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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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Joel H. Magisos
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.

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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

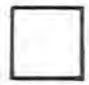
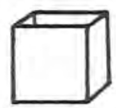
Quantity	Metric Unit	Symbol	Useful Referents
Length	millimetre	mm	Thickness of dime or paper clip wire
	centimetre	cm	Width of paper clip
	metre	m	Height of door about 2 m
	kilometre	km	12-minute walking distance
Area	square centimetre	cm^2	Area of this space 
	square metre	m^2	Area of card table top
	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

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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

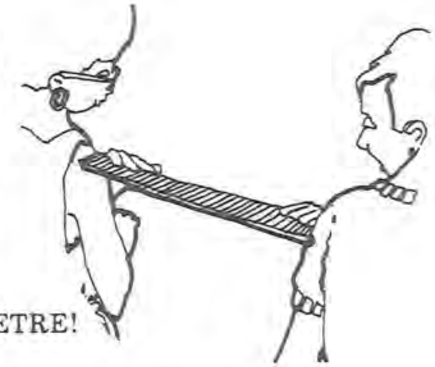
1. Pick up one of the metre sticks and stand it up on the floor. Hold it in place with one hand. Walk around the stick. Now stand next to the stick. With your other hand, touch yourself where the top of the metre stick comes on you.

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.

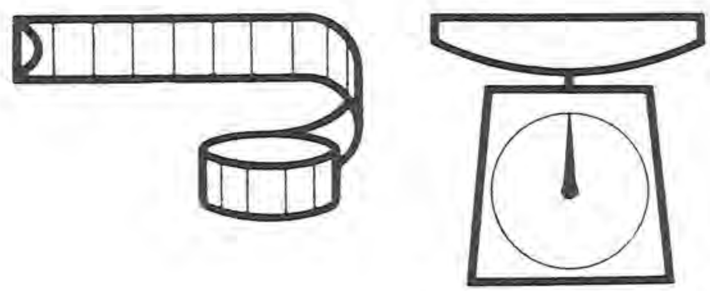
SUGGESTED TEACHING SEQUENCE

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 COMMERCIAL, INDUSTRIAL, RESIDENTIAL ELECTRICITY

Quantity	Unit	Symbol	Use
Linear dimensions	millimetre	mm	wire thickness, fastener length and diameter
	centimetre	cm	measure for box openings and box sizes
	metre	m	wire lengths
	kilometre	km	power lines, underground pipe, travel, shipping distances, customers' locations
Area	square millimetre	mm^2	cross-sectional area of wire
	square metre	m^2	floor space for power panel, room size for lighting
Volume	cubic centimetre	cm^3	storage space in cabinet and tool boxes; space needed for a wiring box, or space available inside a wiring box
	cubic metre	m^3	size of a room or building
Mass	kilograms	kg	supplies and materials, fixtures, panels
Heat energy	kilojoule	kJ	warm air to heat room
*Temperature	degree Celsius	$^{\circ}C$	used to give ambient reference temperature for wire resistance standards, oil temperature
Pressure	kilopascal	kPa	measure pressure in air lines
Flow rate (liquids or gases)	litres per minute	l/min	air flow for heating or cooling
	litres per hour	l/h	pump or metering capacities

Table 2

*Kelvin may be used in some product specifications or technical reports. $-273^{\circ}C = 0$ K, $0^{\circ}C = 273$ K, $100^{\circ}C = 373$ K.

NOTE: All other electrical units are currently metric and they will not change.
NEMA will be issuing information on electrical metric standards in the future.

