Math Lab 2 MS 3
Reading Voltage Scales on Multimeters
Solving Electrical Work Problems

For best results, print this document front-to-back and place it in a three-ring binder.
Corresponding teacher and student pages will appear on each opening.

TEACHING PATH - MATH SKILLS LAB - CLASS M

PREPARATORY MATH SKILLS NEEDED TO COMPLETE THIS LAB.

There are four Preparatory Math Skills Labs available in a separate book entitled *PT Resource Manual* that contain concepts your students should have mastered before they begin this Math Skills Lab. These Preparatory Math Skills Labs are coded PMS5 through PMS8. They are titled "Learning How to Measure Angles in Radians," "Area and Volume Measurement," "Working with Percents" and "Substituting in Formulas." Encourage students who need these skills to study the material in PMS5 through PMS8.

RESOURCE MATERIALS

Student Text: Math Skills Lab

PT Resource Manual

VOM meter or copy of a VOM dial face

CLASS GOALS

1. Teach students how to read VOM scales.
2. Teach students how to solve electrical work problems.

CLASS ACTIVITIES

1. Take five or ten minutes to go through the Student Exercises. Make sure that your students understand the correct answers.
2. Complete the activities. Students already should have read the discussion material and looked at the examples for each activity before coming to class. (How much is accomplished depends on the skills that your students already have.)
   a. Summarize for the students that explanatory material for Activity 1: "Reading Voltage Scales on Multimeters." Then have students complete the Practice Exercises given at the end of Activity 1.
   b. Summarize the explanatory material for Activity 2: "Solving Electrical Work Problems." Then have students complete the Practice Exercises given at the end of Activity 2.
3. Supervise student progress. Help students obtain the correct answers.
4. Before the class ends, tell your students to read Lab 2E1, "Work Done by a Motor," as homework.

Math Skills Laboratory

Lab 2 MS 3

MATH ACTIVITIES

Activity 1: Reading Voltage Scales on Multimeters

Activity 2: Solving Electrical Work Problems

MATH SKILLS LAB OBJECTIVES

When you complete these activities, you should be able to do the following:

1. ***Read the voltage indicated on the scale of a multimeter when the meter range and function are specified.***
2. ***Solve electrical work problems, given voltage and charge information.***

LEARNING PATH

1. ***Read the Math Skills Lab. Give particular attention to the Math Skills Lab Objectives.***
2. ***Solve the Practice Exercises for Activities 1 and 2.***

ACTIVITY 1

Reading Voltage Scales on Multimeters

EQUIPMENT

You'll need a volt-ohm-milliampere (VOM) meter or a copy of a VOM dial face for this activity.

Multimeters are common instruments used to measure electrical voltage, current and resistance. There are two basic types of multimeters—digital-readout meters, and VOM meters.

Digital-Readout Type: This type of multimeter gives a direct readout on a digital display. With this type of meter, you don't have to read scales. You just set the function and range switches and then read the number on the display.

VOM-Type: The volt-ohm-milliampere (VOM) meter has a large meter face (dial) that's calibrated for measurements of electrical voltage, current or resistance. A ***function switch*** sets the meter to read DC or AC. The setting depends on the voltage or current source you want to measure. A ***range switch*** sets the maximum value of voltage or current that you can read on the scales.

When you read the position of the needle on the meter scale, your position is important. You must be careful to avoid "parallax" errors while reading the VOM scale. These errors occur when your eyes aren't centered directly over the top of the needle. High-quality meters have a strip of mirror on the face of the meter. If you ***can see*** the image of the needle in the mirror while reading the scale, the meter reading taken at this position ***will be in error.*** If you ***cannot see*** the needle image while reading the scale, your eyes are directly over the needle and your reading ***will be correct.***

NOTE: To help students "see" the scales on the face of a multimeter, provide students with a real VOM (such as a Simpson meter) or make photocopy transparencies of a dial face that can be projected onto a screen. Then help students understand the choice of scales available. Explain how you decide which scale to use to read the needle position.

NOTE: Work through Example A carefully. Make sure that students understand why the 10-volt, DC scale is the one to be read. Then make sure that they can arrive at the correct reading of 7.4 volts. You will have to talk about scale divisions and volts per division on the scale.

