Experiment no: 04

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Name of the Experiment: Determination of the resistance of a galvanometer by half deflection method.

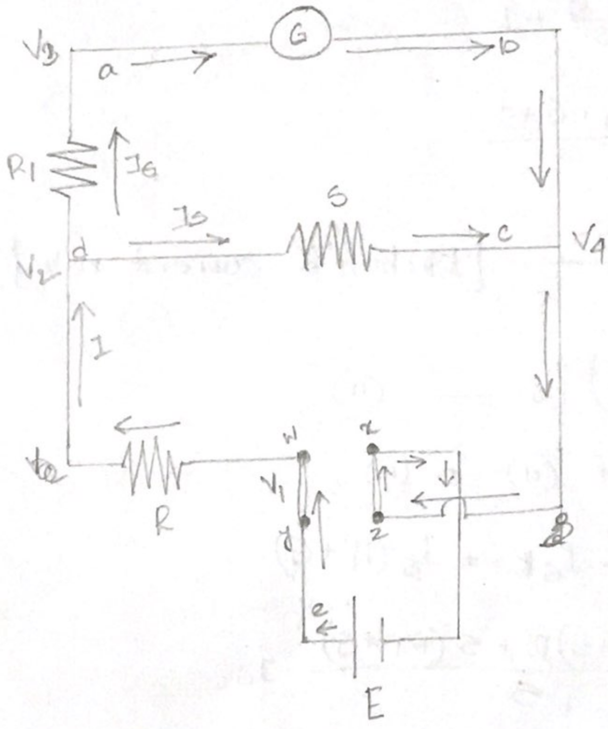
Questions on theory (all diagrams should be drawn by using a pencil and a scale)

*1) What is resistance of the galvanometer? [0.25]

Ans: The resistance of the galvanometer is the resistance of a coil of wire wound over a rectangular frame kept in a magnetic field inside the galvanometer.

*2) Draw the circuit diagram for this experiment. [0.25]

Ans:



*4) Show th
deflection
Ans:

*3) Derive an expression for the current passing through the galvanometer as a function of the resistances of the shunt box, two resistance boxes and the emf of the voltage source, i.e., equation (8). [2]

Ans: From the circuit diagram, using Kirchoff's loop-voltage rule in the closed loop ~~edabce~~ edabce,

$$IR + I_G R_1 + I_G G - E = 0$$

$$\Rightarrow E = IR + I_G(R+G) \text{ ---- (i)}$$

Now using the same rule in the closed loop abcda,

$$I_G R_1 + I_G G - I_S S = 0$$

$$\Rightarrow I_S S = I_G(R_1 + G)$$

$$\Rightarrow \frac{I_S}{I_G} = \frac{R_1 + G}{S}$$

$$\Rightarrow \frac{I_S}{I_G} + 1 = \frac{R_1 + G}{S} + 1$$

$$\Rightarrow \frac{I_S + I_G}{I_G} = \frac{R_1 + G + S}{S}$$

$$\Rightarrow \frac{I}{I_G} = \frac{R_1 + G + S}{S} \quad \text{[Kirchoff's current rule]}$$

$$\Rightarrow I = \left(\frac{R_1 + G + S}{S}\right) I_G \text{ ---- (ii)}$$

Putting result of (ii) in (i),

$$E = \frac{R_1 + G + S}{S} I_G R + I_G (R_1 + G)$$

$$= \frac{(R_1 + G + S)R + S(R_1 + G)}{S} I_G$$

$$I_G = \frac{ES}{(R_1 + G + S)R + S(R_1 + G)}$$

*4) Show that, the value of R_l for which the galvanometer's deflection is reduced down to the half of the deflection when $R_l = 0$, is approximately equal to the galvanometer's resistance. [2]

Ans: We know that the deflection angle of the galvanometer's pointer θ is proportional to the current passing through the galvanometer, I_G

$$\therefore \theta \propto I_G$$

$$\Rightarrow \theta = \frac{1}{k} I_G$$

$$I_G = k\theta \quad [k = \text{Galvanometer's constant}]$$

If $R_1 = 0$,

$$\frac{SE}{GR + SR + SG} = k\alpha \quad \text{—— (i)}$$

When galvanometer's deflection is reduced down to the half of the deflection,

$$\frac{SE}{(R_1 + G + S)R + S(R_1 + G)} = \frac{k\alpha}{2} \quad \text{— (ii)}$$

$$(i) \div (ii) \rightarrow \frac{(R_1 + G + S)R + S(R_1 + G)}{GR + SR + SG} = 2$$

$$\Rightarrow \frac{(GR + SR + SG) + RR_1 + SR_1}{GR + SR + SG} = 2$$

$$\Rightarrow 1 + \frac{RR_1 + SR_1}{GR + SR + SG} = 2$$

Since S is much smaller than R & G,

$$R_1 = G$$

5) For a certain value of shunt-resistance, S and a certain value of R, when R_l is set to 0 then the deflection of the galvanometer is shown in Figure A.