TRYING OUT METRIC UNITS

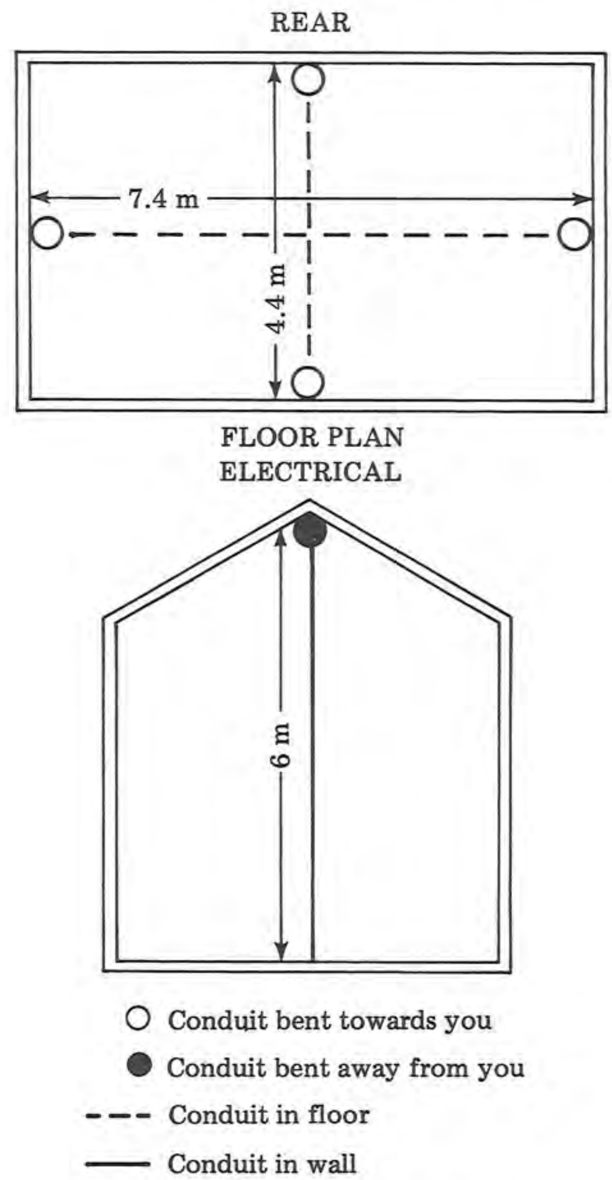
To give you practice with metric units, first estimate the measurements of the items below. Write down your best guess next to the item. Then actually measure the item and write down your answers using the correct metric symbols. The more you practice, the easier it will be.

	Estimate	Actual
Length		
1. Height of outlet from floor		
2. Length of a wall		
3. Length of a fixture		
4. Cartridge fuse length		
5. Width of a double circuit breaker		
6. Diameter of 000 gage wire		
7. Height of switch from floor		
8. Strip and measure a piece of wire for connection to a switch		
9. Length of wire needed for underwriter's knot		
10. Outside diameter of thin wall conduit		
11. Inside diameter of rigid conduit		
12. Thickness of the wall of rigid conduit		
13. Measure length of wood screw used for fastening service entrance cable clamp		

	Estimate	Actual
14. Measure a wood bit used to bore a hole for service entrance cable		
15. Measure the thickness of the entrance wall		
Area		
16. Desk top		
17. Classroom floor		
18. Workbench		
19. Power panel base		
20. Area of room for lighting		
21. Area needed to install control panel		
Volume/Capacity		
22. Junction box		
23. Octogon box		
24. Single gang old work box		
25. Locker		
26. Handy box		
27. Capacity of a tank		
28. Piece of rigid conduit		
29. Small box		
30 Wire capacity of a 13 mm conduit using 3 No. 10 THW gage wire		

	Estimate	Actual
Mass		
31. Piece of pipe		
32. Motor		
33. Light fixture		
34. Electric panel		
35. 3 metre stick of rigid conduit		
36. 3 metre stick of thin wall conduit		
37. Wall clock		
38. Wire stripper		
39. A litre of water (net)		
Temperature		
40. Outside		
41. Inside		
42. Hot water tap		
43. Cold water tap		
44. Water-cooler water		
45. Transformer oil		
46. Temperature of motor bearing		