After the students understand how the 7.4-volt reading is made, ask them to read the same needle position for meter settings of:

(a) 2.5 volts, DC

(b) 5.0 volts, DC

They should read the position as:
(a) 1.85 V for the 2.5-volt, DC range setting
(b) 3.70 V for the 5.0-volt, DC range setting

Most meter faces have multiple ranges for AC and DC readings. For example, the meter face shown in Figure 1 has three ranges labeled for the AC scales. Those ranges are 0-2.5, 0-5 and 0-10. Depending on the measurement to be made, the technician selects the proper function and range. For instance, if the technician has the meter set to read DC voltage in a 0-5-volt range, the technician uses the DC meter scale that's labeled "0-5."

The following example indicates how to read the needle position on a multimeter VOM scale.

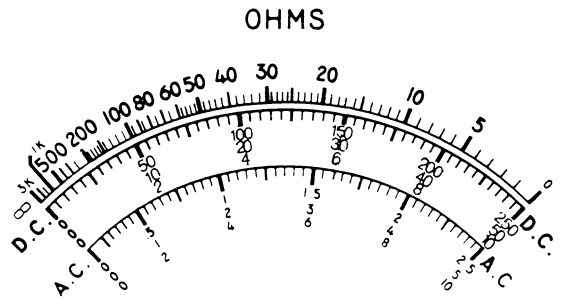
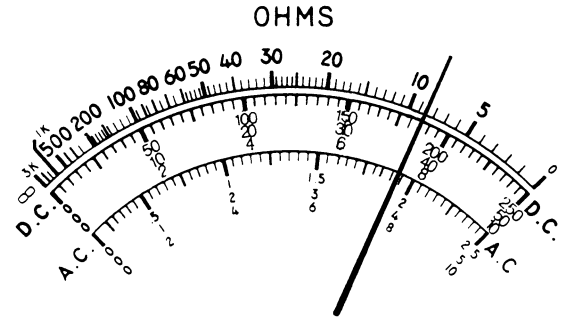


Fig. 1 Typical scales on a multimeter dial face. Note the three choices of scale for reading either AC or DC values. (The single scale at the top measures RESISTANCE, from right to left).

Example A: *Reading Voltage on a Multimeter*



Given: The function/range switch is set on DC/10 V. The needle indicates the readings shown in the figure above.

Find: The voltage reading.

Solution: The needle intersects the DC/10-volt scale between the 7- and 8-volt marks. Since there are five intervals between 7 and 8, each index line represents ⅕ of a volt—or 0.2 volt. The needle lies on top of the second line past the 7-volt mark. Thus, the reading is 7 volts + (2 × 0.2 V), or 7 volts + 0.4 volts.

The correct reading, then, is 7.4 V, DC.

Note: If the function/range switch had been set at DC/2.5 volts, the meter reading shown in Example A would have been ***1.85 volts.*** If the function/range switch had been set at DC/5 volts, the meter reading would have been ***3.7 volts.*** (See your instructor if you can't verify these results on your own.)

PRACTICE EXERCISES

Needle positions are shown on the face of a VOM meter with the given function/range setting. You should determine the correct voltage readings (indicated by the needle position) for each problem.

NOTE: You may wish to make transparencies of the meter faces shown in Problems 1 and 2 of the Practice Exercises. Then if your students have a hard time determining the correct answer, you can project the transparency and point to the dial face as you explain how to read the needle position.

ANSWERS TO PRACTICE EXERCISES

Problem 1:

Function/Range: 10 V, DC; Reading is 5.0 V, DC (on 10-V scale).
Function/Range: 5 V, DC; Reading is 2.5 V, DC (5.0 ÷ 2).
Function/Range: 2.5 V, DC; Reading is 1.25 V, DC (5.0 ÷ 4).

Problem 2:

Function/Range: 10 V, AC; Reading is 9.0 V, AC (on 10-V scale).
Function/Range: 5 V, AC; Reading is 4.50 V, AC (9.0 ÷ 2).
Function/Range: 2.5 V, AC; Reading is 2.25 V, AC (9.0 ÷ 4).

ANSWERS TO PRACTICE EXERCISES, ACTIVITY 2

Problem 1: a. $W = V \times q$ where: $V = 8$ volts
$W = 8$ volts $\times$ 5 coulombs $q = 5$ coulombs
$W = (8 \times 5)$(volt•coulombs)
$W = 40$ volt•coulombs.

b. Since one volt•coulomb is equal to one joule, the electrical work also is equal to 40 joules.

Problem 2: $W = V \times q$ where: $W = 400$ J
Solve for q. $V = 6$ V

$$q = \frac{W}{V} = \frac{400 \text{ J}}{6 \text{ V}}$$

$q = 66.6$ J/V (One coulomb is equal to one joule per volt, so the charge moved is 66.6 coulombs.)

