Experiment No. 4
Voltmeter and Ammeter

Objective:

(a) To convert a galvanometer into a voltmeter reading up to V volts and calibrate it.

(b) To convert a galvanometer into an ammeter reading up to I amperes and calibrate it.

Apparatus:

A galvanometer, a decade resistance box, a power supply, a multimeter, a piece of resistance wire and a cm scale.

Theory:

Converting a galvanometer into a voltmeter:

Let i_g be the current for full-scale deflection of the galvanometer and let R_g be the resistance of the galvanometer. Let R be the resistance which should be connected in series with the galvanometer coil (Fig. 4.1) to convert it into a voltmeter reading upto V volts. Then

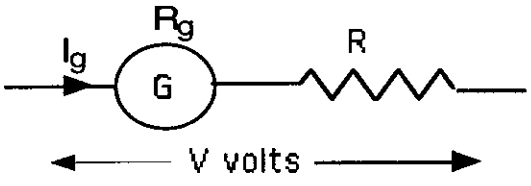

Fig. 4.1

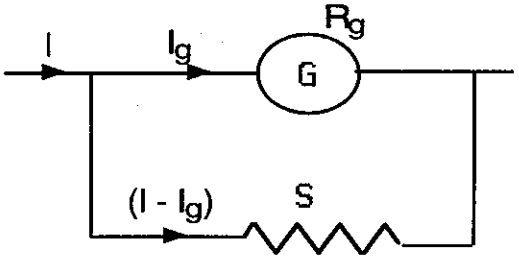

Fig. 4.2

$$V = I_g(R + R_g),$$

or
$$R = \frac{V}{I_g} - R_g \qquad (1)$$

Note that I_g should be in amperes.

Conversion of a galvanometer into an ammeter:

To convert a galvanometer into an ammeter reading upto I amperes, a suitable small resistance S (known as shunt) is connected in parallel with its coil (Fig. 4.2). Thus

$$(I - I_g)\,S = I_g R_g$$

or
$$S = \frac{I_g R_g}{(I - I_g)}. \qquad (2)$$

Remember that I and I_g should be in amperes.

Procedure:

Precaution: Do not switch on the circuit without including a large resistance in series with the galvanometer. Keep the applied voltage low.

Determination of the resistance of the galvanometer:

(a) If the resistance of the galvanometer is not known, determine it by the method described in Experiment No. 3.

(b) Record the number of units (not divisions) marked on the dial of galvanometer.

Determination of the current for full-scale deflection:

(c) Make the circuit as shown in Fig. 4.3. Adjust the current limit to maximum and the voltage of the power supply to zero. Adjust the resistance (R) of the decade box to about 10,000 Ω.

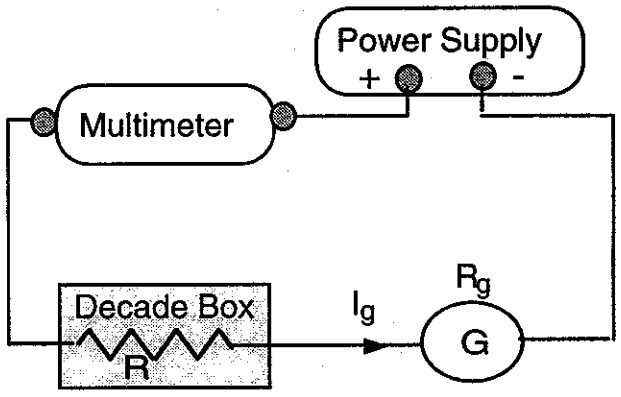

Fig. 4.3

(d) Now gradually increase the voltage of the power supply such that the galvanometer shows a full-scale deflection. Record the current for full-scale deflection as shown by the multimeter.

(e) To obtain two more readings of the current for full-scale deflection, decrease the voltage to zero, change R by about 1000 ohm and repeat step (d).

(f) Calculate the average value of i_g.

Conversion of the galvanometer into a voltmeter:

(g) Choose a range V (2.4, 1.6 or 1.2 volt) for the voltmeter.

(h) Calculate R by Eq. (1). To convert the galvanometer into a voltmeter connect a resistance R in series with the galvanometer.

Calibration of the voltmeter:

(i) Make the circuit as shown in Fig. 4.4. The multimeter should be set to read D.C. voltage. Adjust R to the value obtained in step (h).

