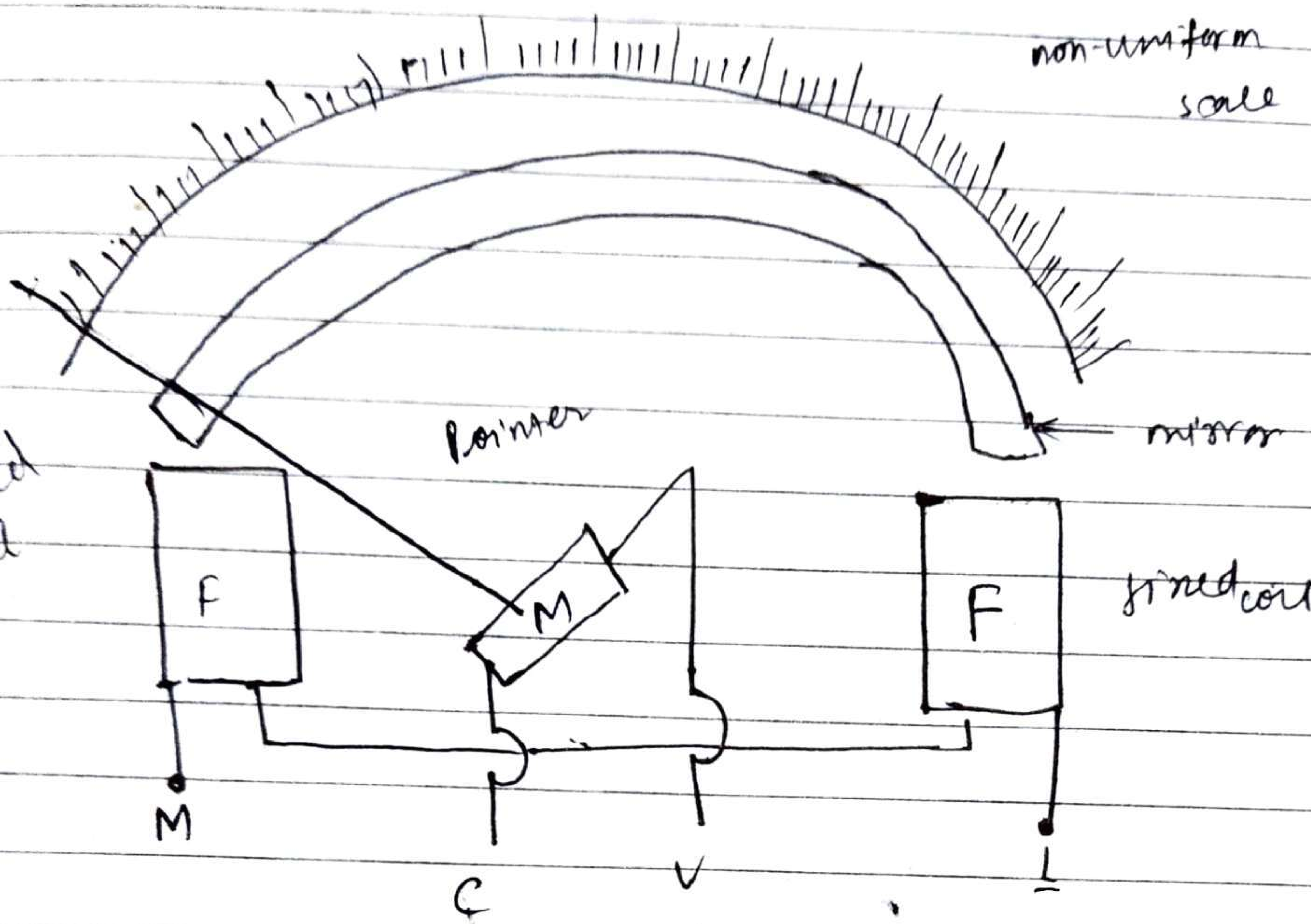
ELECTRODYNOMOMETER TYPE WATTMETER



Constructions ~~of~~ electrodynometer type wattmeter

Working principle -

Current carrying moving coil is placed in the magnetic field by the fixed coil

(2) Hence, force is exerted over the moving coil which is placed by as
$F = BIL\sin\theta$

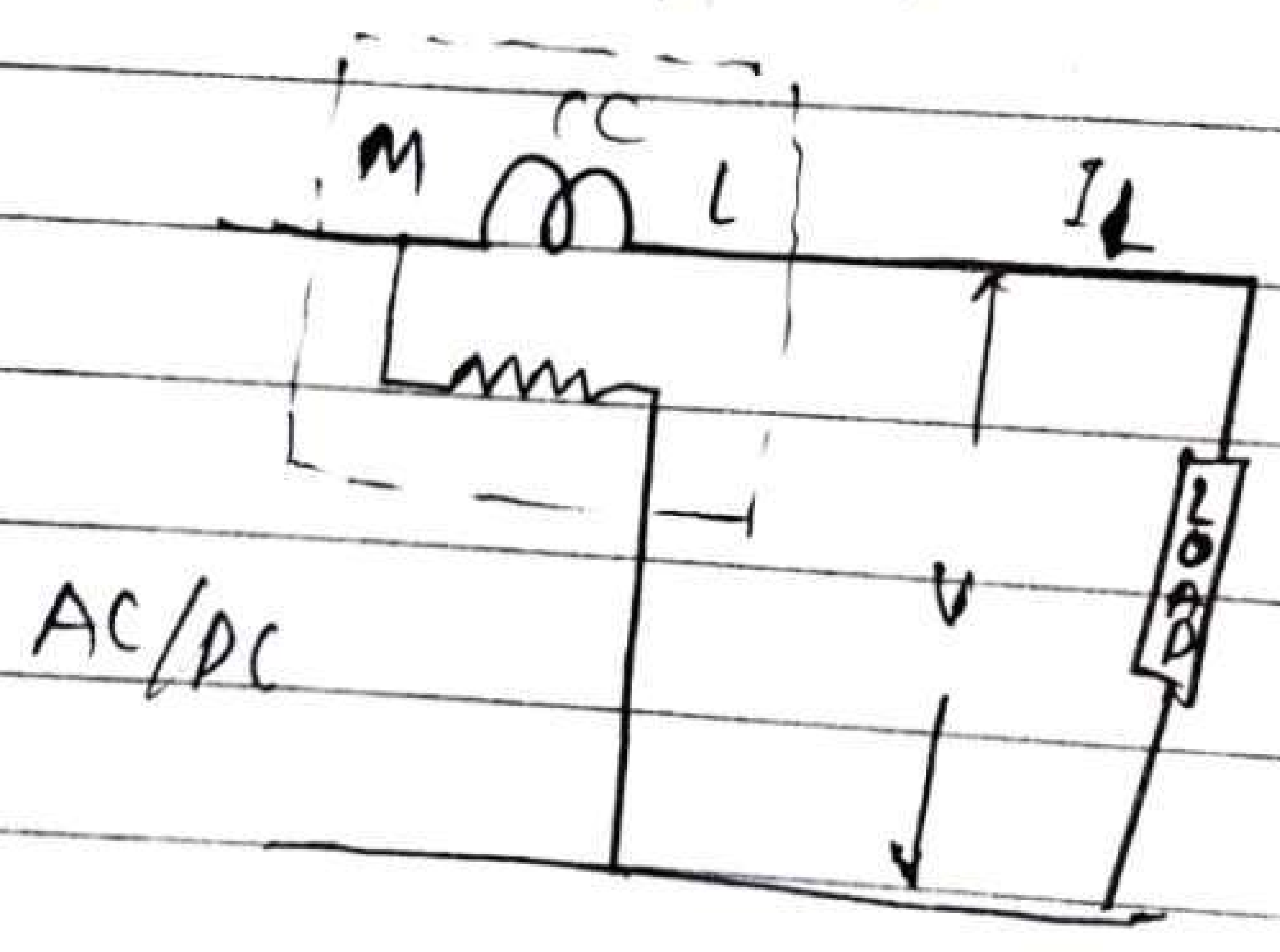
Where, F = force exerted on moving coil
B = Magnetic flux density
I = current in moving coil
L = ~~Active~~ active length of conductor in meter.