$q = 66.6$ coulombs.

ANSWERS TO PRACTICE EXERCISES, ACTIVITY 2, Continued

Problem 3: $EFF\ (\%) = \frac{\text{Work Out}}{\text{Work In}} \times 100\%$ where: Work Out = 1500 N•m, Work In = 1800 joules = 1800 N•m

$EFF\ (\%) = \frac{1500\ \cancel{N \cdot m}}{1800\ \cancel{N \cdot m}} \times 100\%$

$EFF\ (\%) = 0.83 \times 100\%$

$EFF\ (\%) = 83\%.$

Problem 4: $W = V \times q$ where: W = 1500 J, q = 50 coulomb

Solve for V.

$V = \frac{W}{q} = \frac{1500\ J}{50\ \text{coulomb}}$

$V = 30\ \frac{J}{\text{coulomb}}.$ (One volt is equal to one joule per coulomb, so the voltage supplied to the motor was 30 V.)

Problem 5: $W = V \times q$ where: V = 6 V, q = 2 coulomb

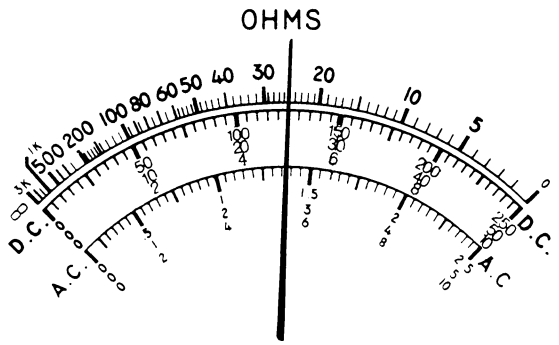
a. $W = 6\ V \times 2\ \text{coulomb}$

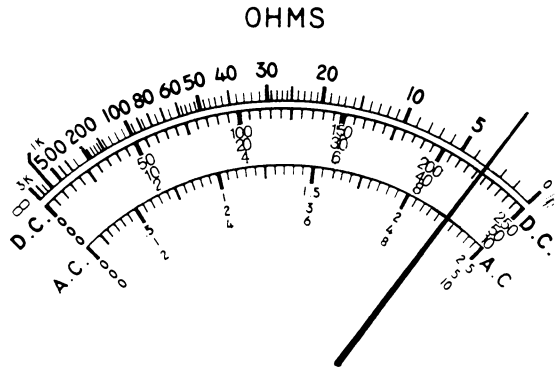
$W = 12\ \text{volt} \cdot \text{coulomb}.$ (One volt•coulomb is equal to one joule, so the electrical work done is 12 joules.)

b. One coulomb = 6.25×10^{18} electrons

2 coulomb = 2 (6.25×10^{18} electrons)

2 coulomb = 12.50×10^{18} electrons.





Problem 1:

Function/Range: DC/10 V
Reading is _____ volts, DC.
Function/Range: DC/5 V
Reading is _____ volts, DC.
Function/Range: DC/2.5 V
Reading is _____ volts, DC.

Problem 2:

Function/Range: AC/10 V
Reading is _____ volts, AC.
Function/Range: AC/5 V
Reading is _____ volts, AC.
Function/Range: AC/2.5 V
Reading is _____ volts, AC.

ACTIVITY 2

Solving Electrical Work Problems

Electrical work is given by the formula,

$W_{ELEC} = (\Delta V) \times q$

where: W_{ELEC} = the electrical work done in joules
ΔV = the voltage difference in volts
q = the charge moved in coulombs

The units of electrical work are joules. One joule is equal to one volt·coulomb.

PRACTICE EXERCISES

Problem 1:
Given: Five coulombs of charge flow in an electrical circuit. The charge is "pushed" by a voltage difference of 8 volts.
Find: a. The electrical work done in units of volt·coulombs.
b. The electrical work done in units of joules.
Solution:

Problem 2:
Given: A 6-volt DC motor does 400 joules of useful work.
Find: The charge that was moved to do this work.
Solution:

Problem 3:
Given: A motor/pump unit does 1500 N·m of work while pumping water. The motor/pump unit uses 1800 joules of electric energy while doing the work.
Find: The efficiency of the motor/pump unit.
Solution:

Problem 4:
Given: An industrial motor does 1500 joules of work while moving 50 coulombs of charge.
Find: The voltage supplied to the motor.
Solution:

Problem 5:
Given: Two coulombs of charge are moved by a 6-volt battery.
Find: a. The electrical work done.
b. The number of electrons displaced by the battery.
Solution: