Experiment No. 3
Galvanometer

Objective:

(a) To determine the resistance of a galvanometer.
(b) To verify that the deflection of a galvanometer is proportional to the current in it.
(c) To determine the current sensitivity and the voltage sensitivity of the galvanometer.

Apparatus:

A galvanometer, a power supply, a multimeter, two decade resistance boxes.

A galvanometer is an instrument used for detecting small electric currents and potential differences. Ammeters and voltmeters are basically galvanometers which have been suitably modified to measure currents and voltages, respectively. A pivoted-coil type galvanometer (Fig. 3-1(a)) consists of a coil of fine insulated copper wire, wound around a light metal frame and pivoted between two jeweled pivots P_1 and P_2. The coil moves in the magnetic field between the pole pieces (N, S) of the U-shaped magnet. When there is an electric current in the coil, a deflecting torque acts on it. The hair springs (H_1 and H_2) attached to the frame provide the restoring torque when the coil is deflected. The coil attains an equilibrium position when the deflecting torque becomes equal to the restoring torque.

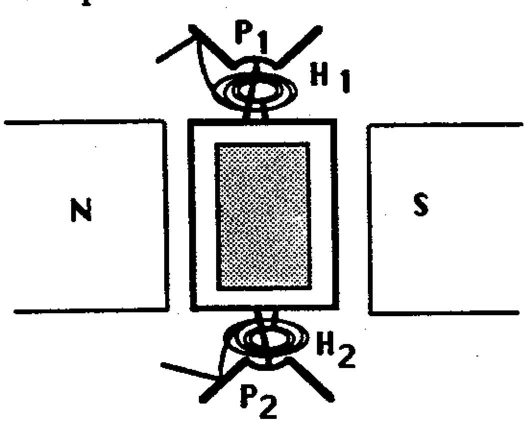

Fig. 3-1(a)

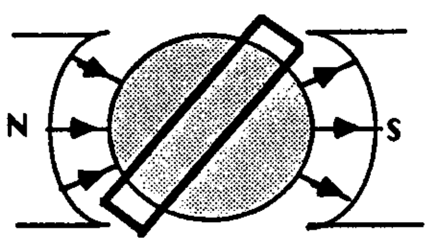

Fig. 3-1(b)

The pole pieces of the magnet are concave. Thus the gap between them is cylindrical. A soft iron cylinder is placed centrally in the gap between the pole pieces. Thus the magnetic field in the air-gap is redirected normal to the curved surface of the cylinder. Consequently, the magnetic field acting on the current is parallel to the plane of the coil. This makes the deflection of the coil directly proportional to the current in the coil. When the metal frame on which the coil is wound moves in the magnetic field, eddy currents are induced in it and thus the oscillations of the coil are damped. A light aluminum pointer attached to the coil moves along the scale of the instrument. Sometimes, a large resistance is provided which can be connected in series with the coil to make it less sensitive.

Theory:

Resistance of a galvanometer:

In Fig. 3-2(a), let R_1 be the resistance connected in series with the galvanometer when the galvanometer shows full-scale deflection. Then, keeping the voltage (V) of the power supply unchanged, resistance R_{sh} is connected in parallel with the galvanometer by closing the switch S (Fig. 3-2(b)), and, thus the galvanometer deflection becomes about one-half of its maximum value. Next, the series resistance is changed from R_1 to R_2 so as to restore the deflection of the galvanometer to its original value (full-scale).