(3) This force exerted gives the deflection of pointer $\propto$ to power consumption in the load.

- Deflecting torque- (τ_d)

$$\boxed{\tau_d \propto i_{cc} \times i_{pc} \times \cos\phi}$$

Where,
i_{cc} = current flowing through current coil
i_{pc} = " " " pressure coil (voltage coil)
$\cos\phi$ = power factor



Working of electrodynometer type wattmeter

From above connection diagram it is clear that
$\boxed{i_{cc} = I_L}$ &

$$\boxed{i_{pc} = \frac{V}{R_{pc}}}$$

$R_{pc} \rightarrow$ Resistance of pressure coil

$$\boxed{T_d = I_1 \times \frac{V}{R_{pc}} \times \cos\phi}$$

R_{pc} is constant

$$\boxed{T_d \propto V I_1 \cos\phi}$$

$$\boxed{T_d \propto P}$$

Scale of electrodynamometer type wattmeter is non-uniform as deflecting torque is $\propto$ to product of ~~$V, I_1, \cos\phi$~~ & $V, I_L \cos\phi$
i.e.

$$\boxed{T_d \propto V I_L \cos\phi}$$

This meter can be used for measured of AC & DC power

Error in wattmeter-

Error due to method of correction
Due to pressure coil induction
Due to pressure coil capacitance
Error due to mutual inductance effect
Error due to stray magnetic field
Due to temperature

MEASURING INSTRUMENT

Notes-

* Measuring Instrument -

A device which is used for quantitative comparison between a predefined standard and an unknown quantity known as measuring instrument.

* TYPES OF INSTRUMENTS-

(a) Absolute instruments
(b) Secondary instruments

→ Classification of secondary instruments-

(A) Based on nature of operation-

- Indicating instruments
- Recording instruments
- Integrating instruments

(B) Based on type of Quantity being measured -

- AC instruments ⇒ Induction type instruments
- DC instruments ⇒ PMMC
- AC/DC instruments ⇒ Moving iron instruments
  Dynometer instruments etc.

(B) • D.C INSTRUMENTS -

→ PMMC - Permanent moving coil Instruments

It is also known as d' Acsonoval instruments work on the "electronic effect of current" PMMC is used to produce magnetic flux and a coil that carries the current to be measured, moves in their fied. As the pointer is connected to be coil it is also gets deflected in proportion with current ckt.

• Construction -

1. A high rectangular coil around on a metal frame (usually Al) is, pivoted with in the gaps b/w the two poles of PMMC magnet and a cylindrical soft iron core.

2. This coil carries the current to be measured. Soft iron core provided formation of uniform magnetic ~~flux~~ field The Al frame supports the coil as well as provide eddy current clamping.

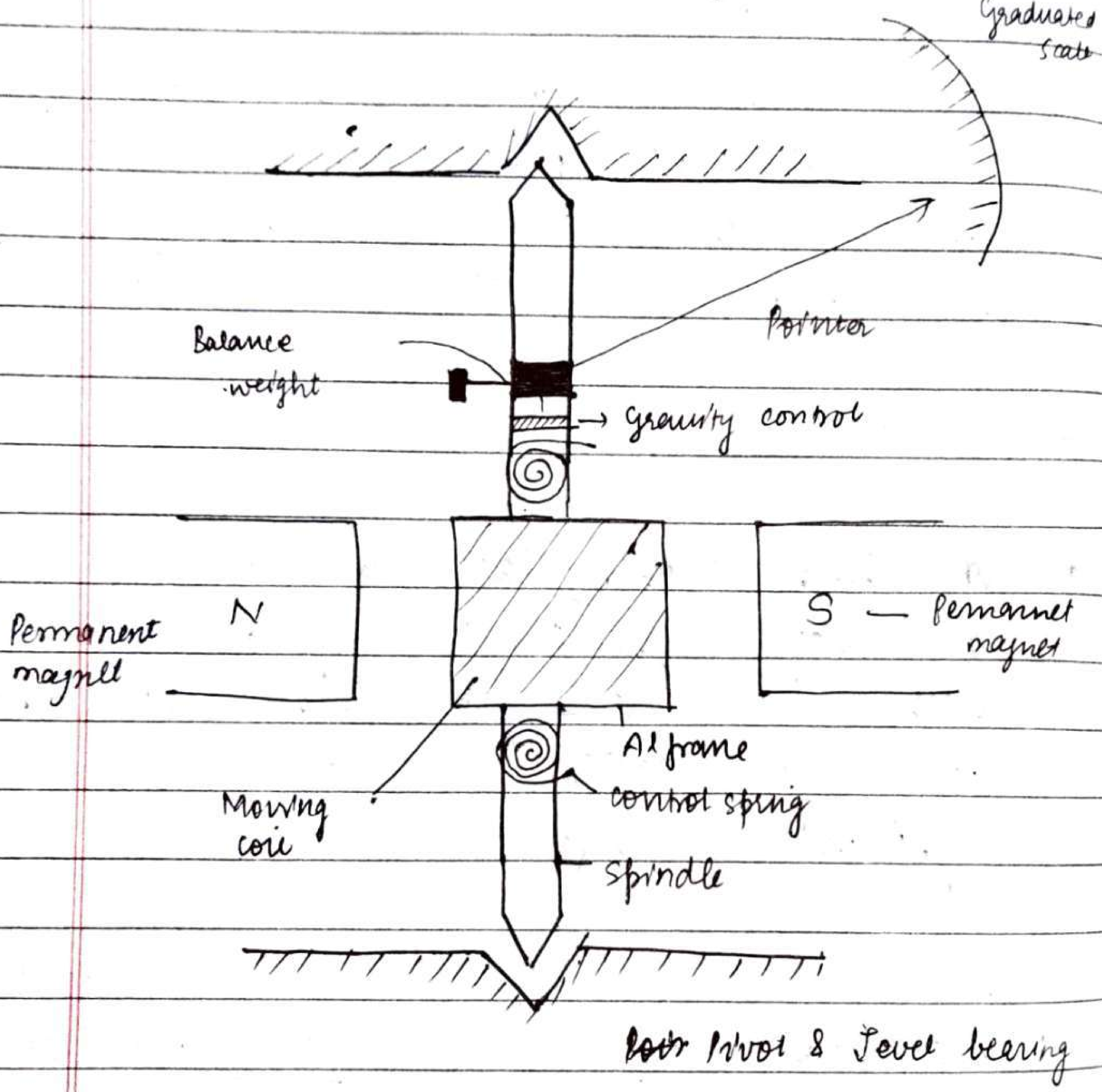
3. Two phasphor - Bronze spring coiled in opposite directions serve as beads for the current in the coil. The spring also provide controlling torque

Chitra

4. The moving system is balanced by three balance weight.

5. The moving Spindle is pivoted in jewelled bearings. The construction of instrument as shown in fig.

Diagram / construction fig.



Working Principle -

1. A current carrying conductor placed in magnetic field expression as force

$$\boxed{F = BIL}$$

where, F = Force I = current
B = flux density l = length of conductor

1. The current I, which is to be measured is passed through the moving coil, and express a force which is directly proportional to this current. This means deflecting torque

$T_d \propto I$

so, $\theta \propto I$, at final position

as $T_c = T_d$

$\boxed{\theta \propto I}$

Scale is linear.