SAMPLE METRIC DRAWING



WIRING WITH METRICS

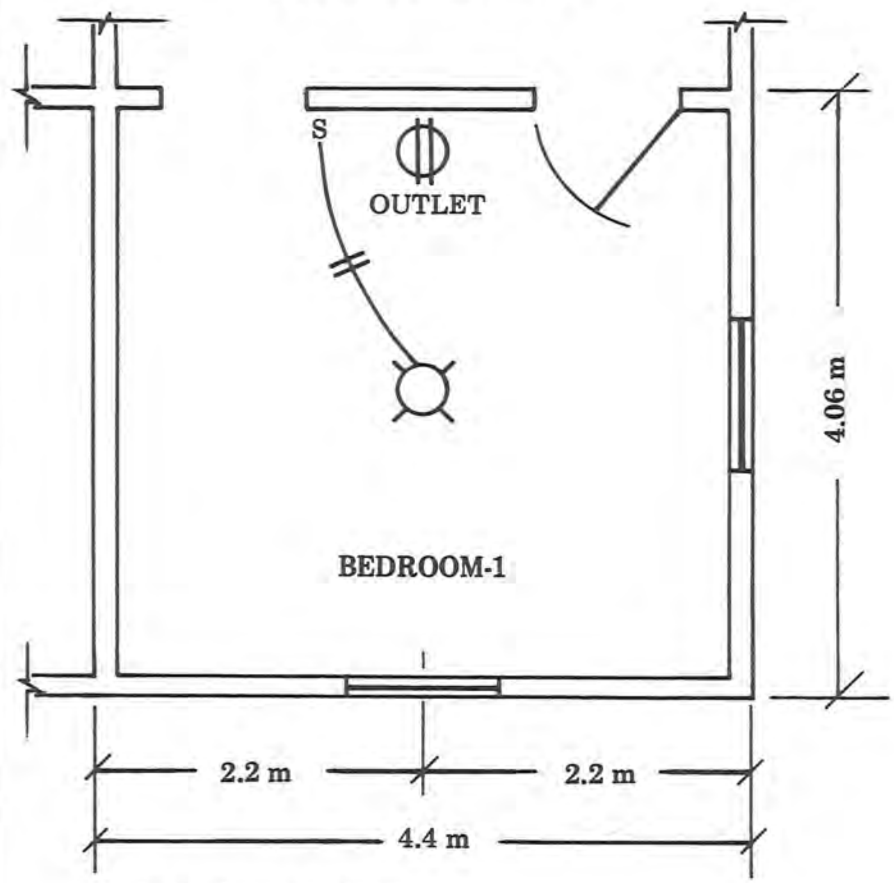
It is important to know what metric measurement to use. Show what measurement to use in the following situations.

1. Length of conduit needed from ceiling to switch box.	
2. Determine the dimensions of a wall support needed for 13 mm conduit.	
3. Measure the intervals for support clamps for 13 mm conduit.	
4. Measure the length of cable needed to run a switch loop from ceiling outlet to the wall switch in the room.	
5. Depth of ditch needed for an underground wire to be used for a ground.	
6. The distance from the ground to the weatherhead.	
7. Height of meter on outside wall.	
8. Capacity of wash basin.	
9. Fuel tank capacity of a portable power generator.	
10. Width of the wire groove in porcelain insulators used for the service wires.	
11. Measure a pipe that would be needed to accommodate four wire, three phase electric service, 500 amperes.	
12. Measure the length of a coupling used with rigid conduit.	
13. Temperature of hot water from the tap	
14. Diameter of a solenoid	
15. The depth of a power control console	
16. Length of a porcelain insulator	
17. Length of a fluorescent fixture reflector	
18. Diameter of a pipe for power entrance	
19. Length of fire extinguisher	
20. Cut opening in panel for installing an AC voltmeter	
21. Length of extension cord needed to provide power to the center of the classroom	
22. Length of three wire cable used in residential wiring	
23. Circular mil of entrance cable	
24. Thickness of copper wire including insulation that is used for wiring a chime	
25. Distance of outlet switch from floor	
26. Drill bit for holes for wiring runs	

WIRING WITH METRICS

27. Dimensions of outlet box: a. Length	
b. Width	
c. Thickness	
28. Dimensions of screw for installing duplex outlet: a. Length	
b. Diameter	
29. Length of screwdriver blade	
30. Length of wire needed from ceiling outlet to wall switch	
31. Measure the longest wire run from the entrance box	
32. Compute the area of a small room	
33. Volume of an old work box	

METRIC BLUEPRINT



SCALE: 1 mm = 50 mm

UNIT 3

OBJECTIVE

The student will recognize and use metric equivalents.

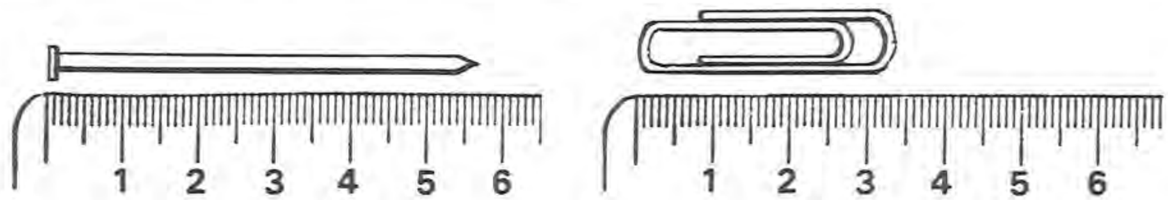
- Given a metric unit, state an equivalent in a larger or smaller metric unit.