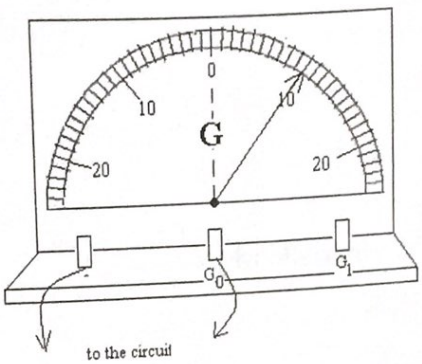
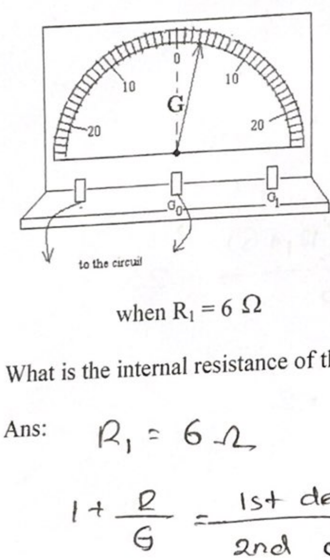
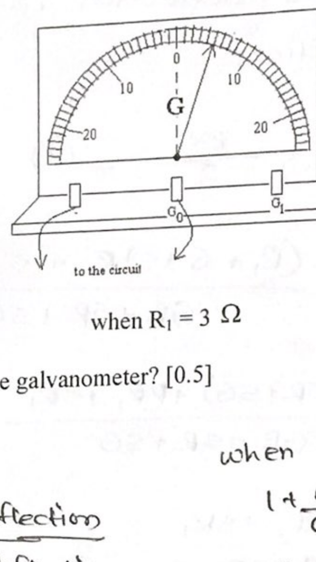


Figure A: Deflection when $R_l = 0$

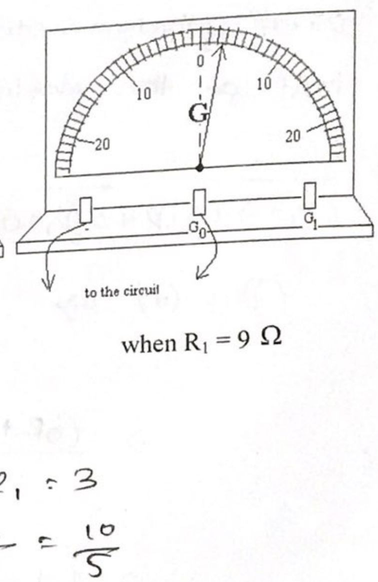
By keeping S and R fixed the deflections of the galvanometer for different values of R_l are shown in the following figures.



when $R_l = 6\ \Omega$



when $R_l = 3\ \Omega$



when $R_l = 9\ \Omega$

What is the internal resistance of the galvanometer? [0.5]

Ans: $R_l = 6\,\Omega$

$$1 + \frac{R}{G} = \frac{\text{1st deflection}}{\text{2nd deflection}}$$

$$1 + \frac{R}{G} = \frac{10}{3}$$

$$G = \frac{6 \times 3}{7}$$

$$= 2.57\,\Omega$$

when $R_l = 3$

$$1 + \frac{R}{G} = \frac{10}{5}$$

$$\frac{R}{G} = 1$$

$$R = G = 3\,\Omega$$

when, $R_l = 9\,\Omega$

$$1 + \frac{R}{G} = \frac{10}{2.5}$$

$$\frac{R}{G} = 4.1$$

$$G = 3\,\Omega$$

Internal resistance $= \dfrac{3 + 3 + 2.53}{3}$

$= 2.92 = 3\,\Omega$

- **Draw the data table(s) and write down the variables to be measured shown below (in the 'Data' section), using pencil and ruler BEFORE you go to the lab class.**
- **Write down your NAME and ID on the top of the page.**
- **This part should be separated from your Answers of "Questions on Theory" part.**
- **Keep it with yourself after coming to the lab.**