2. Due to this force the coil rotates and the pointer attached to its coil also move.

3. The angle through which the pointer moves is proportional to current I. Hence,

Advantages -

1. It has uniform scale. The scale may be very long, over about 250.

2. The instrument consumes less power

3. It has very high accuracy

4. The instrument is from hysteresis error.

5. With a powerful permanent magnet its torque to weight ratio is very high

Disadvantages-

1) The cost of the instrument is comparatively high

2) Suitable for DC measurement only.

- AC / DC INSTRUMENTS -

→ Dynamometer Instruments-

It is a modification of PMMC instrument. Permanent magnet in PMMC is replaced by two fixed coils. Soft Iron core in PMMC is also removed, Thus moving coil is also air cored.

Construction-

1. As below in fig - f_1, f_2 are two identity circular, air cored coils. They are connected in series & these coils are placed $\parallel$r to each other.

2. They produce a uniform magnetic field, M is a light moving coil. It lenes in the magnetic field produced by f_1, f_2 moving coil is supported by a spindle & jewelled bearing

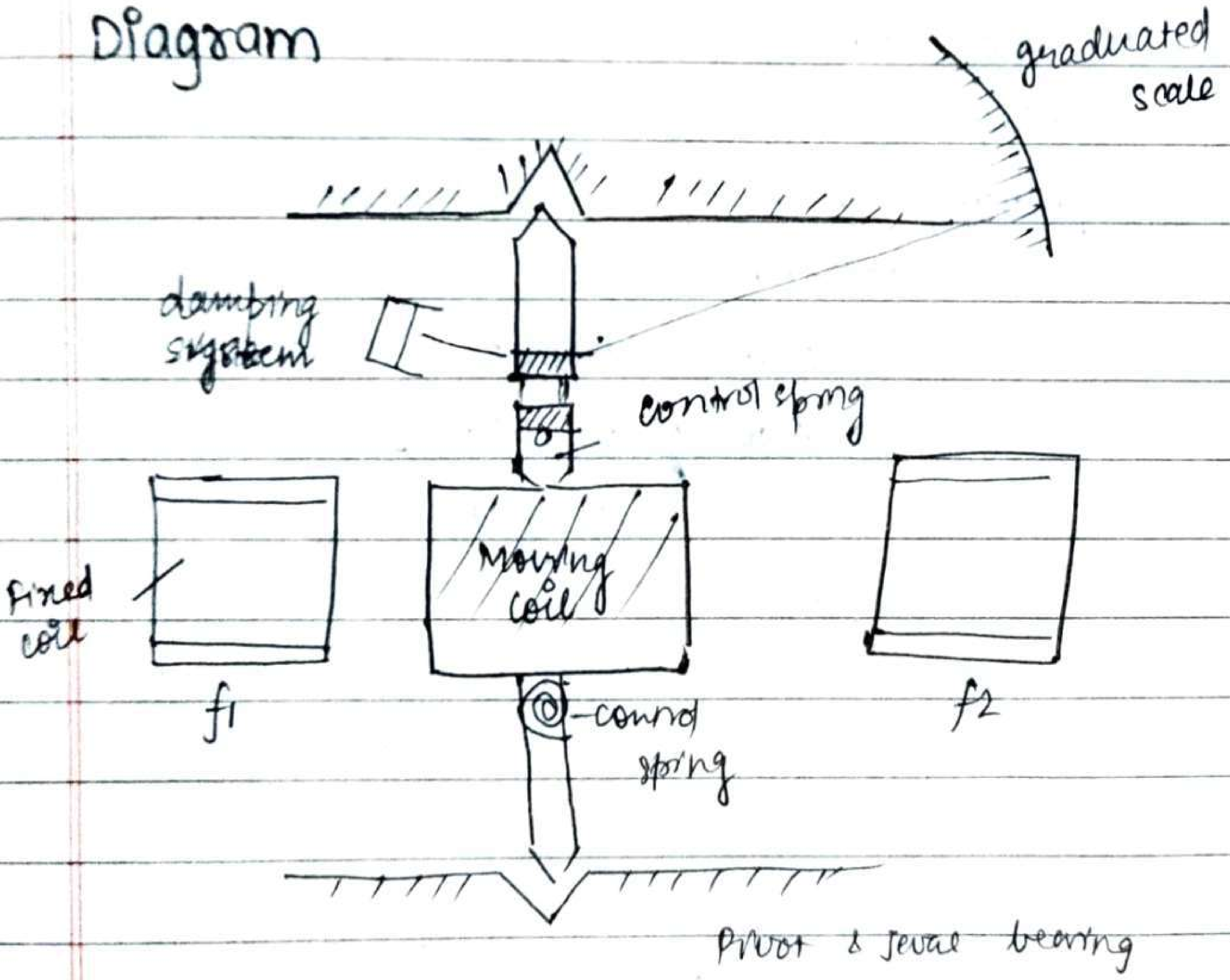
3. Dynamometer type instrument is current sensitive. The capacity of carrying current of moving coil greater than in PMMC instrument.

4. Two control spring wound in opp. directions are used as lead to pass current in moving coil. These springs exert controlling torque. Damping torque is obtained by using air friction damping.

Also for the dynometer

$$T_d \propto I$$

Diagram



Working Principle-

1. It works on simple principle i.e. whenever a current carrying conductor is placed

In a magnetic field force is excuted on the conductor. this is same as that PMMC instrument.

2. In the case, field fixed coils procedure magnetic field whenever they are energized. Moving coil carrying the current to be measured is suspended in this magnetic field.

3. Hence, its experience a torque. Thus status through an angle proportional to the current flowing throw moving coil.

4. As the pointer is attached to the moving coil, we get the pointer deflection propotional to the current to be measured

Deflecting torque $Td \propto I_m I_f$

Controlling torque $Tc \propto Q$

$\therefore$ At steady state $Tc = Td$

$\theta \propto I_t$

so, scale is non-linear.

Advantages-

1) Use of iron instrument avoided. Hence it is free from Hysteresis & eddy current loss.

