludge solids in the flow is expressed as:

    [A] kw/m^3

    [B] litre/m^3

    [C] m^2/m^3

    [D] g/m^3

13. The metric expression kg/h/m^2 is used to describe:

    [A] water flow through a filter

    [B] wet sludge on a heating surface

    [C] weir overflow rate

    [D] chlorine demand of an effluent

14. The metric expression mg/litre is used to describe:

    [A] chlorine demand of an effluent

    [B] weir overflow rate

    [C] water flow through a filter

    [D] wet sludge on a heating surface

SECTION E

15. The metric unit which replaces the fluid ounce is:

    [A] millilitre

    [B] gram

    [C] litre

    [D] hectare

16. The metric unit which replaces the acre is:

    [A] metre

    [B] hectare

    [C] cubic centimetres

    [D] gram

Use this conversion table to answer questions 17 and 18.

m^3	gal.
10 000	2,641,720
20 000	5,283,441
30 000	7,925,161
40 000	10,566,880
50 000	13,208,600
60 000	15,850,320

m^3	gal.
1 000	264,172
2 000	528,244
3 000	792,516
4 000	1,056,688
5 000	1,320,860
6 000	1,585,032

17. The equivalent of 15 000 m^3 is:

    [A] 15,000,000 gal.

    [B] 15,000 gal.

    [C] 3,962,580 gal.

    [D] 2,641,720 gal.

18. The equivalent of 61 000 m^3 is:

    [A] 15,850,320 gal.

    [B] 16,114,492 gal.

    [C] 61,000 gal.

    [D] 61,000,000 gal.

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
b) 58.3 cm
c) 9.4 cm
d) 68.0 cm
e) 13.2 cm
f) 80.2 cm
g) 140.0 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) 0.34 litre
b) 0.023 kg
c) 2.3 kg
d) 3.4 t
e) 12 cm
f) 1.3 m
g) 29 000 ml
h) 50 mm
i) 0.25 litre
j) 250 ml
k) 25 cm
l) 750 g
m) 2 400 kg
n) 40 000 ml

EXERCISE 15

1. m^3/s
2. m^3/yr
3. m^3/m^3
4. m^2/m
5. $g/d/m^2$
6. $g/d/m^3$
7. kJ/kg
8. g/d/g
9. $m^3/d/m$
10. $kg/h/m^2$
11. g/m^3
12. m^3/h
13. m/yr

EXERCISE 16

1. m^3/d, m^3/d
2. g
3. kW
4. mg/litre
5. m^3/d, mg/litre, m^3/d
6. °C
7. kg
8. g
9. kg
10. m^3
11. 12°C

EXERCISE 17

Part 1.

a) 30 028 m^3
b) 28 390.7 m^3
c) 30 557.9 m^3
d) 32 817.9 m^3
e) 37 854 m^3
f) 36 567.3 m^3
g) 26 959.8 m^2

Part 2.

a) 10,566,880 gal.
b) 6,340,129 gal.
c) 15,586,148 gal.

Part 3.

a) 237.76 gal.
b) 224.55 gal.
c) 210.55 gal.
d) 253.08 gal.
e) 184.67 gal.
f) 240.40 gal.
g) 207.37 gal.

Part 4.

a) 3 406.8 litres
b) 2 952.5 litres
c) 3 160.8 litres
d) 2 642.1 litres

TESTING METRIC ABILITIES

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

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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

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

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

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

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.

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, vernier calipers, rules, dial indicators.

Metric Practice Guide. American Society for Testing and Materials, Philadelphia, PA, 1972, 34 pages, $1.50, paper, ASTM Designation: E380-72e.

Commonly known as "ASTM E 380," makes detailed presentation on SI units and symbols, rules for SI style and usage, rules for conversion and rounding. Appendices on terminology, development of SI units, and conversion factors. This latest revision of the practice guide includes all current base and derived SI units, approved deviation from SI, and several sections expanded and rewritten for greater clarity. Order from: American Study for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

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.

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.

Millimeter Industrial Supply Corporation, 162 Central Avenue, Farmingdale, L. I., NY 11735.

Industrial fasteners, taps, dies, reamers, drills, wrenches, rings, bushings, calipers, steel rules and tapes, feeler gages.

Ohaus Scale Corporation, 29 Hanover Road, Florham Park, NJ 07932.

Instructional quality and precision balances and scales, plastic calipers and stackable gram cubes for beginners.

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.