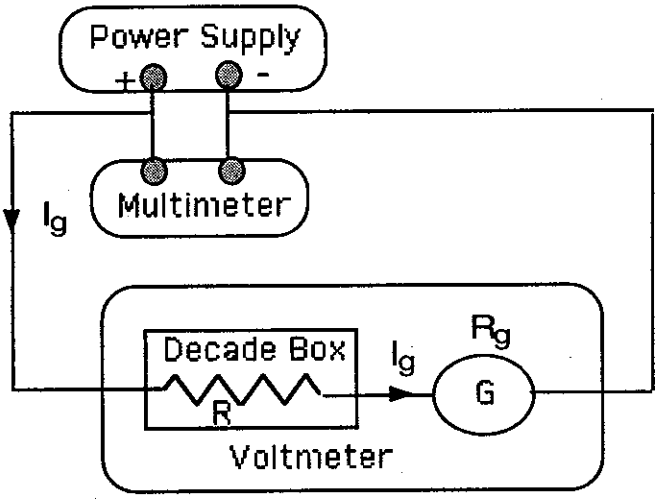

Fig. 4.4

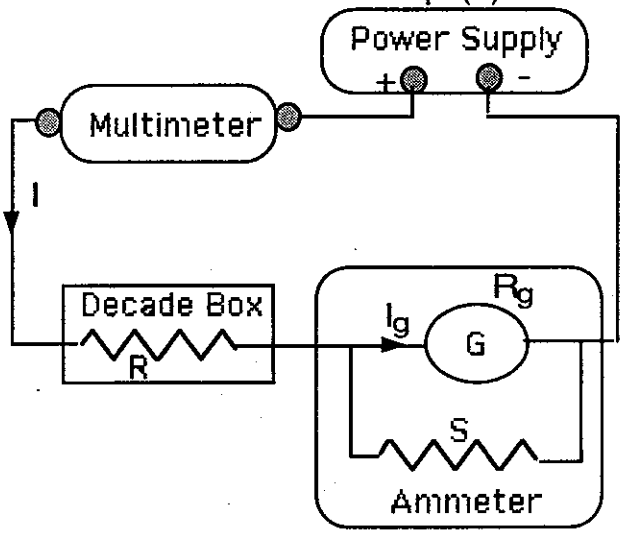

Fig. 4.5

(j) Adjust the voltage of the power supply and take the readings of the multimeter when the deflection of the galvanometer (converted into a voltmeter) is 20, 40, 60, 80 and 100 units.

(k) Plot the calibration curve.

Conversion of the galvanometer into an ammeter:

(l) Choose a range I (15, 20 or 25 mA) for the ammeter.

(m) Calculate S (the value of the shunt resistance) by Eq. (2). Find the length l of the shunt wire whose resistance is S. To convert the galvanometer into an ammeter, connect the shunt wire (of length l) across the terminals of the galvanometer so that the shunt wire is parallel with the galvanometer.

Calibration of the ammeter:

(n) Make the connections as shown in Fig. 4.5. The multimeter should be set to read D.C. current. Adjust the voltage of the power supply to zero and adjust R to about 2000 W.

(o) Adjust the voltage of the power supply such that the deflection of the galvanometer (converted by you into an ammeter) is 20, 40, 60, 80 and 100 units, and record the corresponding readings of the current shown by the multimeter.

(p) Plot the calibration curve.

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Physics II Name:

Experiment No. 4: Pre-Lab Questionnaire

1. In this experiment, different sets of readings for current for full-scale deflection are obtained by _____

2. The resistance of a galvanometer is 45 ohm, the current for full-scale deflection is 1.2×10^{-4} A and it has 100 units marked on its scale.

   (a) Calculate the series resistance to convert it into a voltmeter reading up to 3 V. (b) Find the shunt resistance needed to convert it into an ammeter reading up to 20 mA. (c) If the resistance of the shunt wire is 0.03 ohm/cm, what should be the length of the shunt wire?

3. The range of a voltmeter is 3 V and it has 100 units on its scale. If it shows a deflection of 60 units, the applied potential difference is _____

4. The range of an ammeter is 25 mA and it has 100 units on its scale. If it shows a deflection of 60 units, the current in the ammeter is _____

Experiment No. 4

Name: Marks:

Partner: Remarks:

Section:

Date Submitted:

Title:

Objective:

Theory/Formulas:

Experiment No. 4
DATA SHEET

Observations: Galvanometer Number:

(Use the same galvanometer as you did in Expt. No, 3)

Number of units marked on the dial of the galvanometer =

Resistance of the galvanometer R_g . . . . . =

Current for full-scale deflection I_g . . . . . (i) =

(ii) =

(iii) =

Average I_g =

Calculation of series resistance R required to convert the galvanometer into a voltmeter reading upto V = volts:

$$R = \frac{V}{I_g} - R_g =$$

Calculation of shunt resistance S required to convert the galvanometer into an ammeter reading upto I = amperes:

$$S = \frac{I_g R_g}{(I - I_g)} =$$

Resistance per unit length of the shunt wire =

Length of the shunt wire ℓ . . . . . =

Calibration of voltmeter:

No.	Deflection (in units)	V (multimeter)	V (voltmeter)
1	20		
2	40		
3	60		
4	80		
5	100		

Plot a calibration curve [V(voltmeter) vs. V(multimeter)].

Calibration of ammeter:

No.	Deflection (in units)	I (multimeter)	I (ammeter)
1	20		
2	40		
3	60		
4	80		
5	100		

Plot a calibration curve [I(ammeter) vs. I(multimeter)].

Questions:

1. Two resistors, R_1 = 400 ohms and R_2 = 600 ohms are connected in series with a power supply whose voltage V = 12 volts. What is the percent error in the potential difference across the 600-ohm resistor measured by using a voltmeter whose resistance is 1800 ohms? What will be the percent error if a voltmeter whose resistance is 6000 ohms is used?

2. Why should a voltmeter have large resistance? What is the resistance of the voltmeter obtained by you?

3. A circuit contains a power supply of voltage 2.4 volt and a resistance of 48 ohms. If an ammeter whose resistance is 2 ohms is used to measure the current in the circuit, what will be the percent error in current? What will be the percent error if a 0.002-ohm ammeter is used?

4. Why should an ammeter have negligible resistance? What is the resistance of the ammeter obtained by you?

5. Why is it necessary to calibrate an ammeter and a voltmeter?