2) High degree of accuracy

3) It is useful for both a.c & dc measurements

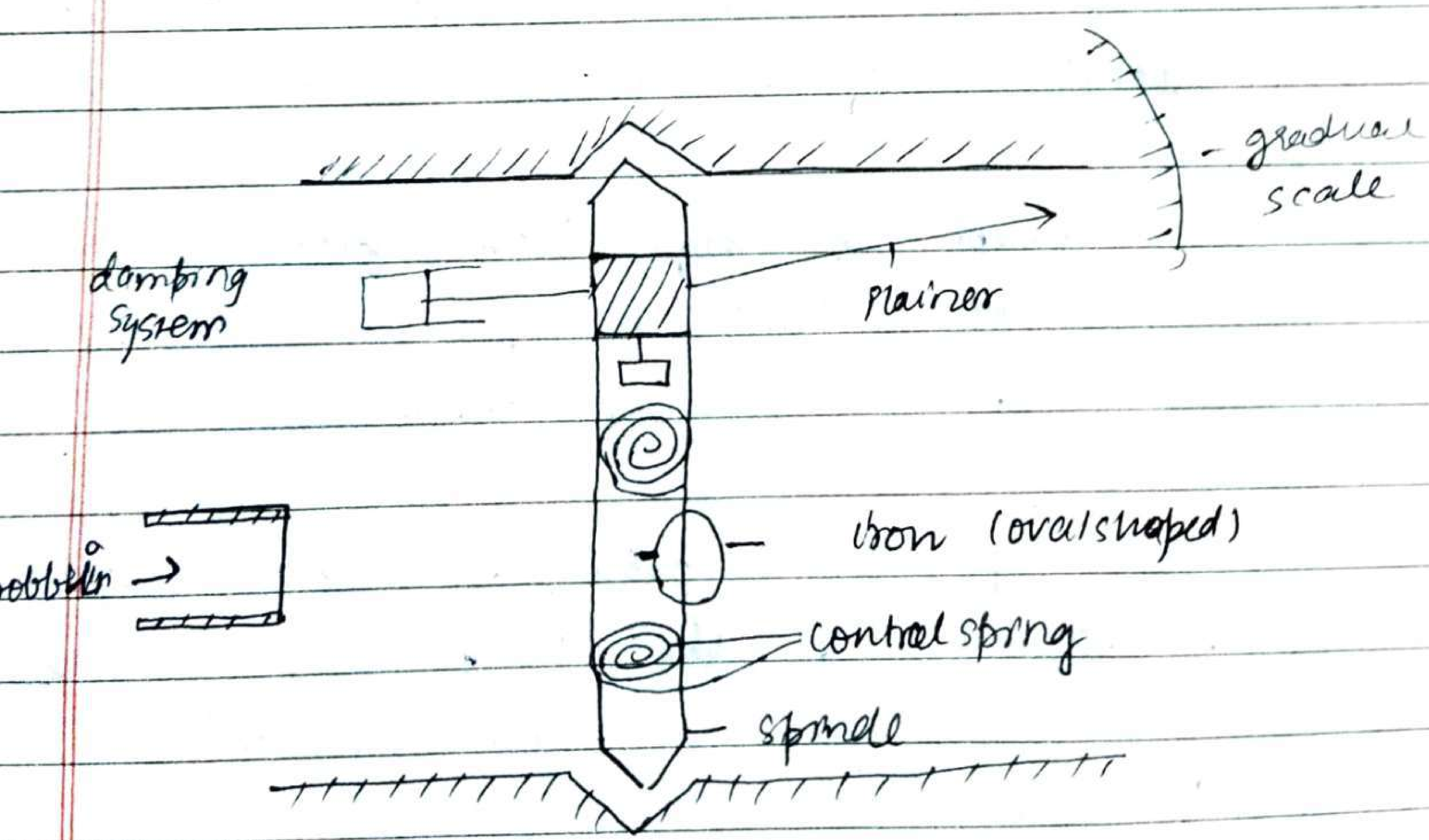
Disadvantages -

1) Scale is non-linear
2) Torque to weight ratio is small
3) It is an expensive instrument.
4) The Instrument has low sensitive. (about 20 to 1000 Ω/volt)

→ Moving Iron Instruments -

Where ruggedness is more important than high degree of accuracy, moving iron instrument are used. These are of two types -

(a) Attraction type moving iron instrument -



The fig shown a fixed coil c and an oval shaped, the soft iron piece, ecentrally mounted on a spindle.

1. The spindle is separated b/w jewel bearing and its carries the pointer. The instrument may damping is provided by a moving in air sharper.

2. The piston is done attached to the main spindle such instrument, eddy current damping is not used because the presence of permanent magnet required for damping purpose would effect operating field of instrument.

3. When current to be measured is passed through the fixed coil c It produces a magnetic field Due to this field the soft iron piece get attached inside and the pointer deflects over a calibrated scale.

4. The shape of soft iron piece is so adjustment that as far as possible a uniform scale is obtained.

5. The soft iron piece is always attached, irrespective of the d/m, of the mag field of coil, ∴ the instrument can be used both for a.c & d.c measurement

6. The damping is provided by the piston attached to the spindle

7. Deflection torque to its α is square of current passing through coil.
$\boxed{Td \propto I^2}$

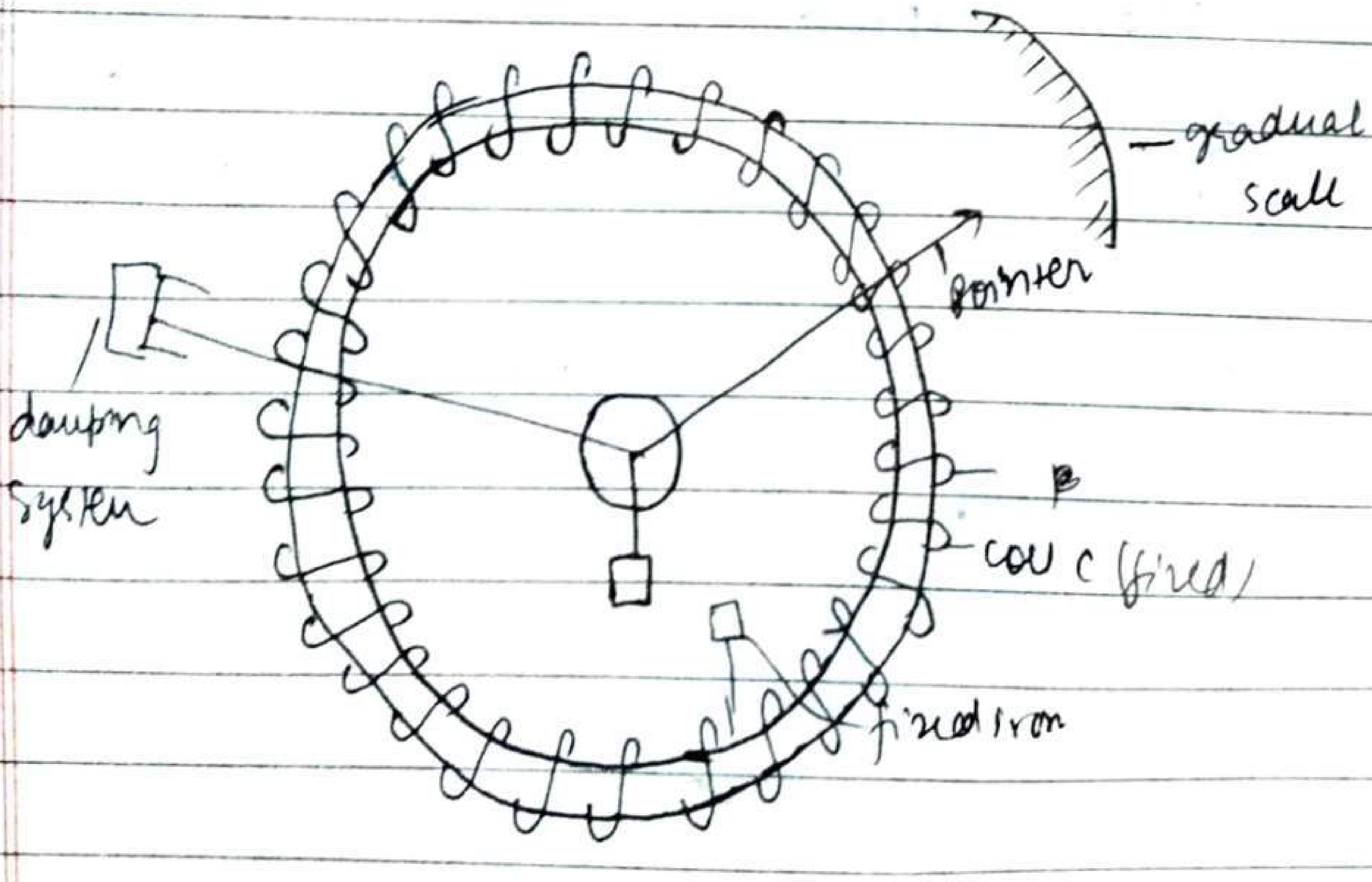
8. So deflection of the pointer is also propotional to the square of current.
$\theta \propto I^2$.

9. Scale of instrument is non-linear. It is coomped at beginning & open at the upper & of the scale.

Working Principle-

The basic principal of operation is that, a soft iron piece get through near a magnet gets attracted by the magnet.