Data

Table: Data for determining the resistance of a galvanometer

No. of observation	R (Ω)	S (Ω)	Flow of current	Deflection when R_1=0 (θ_0)	R_1($\neq$ 0) (Ω)	Deflection when $R_1 \neq 0$ (θ)	$G \approx R_1 / \left(\frac{\theta_0}{\theta} - 1\right)$ (Ω)	Mean G (Ω)
1	200	0.5	D	21	160	10.5	160	136.08
			R	21	153	10.5	153	
2	200	0.4	D	13	120	6.5	120	
			R	13	140	6.5	140	
3	200	0.3	D	12	155	6	155	
			R	12	140	~~10~~ 6	140	
4	300	0.5	D	20	100	10	100	
			R	20	140	~~6~~ 10	140	
5	300	0.4	D	12	155	6	155	
			R	12	110	6	110	
6	300	0.3	D	11	150	5.5	150	
			R	11	110	5.5	110	

- **READ the PROCEDURE carefully and perform the experiment by YOURSELVES. If you need help to understand any specific point draw attention of the instructors.**
- **DO NOT PLAGIARIZE data from other group and/or DO NOT hand in your data to other group. It will bring ZERO mark in this experiment. Repetition of such activities will bring zero mark for the whole lab.**
- **Perform calculations by following the PROCEDURE . Show every step in the Calculations section.**
- **Write down the final result(s)**

Calculations

Results: the resistance of a galvanometer is 136.08 Ω

Questions for Discussions

1) Is the method applicable for a galvanometer of any resistance? How do you find the resistance of a galvanometer when its resistance is very small? [0.5]

Ans: Yes, the method is applicable. To find the resistance of the galvanometer, when its resistance is very small we need to increase the resistance of the galvanometer.

2) Will you prefer a low or high resistance of a shunt? [0.5]

Ans: I will prefer low resistance of a shunt.

3) If for a particular value of the resistance R_1 the deflection of the galvanometer's pointer drops down to one-n'th of its deflection when R_1 was zero, then what is the galvanometer's resistance? [0.5]

Ans: The resistance will be $R/(n-1)$

4) In your experiment the galvanometer which you have used, the angle of deflection of its pointer is directly proportional to the current passing throw its coil. However, there are some galvanometers called 'sine galvanometers' and 'tangent galvanometers', where the trigonometric sine or tangent of the angle of deflection respectively, is proportional to the current passing through them. How will you perform your experiment with anyone of these galvanometers? [0.5] (You may use additional paper)

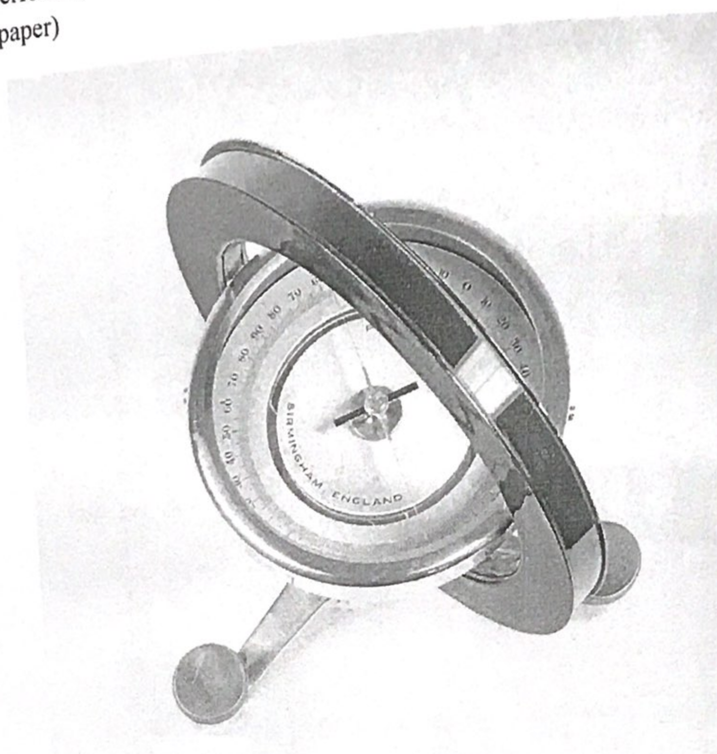


Figure 3: A tangent galvanometer (courtesy: Wikimedia.org)

Ans: We have to connect the wire in the north - south deflection of the magnet and the compass middle is acted by horizontal component of magnetic field of the earth. The coil is now rotated through an angle θ until the plane of the coil meets the niddle. The two torque acting on ~~needs~~ needles are perpendicular to coil, $B \sin\theta$

$\therefore I_G \propto \sin\theta$.