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

Exercise 8

Metres, Centimetres, and Millimetres

There are 100 centimetres in one metre. Thus,

$2\text{ m} = 2 \times 100\text{ cm} = 200\text{ cm},$
$3\text{ m} = 3 \times 100\text{ cm} = 300\text{ cm},$
$8\text{ m} = 8 \times 100\text{ cm} = 800\text{ cm},$
$36\text{ m} = 36 \times 100\text{ cm} = 3\ 600\text{ cm}.$

There are 1 000 millimetres in one metre, so

$2\text{ m} = 2 \times 1\ 000\text{ mm} = 2\ 000\text{ mm},$
$3\text{ m} = 3 \times 1\ 000\text{ mm} = 3\ 000\text{ mm},$
$6\text{ m} = 6 \times 1\ 000\text{ mm} = 6\ 000\text{ mm},$
$24\text{ m} = 24 \times 1\ 000\text{ mm} = 24\ 000\text{ mm}.$

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

$$\begin{aligned} 0.75\text{ m} &= 0.75 \times 1\ 000\text{ mm} \\ &= \frac{75}{100} \times 1\ 000\text{ mm} \\ &= 75 \times \frac{1\ 000}{100}\text{ mm} \\ &= 75 \times 10\text{ mm} \\ &= 750\text{ mm}. \end{aligned}$$

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,

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

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.

$500\text{ ml} = \frac{500}{1\ 000}$ 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 metric equivalents by completing these statements.

a) 500 cm of wire is ______________ m
b) 250 ml of solution is ______________ l
c) 5 cm diameter pipe is ______________ mm
d) 2 500 g of oil is ______________ kg
e) 120 mm of tape is ______________ cm
f) 0.25 litre of liquid solvent is ______________ ml
g) 2 000 kg of compound is ______________ t
h) 0.5 litre of concentrate is ______________ ml
i) 2 m board is ______________ mm
j) 500 g of nails is ______________ kg
k) 500 ml of cleaner is ______________ l
l) 0.5 t of cement is ______________ kg
m) 10 m of wire is ______________ cm
n) 2.5 cm diameter pipe is ______________ mm
o) 2 400 mm wall panel length is ______________ cm

Exercise 14

UNIT 4

OBJECTIVE

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

- Give metric and Customary tools, instruments, or devices, differentiate between metric and Customary.
- Given a residential electricity task, select and use an appropriate tool, instrument or device.
- Given a metric measurement task, judge the metric quantity within 25% and measure within 5% accuracy.

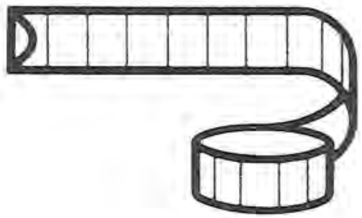
SUGGESTED TEACHING SEQUENCE

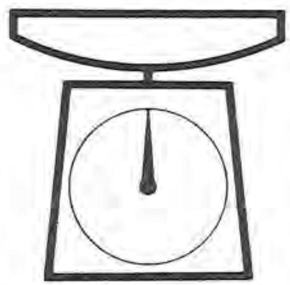
1. Assemble metric and Customary measuring tools and devices (rules, scales, ^{0}C thermometer, drill bits, wrenches, micrometer, vernier calipers, feeler gages) and display in separate groups at learning stations.
2. Have students examine metric tools and instruments for distinguishing characteristics 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 Exercise 15 and the appropriate Exercise 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 sales form, damaged materials, or injury to self or fellow workers. For example, putting 207 pounds per square inch of pressure (psi) in a truck tire designed for 207 kilopascals (about 30 psi) could cause a fatal accident. 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, etc.
5. Look for decimal fractions (0.25) or decimal mixed fractions (2.50) rather than common fractions (3/8) on drill bits, feeler gages, etc.
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.