(b) Repulsion type Moving Iron Instrument-



Principle-

The basic principle of this instrument work is that of two soft iron piece magnetised in the same direction are placed very near to each other they repel

Construction -

1. The strip A is attached to the Babbin over which the coil C is wound. The other strip B is attached to spindle & therefore it is movable

2. Due to this force of repulsion strip B is moves away from strip A & therefore the pointer is attached to spindle deflects.

3. Force of repulsion between two strip depends upon their relative field strength. Strength is propotional to the current is the coil

4. Deflecting torque is propotional to the square of current.

Advantages-

Suitable for both AC & DC.

Good accuracy

A large scale of length about 240.

The instrument can be used for low frequency measurement also.

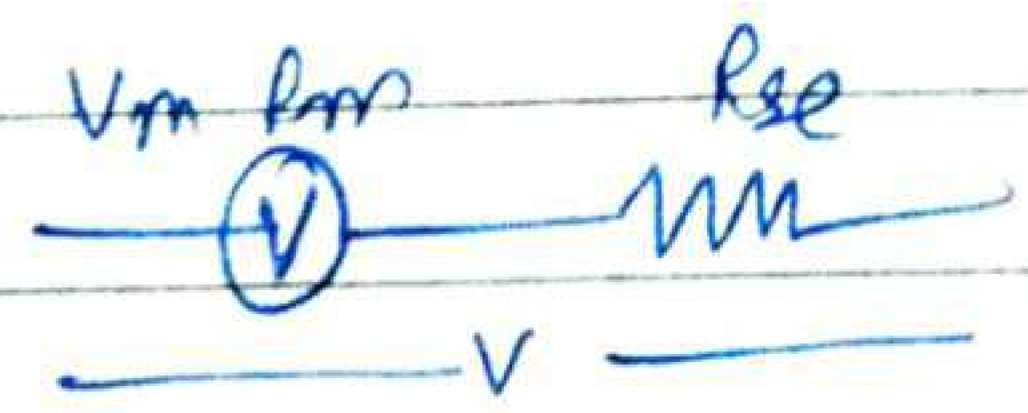
Disadvantages-

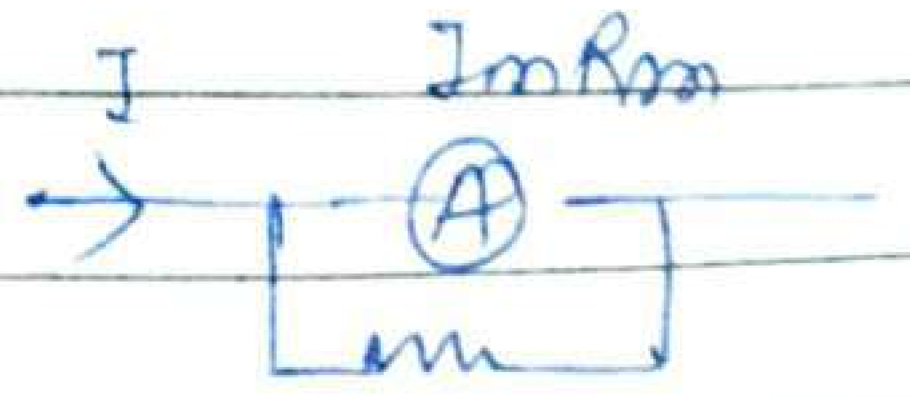
The scale is non-uniform

Due to the presence of iron part in the operating system. Error due to hysteresis loss is ~~lrd~~ introduced to reduce their effect nichel, iron, alloy are used.

Note-

Selectivity - $\frac{1}{\text{Band with}}$





$$V_m = V\frac{R_m}{R_m + R_{se}}$$

$$I_m = I\frac{R_{sh}}{R_m + R_{sh}}$$

Junction transformer... loss of clock

UNIT-3

MEASUREMENT OF PARAMETERS
(R, L, C)

Measurement of resistance-

Low resistance measurement ($R < 1\Omega$)
Medium resistance measurement ($1\Omega < R < 0.1M\Omega$)
High resistance measurement (above $0.1M\Omega$)

Medium resistance measurement ($1\Omega < R < 0.1M\Omega$)

Voltmeter- Ammeter method. (Also useful for Low Resistance)
Substituting method
Wheatstone's bridge
Ohm- meter method

Voltmeter- Ammeter method-

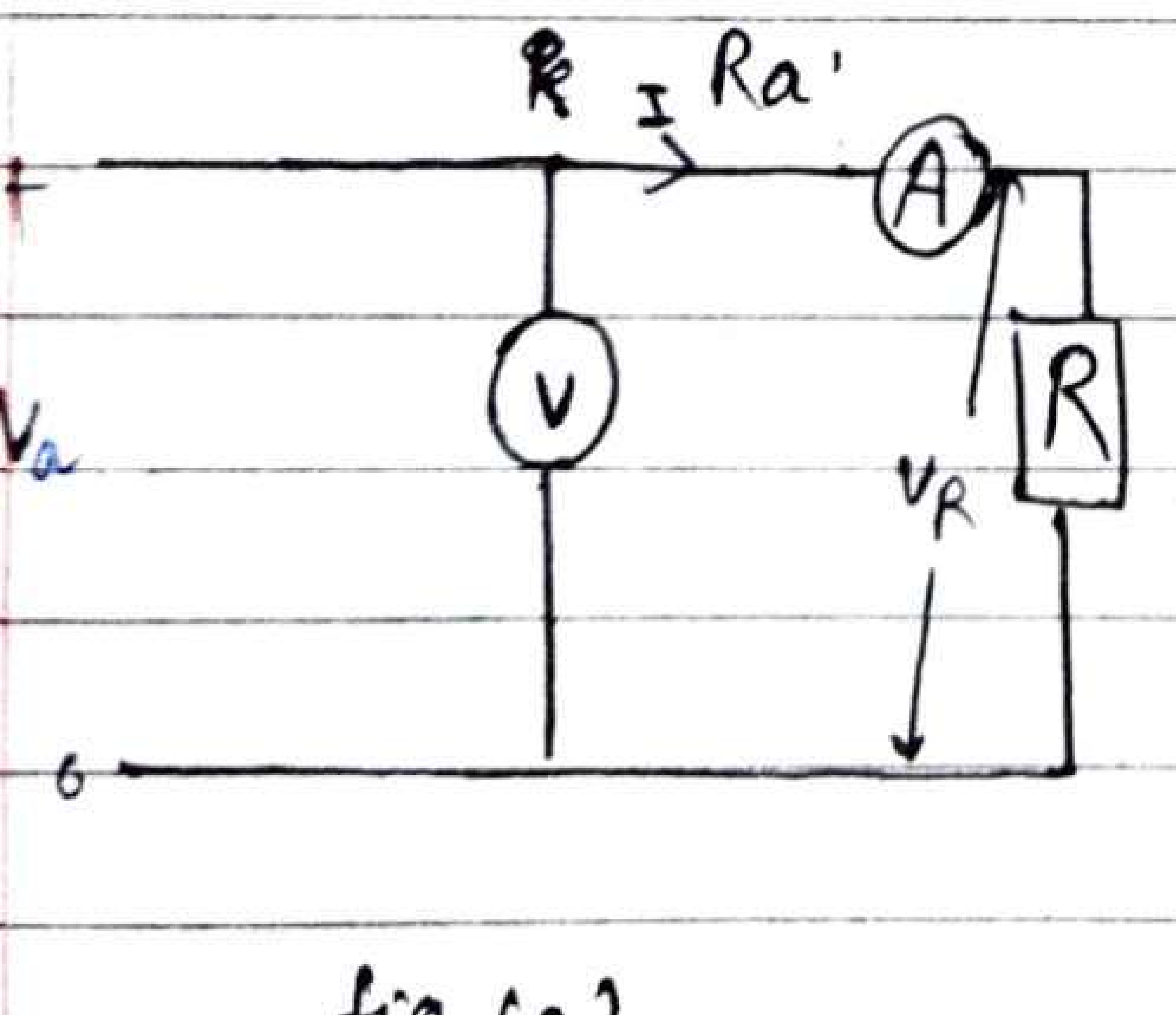


fig (a)

