B. Sc. Part II
Paper IV

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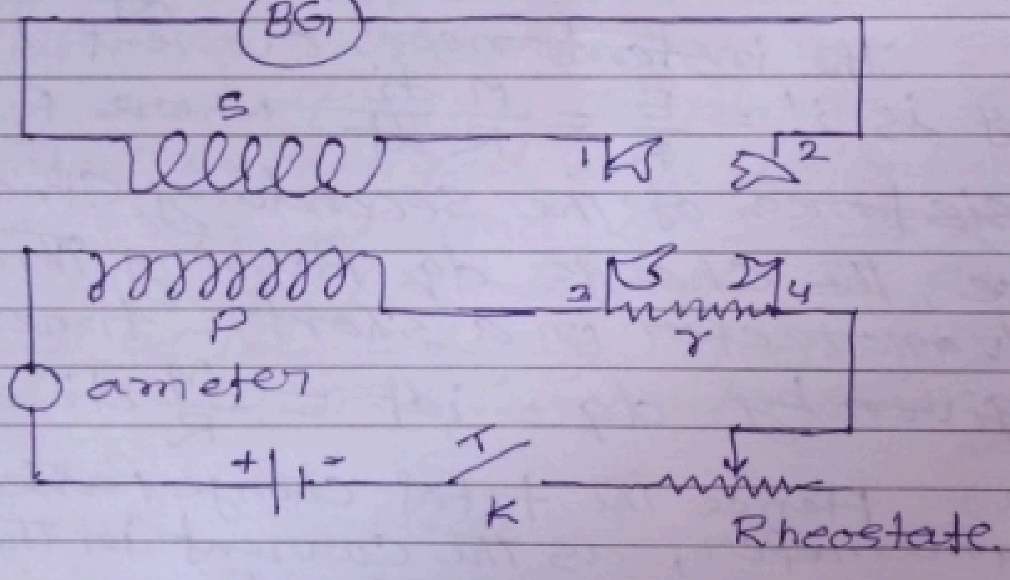
Current Electricity

Measurement of Mutual Inductance :—

The Circuit diagram for measurement of mutual - inductance is as shown in figure. Primary P and Secondary S are two coils whose Mutual inductance M is to be determined. Ballistic Galvanometer (B.G) is C is a four segment commutator and r is a very small resistance of the order of 1/100 ohm.



Working :—

First of all the Segment 1 and 2 are Connected together so that the ballistic galvanometer and the secondary coil S form a closed Circuit. The resistance r is kept short circuited by Connecting 3 and 4.

The rheostate is adjusted so that a suitable current passes through the primary on depressing the key K. As the key K is depressed, the current in the primary P takes some time to grow and the flux through the secondary S changes during this time.

Hence an induced e.m.f. is set up in the secondary and a momentary current flow and the galvanometer gives a throw.

Let i be the current at any instant in the primary, the e.m.f. induced in the secondary is given by

$$E = -M\frac{di}{dt}$$

The instantaneous current i in the secondary is $i' = \frac{E}{R} = \frac{M}{R}\frac{di}{dt}$ where R is the total resistance of the secondary circuit. Therefore, the charge dq passing through the galvanometer in a short - time interval dt is given by $dq = i\,dt = \frac{M}{R}di$

Hence the total charge passed through the galvanometer, as the current in the primary grows from zero to a steady maximum value i_0, is given by

$$q = \int_0^{i_0} \frac{M}{R}\,di = \frac{M}{R} i_0$$

Let Q_1 be the first observed throw the coil of the ballistic galvanometer,

Then $q = \frac{T}{2\pi}\,\frac{C}{NBA}\,Q_1\left(1+\frac{\lambda}{2}\right)$

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Where The Symbols have Their usual Meanings Hence,

$$\frac{M}{R} i_0 = \frac{T}{2\pi} \frac{C}{NBA} \theta_1 \left(1 + \frac{\lambda}{2}\right) \quad \text{—— (I)}$$

The eliminate i_0 and C/NBA. The Contact between 1 and 2. and That between 3 and 4 are broken. The Contact between 1 and 3, and That between 2 and 4 are made. The resistance r is now included in The Primary Circuit. The Same Steady Current i_0 is now passed in The Primary Circuit. As The Value or r is very Small, The Steady current i_0 in The Primary Circuit remains unchanged. The Potential difference across r is $i_0 r$ and it sends a steady Current $i_0 r/R$ Through The galvanometer. Let ϕ be The steady deflection corresponding to this current Then

$$\frac{i_0 r}{R} = \frac{C}{NBA} \phi \quad \text{—— (II)}$$

Dividing equ^n (I) by equ^n (II), we get.

$$\boxed{M = \frac{rT}{2\pi} \cdot \frac{\theta}{\phi}\left(1 + \frac{\lambda}{2}\right)}$$