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. Fill a can with 2 litres of lubricating oil S.A.E. 30.
2. Get 5 kilograms of rags for your work area.
3. Measure the volume of a small room for a new control console installation.
4. Take the temperature of the room.
5. Determine the distance between adjacent work benches.
6. Estimate the maximum length of screws needed to mount a motor on a machine.
7. Measure the length of a standard section of conduit.
8. Order a small spool of number 20 magnet wire.
9. Measure the length of one of the welding electrodes on a spot welder.
10. Measure the width of an electric motor pulley for selecting a belt.
11. Find the length of wire cable needed to hook-up a motor from an overhead buss bar.
12. Measure the diameter of an electric motor drive shaft.
13. Measure the length of bare wire to put around the contact screw on a male plug.
14. Determine how much wire is needed for a "T" splice.
15. Measure the length of conduit needed to suspend a fluorescent fixture from the ceiling.
16. Measure the size wrench needed to tighten the mounting nut on a rotary switch.
17. Measure 6 metres of entrance cable from the spool.
18. Make the measurements for the wire which was used to wire your classroom switches and outlets.
19. Determine how much conduit is needed in your classroom according to the local code.
20. Select the coupling needed to butt two conduits together.
21. Measure the ambient temperature of a running electric motor.
22. Measure the diameter of the spark plug from a portable power unit.
23. Locate the support pole for the service entrance cable.
24. Select the needed tool to secure a conduit to a switch box.
25. Measure the spacing between the room lights.
26. Compute the area of the tool room.
27. Measure 10 metres of 6 mm wire.
28. Fill an order for a spool of 2 mm wire.
29. Measure an outlet box to contain two switches.
30. Determine the shipping mass of 12 ceiling outlet boxes.
31. Select the drill bit for a 6 mm non-metallic three-wire cable.
32. Determine the size of a clamp to fasten the entrance cable to the building.
33. Find the mass of any piece of common house wire 20 metres long to determine the spacing of support staples.

MEASURING UP IN COMMERCIAL ELECTRICITY

For the tasks below, estimate the metric measurement to within 20% of actual measurement, and verify the estimation by measuring to within 5% of actual measurement.

	Estimate	Verify
1. Width of an "I" beam.		
2. Temperature of cooking area.		
3. Width of luminaire reflectors in room.		
4. Length of luminaire reflectors in room.		
5. Length of chain used to suspend luminaires.		
6. Dimensions of a weatherproof outlet box: a. Width		
b. Height		
7. Height of fuse panel.		
8. Length of the threads cut on the end of a rigid conduit.		
9. Thickness of dry wall: a. Side wall		
b. Ceiling		
10. Size of hole needed to install a junction box: a. Length		
b. Width		
11. The width and height of a raceway that would be required to accept three No. 12 gage wires THW: a. Length		
b. Width		

Exercise 16
(Commercial Electricity)

MEASURING UP IN INDUSTRIAL ELECTRICITY

For the tasks below, estimate the metric measurement to within 20% of actual measurement, and verify the estimation by measuring to within 5% of actual measurement.

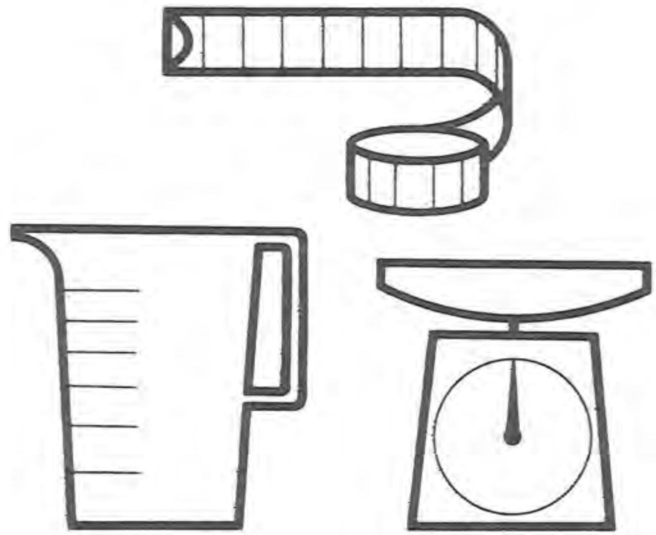
	Estimate	Verify
1. Physical dimensions of an electrical motor.		
2. Mark on a wall the location of an outlet according to code.		
3. Length of a fluorescent tube.		
4. Dimensions of a ballast: Height		
Width		
5. Measure a replacement bushing for an electric motor armature.		
6. The dimensions of a safety cover for an electric motor.		
7. How much oil will a lubrication cup on a machine hold.		
8. Dimensions of a control console: Width		
Length		
9. Volume of a control console.		
10. Measure the height of a voltage transformer.		
11. Measure the diameter of nine pairs of bell wire.		

