AMMETERS AND VOLTMETERS

OBJECTIVE
Electrical devices that measure current and potential difference are called *ammeters* and *voltmeters*, respectively. Often these devices are packed in a single "multimeter" which you have already used in lab. In this experiment you will be building your own ammeter and voltmeter using more fundamental electrical components and the skills you have learned so far in the course.

THEORY
The basic design criterion of all electrical meters is that they must not significantly disturb the circuit being measured, that is, they must have a negligible effect on all currents and potential differences in the circuit.

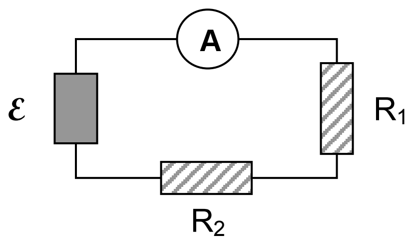


FIGURE 1A

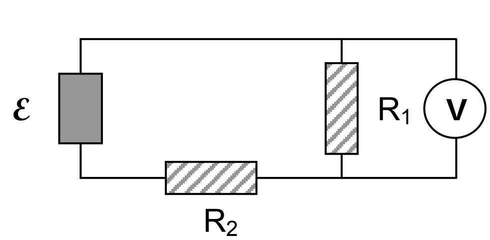


FIGURE 1B

In the series resistive circuit in Figure 1A, the current is being measured by an ammeter placed in series. The ammeter's internal resistance must be much smaller than the resistances R_1 and R_2 in order to insure that the current is not affected by its measurement. In Figure 1B the potential difference across R_1 is being measured by a voltmeter. The voltmeter's internal resistance must be much greater than R_1 in order to prevent a significant amount of current from being diverted into the voltmeter, thereby altering the potential difference.

Before the advent of digital electronics, ammeters and voltmeters were constructed out of simple resistors and galvanometers. A *galvanometer* is a primitive current/potential difference detector. It consists of a coil of wire attached to a rotor inside a permanent magnet. When current flows in the coil, the torque is produced by the magnet's field and the rotor turns and deflects a needle in proportion to the amount of current.

PRE-LAB ACTIVITY
Suppose the circuit in Figure 1 has $\mathcal{E}$ = 12 V, R_1 = 88 Ω, and R_2 = 125 Ω.

1. What is the current in the circuit? Ignore the meters attached.

2. What is the voltage across each resistor? Ignore the meters attached.

3. If the ammeter in Figure 1A has a resistance of 50 Ω, what current does it actually read in the circuit?

4. If the voltmeter in Figure 1B has a resistance of 150 Ω, what voltage does it actually read in the circuit?

EQUIPMENT
Galvanometer, 2 decade resistance boxes, adjustable power supply capable of a 5 V output and a current of 500 mA, patch cords, resistance wire

PROCEDURE

Part 1: Galvanometer Measurements
We need to measure the internal resistance R_g, the current I_g at full-scale deflection, and the voltage V_g at full-scale deflection.

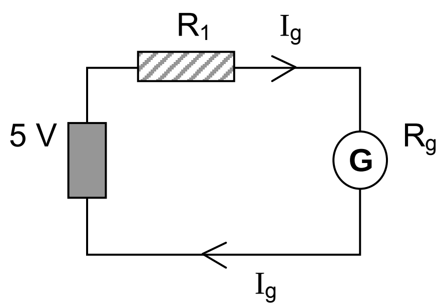


FIGURE 2A

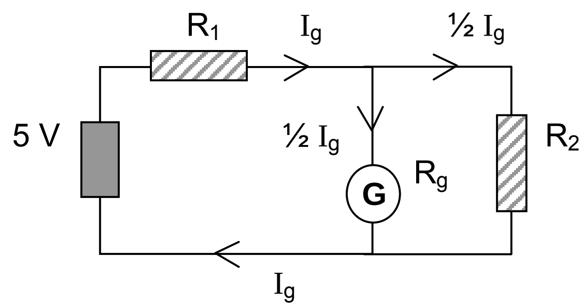
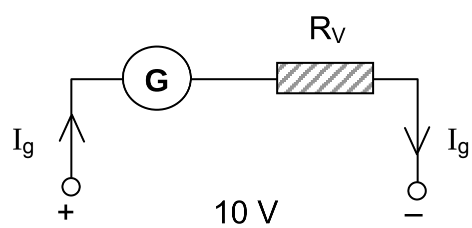


FIGURE 2B

1. Construct the circuit in Figure 2A. Set the decade resistance box R_1 to its highest value before you connect it in the circuit.
2. Slowly decrease R_1 until the needle of the galvanometer deflects full scale. The current I_g is now flowing in the circuit. Record R_1 on your data sheet.
3. Connect the other decade resistance box R_2 (set to its highest value) in parallel with the galvanometer as shown in Figure 2B.
4. Slowly decrease R_2 until the needle of the galvanometer deflects at half of full scale. Half of I_g now flows through the galvanometer and through R_2. Since the voltage across the galvanometer and R_2 is equal, $R_g = R_2$. Record this value on your data sheet.
5. Use Ohm's Law to calculate I_g and V_g in Figure 2A. Record your results on your data sheet.

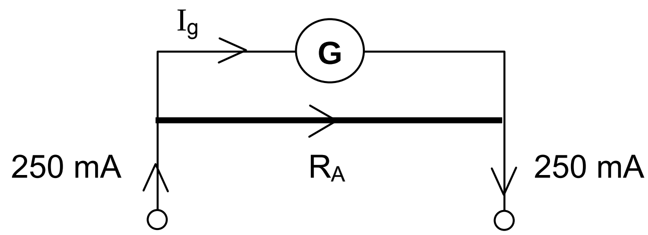
Part 2: Voltmeter Construction
We wish to construct a dc voltmeter that will achieve full-scale deflection at a maximum of 10 V.



1. Use Kirchhoff's Laws to determine the value of R_V. Show your work on the data sheet.
2. Construct the circuit shown above. Ask your lab TA to check your work using an adjustable power supply.

Part 3: Ammeter Construction

We wish to construct a dc ammeter that will achieve full-scale deflection at a maximum of 250 mA.



1. Use Kirchhoff's Laws to determine the value of R_A. Show your work on the data sheet.
2. Construct the circuit shown above. You will need to use the resistance wire for R_A because the required resistance is much smaller than any commercially available resistors. Connect it in parallel with the galvanometer by attaching it directly to its terminals.
3. Connect a known current source to your ammeter. (Your power supply may be able to serve this purpose if it has a variable current knob.) Adjust the length of wire until you achieve full deflection at 250 mA. Ask your lab TA to check your work.
4. <u>Safety Notice</u>: Do not leave the resistance wire attached to your current source too long. The wire is a short circuit and may cause your power supply to overheat and malfunction. Also, the wire will get very hot and may cause severe burns.

Name ____ **Date** ____________

Partners ____

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AMMETER AND VOLTMETER

Part I: Galvanometer Measurements

R_g = ____________________ I_g = ____________________

V_g = ____________________

Part 2: Voltmeter Construction

Show your calculations here:

R_V = __________________________

Part 3: Ammeter Construction

Show your calculations here:

R_A = __________________________