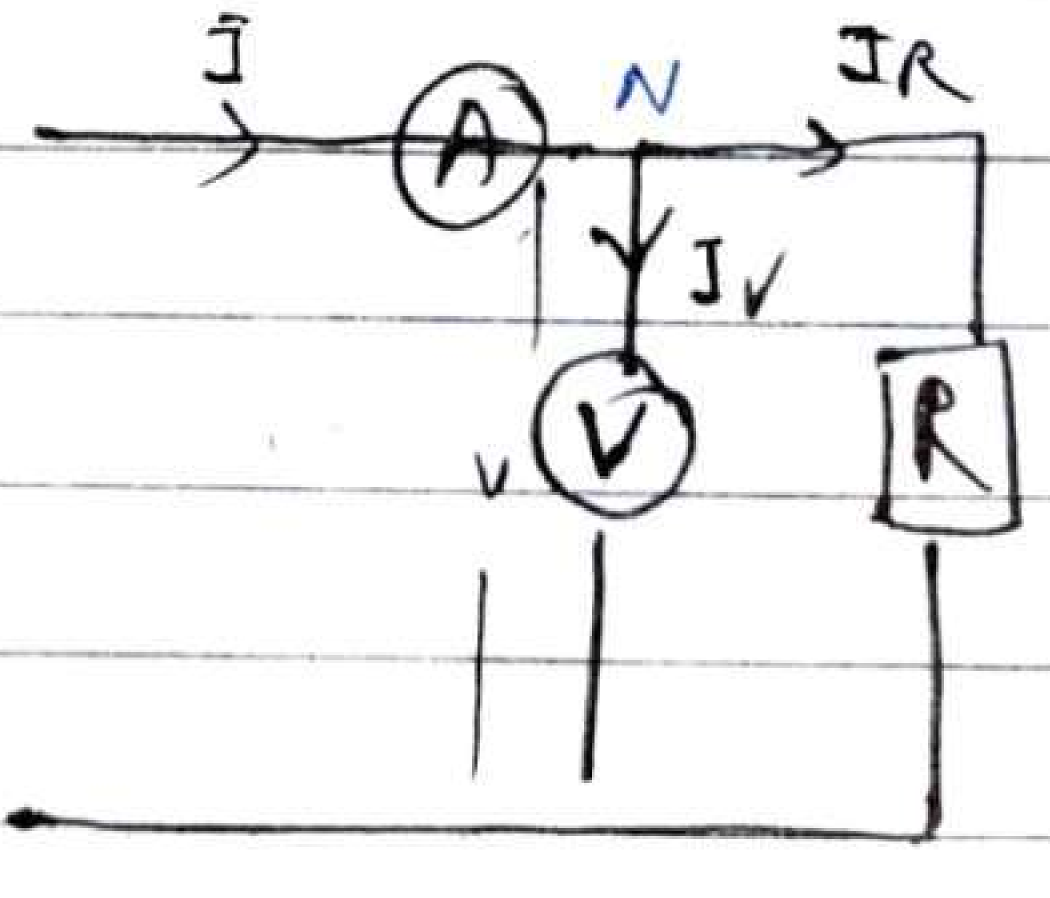


fig (b)

Ra → resistance of ammeter.

For fig (a) -

(voltage across ammeter)

$$V_a = I R_a \quad \text{—— ①}$$

(from KVL) $V = V_a + V_R$ —— ②

Now put value of V_a in eq (2),

$$V = IR_a + V_R$$

$$V = IR_a + IR$$ (Resistance & current [illegible])

$$\boxed{V = I(R_a + R)} \quad -(3)$$

Measured value

$$R_{m_1} = \frac{V}{I}$$

$$= \frac{\cancel{I}(R_a + R)}{\cancel{I}}$$

$$R_{m_1} = R_a + R$$

$$R = R_{m_1} - R_a$$

$$\boxed{R = R_{m_1}\left[1 - \frac{R_a}{R_m}\right]}$$

→ For fig (b) -

Applying KCL at node 'N'

$$I = I_V + I_R$$

Measured value -

$$R_{m_2} = \frac{V}{I}$$

$$R_{m_2} = \frac{V}{I_V + I_R}$$

$$\boxed{R_{m_2} = \frac{V}{\frac{V}{R_V} + \frac{V}{R}}}$$

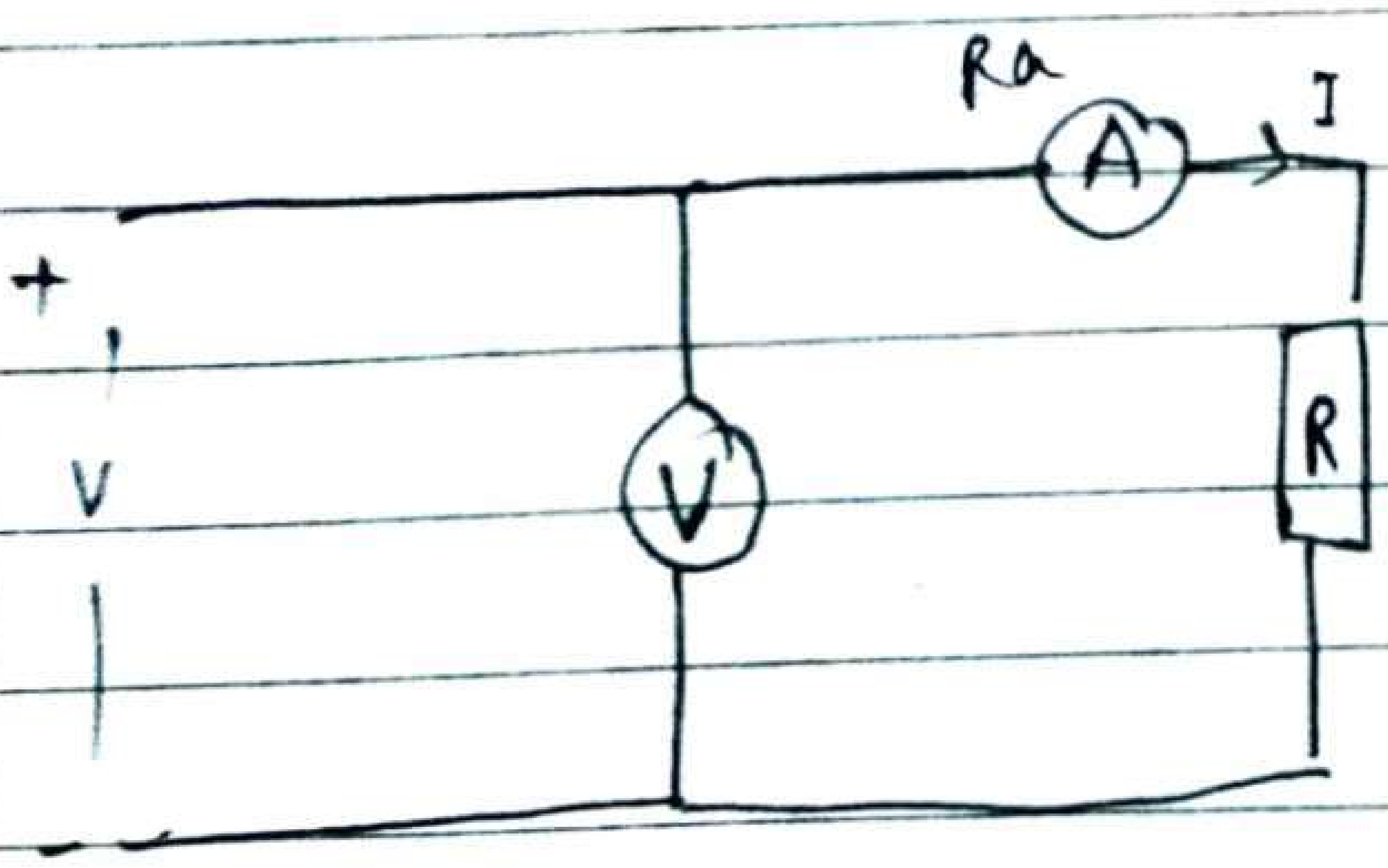
$$R_{m_2} = \frac{1}{\frac{1}{R_V} + \frac{1}{R}}$$