Exercise 16
(Industrial Electricity)

MEASURING UP IN RESIDENTIAL ELECTRICITY

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. Height of wall outlet from floor		
2. Entrance box size: a. Height		
b. Width		
3. Temperature of room		
4. Height from floor for the installation of an electric dryer outlet		
5. Length of wires needed for the installation of the service entrance: a. Wire from meter box to the mast		
b. Wire from the meter to circuit breaker panel		
6. Compute the volume of your present room		
7. Using a part of the classroom wall, show how to locate the outlet in the visual, "Metric Blueprint" (p. 17). The outlet is to be placed halfway between the doors		
8. Find what size hole is needed to mount an outdoor floodlight fixture on a house if a standard junction box is used		
9. The distance from the fuse box to an electric dryer receptacle		
10. Locate the center of the room to install a light fixture: a. Length		
b. Width		



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."

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

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	1.86	2	0.19
3000	278.71	300	27.87	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

Table 3

ANY WAY YOU WANT IT

1. Your are working in an electrical supply store or warehouse. 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 lb. of graphite	
b)	2 qts. of lube oil	
c)	3/4 in. conduit	
d)	20 ft. of wire	
e)	6 ft. piece of conduit	
f)	two-gallon can	
g)	4 in. square box	
h)	8 in. needlenose pliers	
i)	6 fl. oz. of silicone spray	
j)	1/2 lb. of staples	
k)	1/2 in. screw	
l)	2 miles	

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

a)	$90 \text{ ft.}^2 =$	m^2	f)	$800 \text{ m}^2 =$	ft.^2
b)	$30 \text{ ft.}^2 =$	m^2	g)	$1620 \text{ m}^2 =$	ft.^2
c)	$2500 \text{ ft.}^2 =$	m^2	h)	$498 \text{ m}^2 =$	ft.^2
d)	$105 \text{ ft.}^2 =$	m^2	i)	$42 \text{ m}^2 =$	ft.^2
e)	$63 \text{ ft.}^2 =$	m^2	j)	$284 \text{ m}^2 =$	ft.^2
k)	$876 \text{ ft.}^2 =$	m^2	n)	$1159 \text{ m}^2 =$	ft.^2
l)	$46 \text{ ft.}^2 =$	m^2	o)	$490 \text{ m}^2 =$	ft.^2
m)	$1413 \text{ ft.}^2 =$	m^2	p)	$68 \text{ m}^2 =$	ft.^2

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, Job No., etc.). Requisition one of each of the following:
   a) 10 foot piece of 3/4 inch conduit
   b) 1 quart of lubrication oil
   c) 2 pound can of wire ease
   d) 250 foot coil of No. 12 electrical wire
   e) 1 carton of 48 inch 2-pin fluorescent lights

REQUISITION

Date ____________

For ______________________________

____

Job 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 mass of 100 conduit connectors is measured in:**
   - **[A] millilitres**
   - **[B] cubic metres**
   - **[C] kilograms**
   - **[D] litres**

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

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 board 20 centimetres wide is the same as:**
   - **[A] 2 millimetres**
   - **[B] 200 millimetres**
   - **[C] 2 000 millimetres**
   - **[D] 0.2 millimetre**

8. **An electric switch with a mass of 350 grams is the same as:**
   - **[A] 3 500 kilograms**
   - **[B] 0.35 kilogram**
   - **[C] 3.5 kilograms**
   - **[D] 35 kilograms**

SECTION C

9. **For measuring millilitres you would use:**
   - **[A] scale**
   - **[B] container**
   - **[C] pressure gage**
   - **[D] ruler**

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

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

12. **For measuring in metres you would use a:**
    - **[A] container**
    - **[B] scale**
    - **[C] tape**
    - **[D] pressure gage**

13. Estimate the length of the line segment below:
    - [A] 23 grams
    - [B] 6 centimetres
    - [C] 40 millimetres
    - [D] 14 pascals