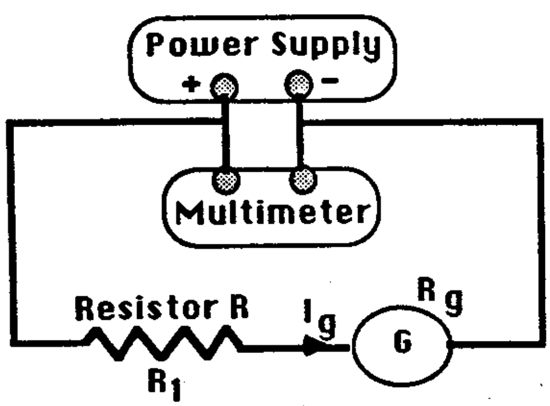

Fig. 3-2(a)

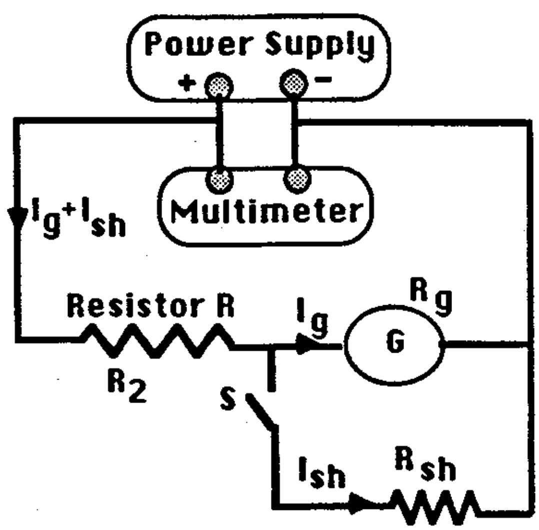

Fig. 3-2(b)

The current in the galvanometer is the same (I_g) in both cases because the deflection in both cases is full-scale. Applying Ohm's law to the circuit of Fig. 3-2(a), we get

$$V = I_g(R_1 + R_g), \quad (1)$$

where R_g is the resistance of the galvanometer.

Now, in Fig. 3-2(b), the potential difference across the galvanometer (G) is equal to the potential difference across the shunt resistance R_{sh}. Thus

$$I_g R_g = I_{sh} R_{sh}. \quad (2)$$

Further, $$V = (I_g + I_{sh})R_2 + I_g R_g. \quad (3)$$

By equating the right-hand sides of Eqs. (1) and (3), we get

$$I_g(R_1 + R_g) = (I_g + I_{sh})R_2 + I_g R_g,$$

or $$I_g R_1 = (I_g + I_{sh})R_2,$$

or $$I_g R_1 = I_g R_2 + I_{sh} R_2.$$

By substituting the value of I_{sh} from Eq. (2),

$$I_g R_1 = I_g R_2 + R_2 R_g I_g / R_{sh},$$

or $$R_g = (R_1 - R_2) R_{sh} / R_2. \quad (4)$$

Thus the resistance of the galvanometer can be determined from Eq. (4).

Current Sensitivity:

The current sensitivity of a galvanometer is defined as the current required to produce a deflection of 1 small division of the scale of the instrument.

Voltage Sensitivity:

The voltage sensitivity of a galvanometer is defined as the potential difference applied across its coil to produce a deflection of 1 small division of the scale of the instrument.

Evidently, if i_s is the current sensitivity of a galvanometer whose resistance is R_g, then the voltage sensitivity of the galvanometer is given by

$$v_s = i_s R_g.$$

If there are n divisions on the scale of the galvanometer, then a current ni_s will produce a full-scale deflection and thus the current for full scale deflection will be

$$I_g = n\, i_s .$$

Similarly, a potential difference of nv_s will produce a full-scale deflection.

Procedure:

(a) Study the construction and working of the galvanometer provided. Make sure that the pointer of the galvanometer is adjusted to zero. (Don't adjust the zero of the galvanometer. Request your instructor to adjust the zero, if necessary.)

Precaution:

Never switch on the circuit without including a large resistance in series with the galvanometer. The applied voltage should be kept low.

Unit 1: Determination of the resistance of the galvanometer:

(b) Make the circuit as shown in Fig. 3-2(b). Adjust the current limit to maximum and the voltage of the power supply to zero. Keep the switch S open. Note that when switch S is open, the circuit is the same as shown in Fig. 3-2(a). Set the resistance of the resistor R between 8,000 and 12,000 ohm. Now gradually increase the voltage of the power supply so that the deflection of the galvanometer becomes maximum. Record V and R_1, the value of the resistance of the resistor R.