$$= \frac{1}{\frac{R + R_V}{R_V R}}$$

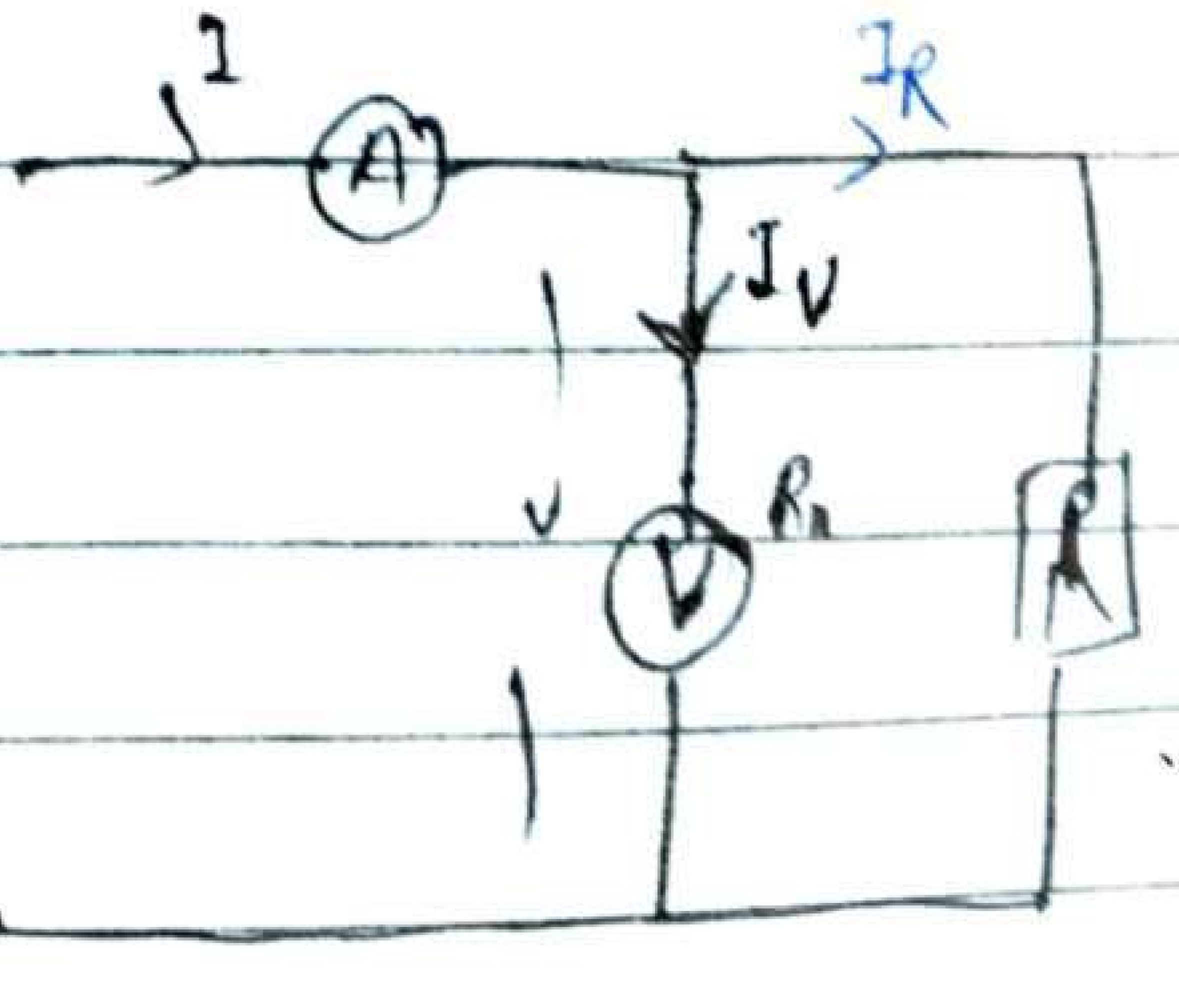
$$\boxed{R_{m_2} = \frac{R_V \cdot R}{R + R_V}}$$

Numerical-

The measurement of resistance by voltmeter ammeter method, connections A and B as showed in figure. are used. The resistance of ammeter is 0.01 Ω, The resistances of Voltmeter 2000 Ω in case of connection B - The current measure is 2A and Voltage is 180V. Find the % error in measurement of resistances. Find the reading of voltmeter in case of connection A when current shown by ammeter is 2A. Find the % error in measurement of resistances