14. Estimate the length of the line segment below:
    - [A] 10 millimetres
    - [B] 4 centimetres
    - [C] 4 pascals
    - [D] 23 milligrams

SECTION D

15. **The metric unit which replaces the fluid ounce is:**
    - **[A] litre**
    - **[B] hectare**
    - **[C] millilitre**
    - **[D] gram**

16. **The metric unit which replaces feet is:**
    - **[A] kilogram**
    - **[B] metre**
    - **[C] millimetre**
    - **[D] pascal**

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TESTING METRIC ABILITIES

17. The metric unit which replaces pounds is:

[A] metric tons

[B] grams

[C] milligrams

[D] kilograms

18. The metric unit which replaces the gallon is:

[A] cubic metre

[B] millilitre

[C] gram

[D] litre

Use this conversion table to answer questions 19 and 20.

m^2	$ft.^2$	m^2	$ft.^2$
10	107.64	1	10.76
20	215.28	2	21.53
30	322.92	3	32.29
40	430.56	4	43.06
50	538.20	5	53.82
60	645.83	6	64.58
70	753.47	7	75.35
80	861.11	8	86.11
90	968.75	9	96.87

19. The equivalent of 12 m^2 is:

[A] 107.64 $ft.^2$

[B] 32.29 $ft.^2$

[C] 36 $ft.^2$

[D] 129.17 $ft.^2$

20. The equivalent of 64 m^2 is:

[A] 968.75 $ft.^2$

[B] 64 $ft.^2$

[C] 688.89 $ft.^2$

[D] 192 $ft.^2$

Use this conversion table to answer questions 21 and 22.

mm	in.	mm	in.
100	3.94	10	0.39
200	7.87	20	0.79
300	11.81	30	1.18
400	15.74	40	1.57
500	19.68	50	1.97
600	23.62	60	2.36
700	27.56	70	2.76
800	31.50	80	3.15
900	35.43	90	3.54

21. The equivalent of 150 mm is:

[A] 5.91 in.

[B] 15 in.

[C] 150 in.

[D] 3.94 in.

22. The equivalent of 610 mm is:

[A] 6.1 in.

[B] 28.84 in.

[C] 24.01 in.

[D] 61 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)	5 m	i)	2 000 mm
b)	0.25 litre	j)	0.5 kg
c)	50 mm	k)	0.5 litre
d)	2.5 kg	l)	500 kg
e)	12 cm	m)	1 000 cm
f)	250 ml	n)	25 mm
g)	2 t	o)	240 cm
h)	500 ml		

EXERCISES 15 AND 16

The answers depend on the items used for the activities.

EXERCISE 17

Part 1.

a)	0.9 kg	g)	10.16 cm
b)	1.9 litres	h)	20.32 cm
c)	1.905 cm	i)	177.6 ml
d)	6.1 m	j)	0.225 kg
e)	1.83 m	k)	1.27 cm
f)	7.58 litres	l)	3.22 km

Part 2.

a) 8.36 m^2
b) 2.79 m^2
c) 232.26 m^2
d) 9.75 m^2
e) 5.85 m^2
f) 8,611.13 $ft.^2$
g) 17,437.54 $ft.^2$
h) 5,360.42 $ft.^2$
i) 452.09 $ft.^2$
j) 3,056.95 $ft.^2$
k) 81.38 m^2
l) 4.28 m^2
m) 131.27 m^2
n) 12,475.37 $ft.^2$
o) 5,274.31 $ft.^2$
p) 731.94 $ft.^2$

Part 3.

a) 3.05 m; 1.905 cm
b) 0.95 litre
c) 0.9 kg
d) 76.25
e) 121.92 cm

TESTING METRIC ABILITIES

1.	C	9.	B	16.	B
2.	B	10.	B	17.	D
3.	C	11.	D	18.	D
4.	B	12.	C	19.	D
5.	D	13.	B	20.	C
6.	D	14.	A	21.	A
7.	B	15.	C	22.	C
8.	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

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

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, 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.

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 Corp., 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

Precision balances and scales, plastic calipers and stackable gram cubes for beginners.

INFORMATION SOURCES

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

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

Metric Committee, National Electrical Manufacturers Association (NEMA), 155 East 44th Street, New York, NY 10017

Trade association. Publications concerning product standards and metric changeover in electrical goods manufacturing.

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

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