(c) Keeping the voltage of the power supply V constant, insert R_s in parallel with the galvanometer by closing switch S. Adjust the value of R_s such that the deflection of the galvanometer is between 20 and 30 divisions. Now change the resistance of resistor R (which is connected in series with the galvanometer) such that the deflection of the galvanometer becomes maximum again. Record R_s and R_2, the value of the resistance of the resistor R. (If R_s is not a standard resistance, measure it with the multimeter.)

(d) Repeat steps (b) and (c) by changing R_1 by about 2000 ohms. Thus take two more readings. Note that V should be kept the same as in step (b) while taking each set of readings.

Unit 2: **Determination of current sensitivity and voltage sensitivity:**

(e) Make the circuit as shown in Fig. 3-2(a). Set the voltage of the power supply at zero and R_1, the resistance of resistor R at about 5000 ohm. Record R_1. Slowly increase the voltage so that the deflection of the galvanometer is 5 divisions. Record the deflection and the voltage in Table 2. Similarly, obtain the deflections of 10, 15, 20, 25, 30, 35, 40, 45 and 50 divisions by gradually increasing the applied voltage and recording it in Table 2. (Remember that the divisions and the units marked on the dial of the galvanometer are different.)

(f) Plot a graph between galvanometer deflection and current in the galvanometer.

(g) Calculate the current sensitivity of the galvanometer from the slope of the graph. Also calculate the voltage sensitivity of the galvanometer.

York College of The City University of New York

Physics II Name:

Experiment No. 3: Pre-Lab Questionnaire

1. A galvanometer is used for ______________________________

____

2. When the coil of the galvanometer is deflected, the torque(s) acting on it is (are) ______________________________

____

3. The magnetic field in the air gap in which the coil moves is made radial by______________________________

____

4. The oscillations of the coil are damped by ______________________

____

5. In this experiment, the circuit should not be switched on without including a large resistance in series with the galvanometer and the applied voltage should be kept low because ____________________

____

6. The current sensitivity of a galvanometer is 1.2×10^{-4} A, its resistance is 45 ohm and it has 50 divisions on its scale. For the galvanometer, the voltage sensitivity, v_s = ______________________ and the current for full-scale deflection, i_g = ______________________

Experiment No. 3

Name:	Marks:
Partner:	Remarks:
Section:	
Date Submitted:	

Title:

Objective:

Theory/Formulas:

Experiment No. 3
Data Sheet

Observations: Galvanometer Number:

Record resistances in ohms, currents in mA and potential differences in volts.

Unit 1: Determination of R_g:

Table 1

No.	V	R_1	R_{sh}	R_2	R_g

Average R_g =

Unit 2: Determination of current sensitivity and voltage sensitivity:

Number of divisions on the dial of the galvanometer =

Resistance R_1 =

Table 2

Number	Galvanometer Deflection (div)	V	$I = \frac{V}{R_1 + R_g}$
1	5		
2	10		
3	15		
4	20		
5	25		
6	30		
7	35		
8	40		
9	45		
10	50		

Calculations:

Coordinates of point 1 on the graph: divisions, mA

Coordinates of point 1 on the graph: divisions, mA

From the slope of the graph,

Current sensitivity =

Voltage sensitivity =

Current for full-scale deflection =

Potential difference for full-scale deflection =

Questions:

(Use the data obtained in the experiment to answer these questions, where applicable.)

1. What is meant by the current sensitivity of a galvanometer?

2. What is meant by the current for full-scale deflection of a galvanometer?

3. What is the voltage applied to the galvanometer (used in this experiment) when it is showing full-scale deflection?

4. What is the advantage of determining the resistance of a galvanometer by using Eq. (4) instead of Eq. (1)?

5. Will you obtain a straight line graph between n (number of divisions of deflection) and the corresponding current I if the soft iron cylinder (placed between the pole pieces of the magnet of the galvanometer) is removed? Explain your answer.