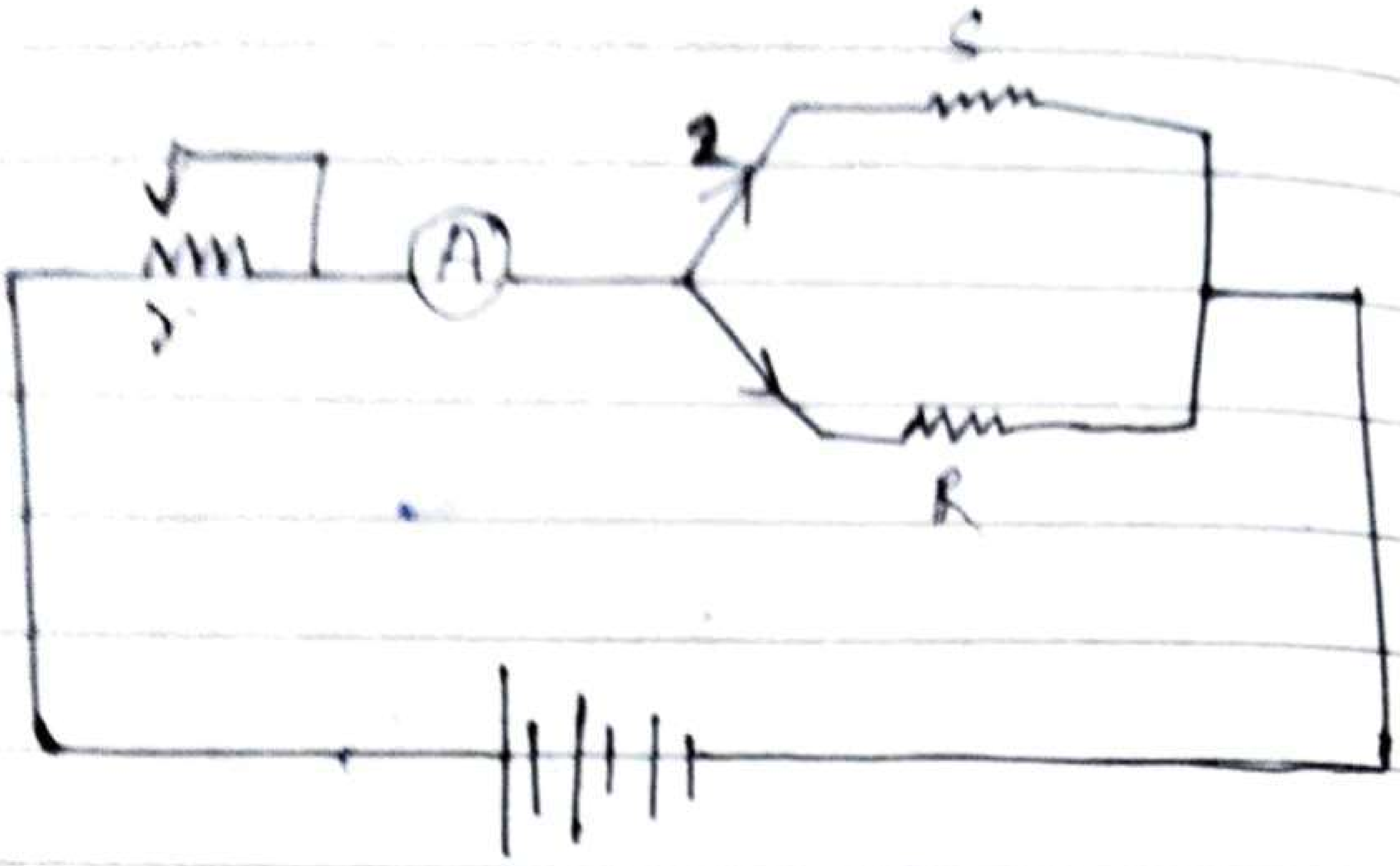


Connection (a)



Connecti (b)

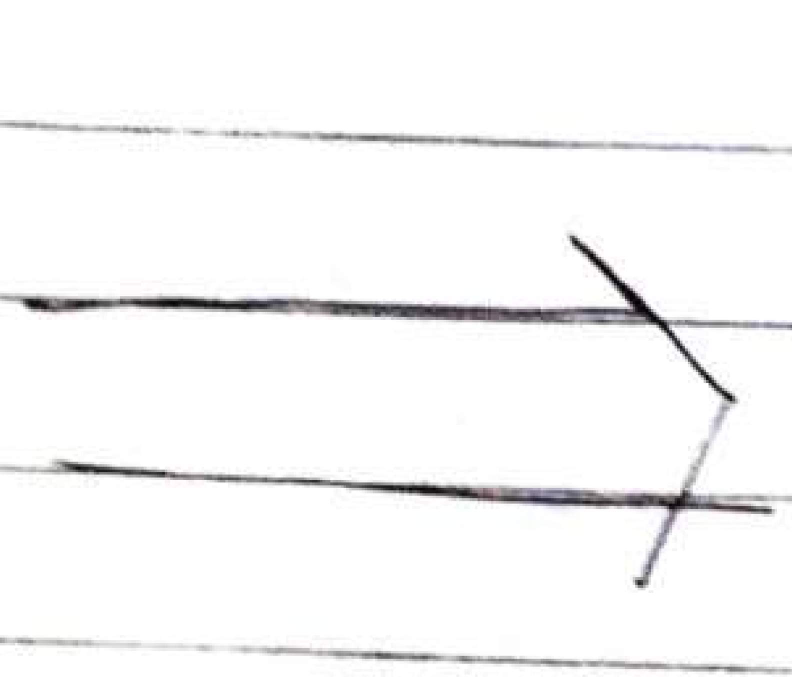
(b). Substitution method-

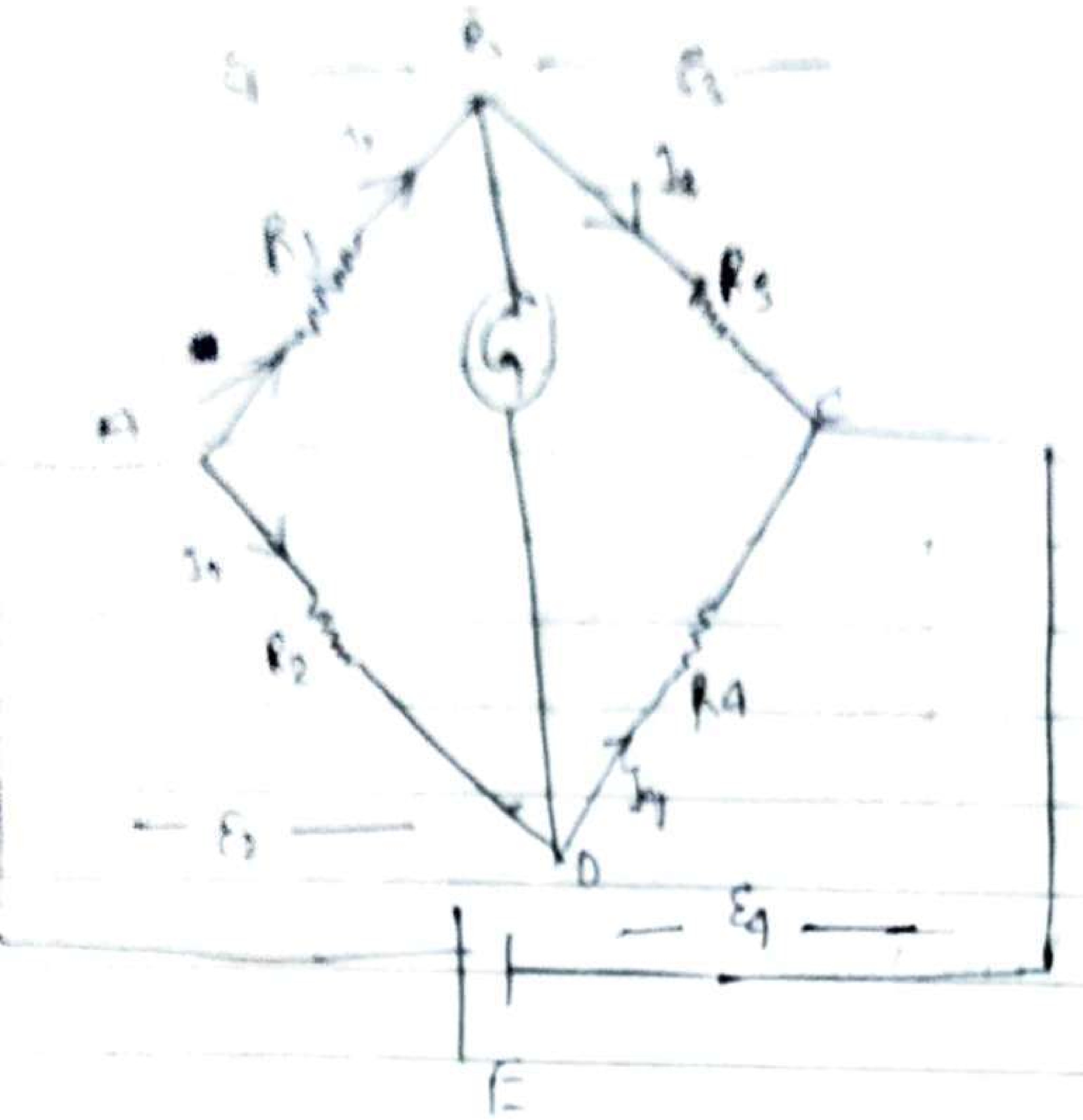


Connection digram for the figure is given above

- 'R' is the unknown resistance while 'S' is the standard variable resistance, 'A' is an ammeter and 'r' is a regulating resistance.
- There is a switch for putting R and S into the circuit alternatively.
- This method is not widely used for simple mel resistance measuremet.

(C) Wheat stone's bridge-





For balancing condition-

$$\boxed{E_1 = E_2}$$

$$I_1 R_1 = I_2 R_2 \quad \text{——— (1)}$$

Here,

$$I_1 = \frac{E}{R_1+R_3}$$

$$I_2 = \frac{E}{R_2+R_4}$$

Now, putting I_1 & I_2 values in eq (1)

then,

$$R_1\left(\frac{E}{R_1+R_3}\right) = R_2\left(\frac{E}{R_2+R_4}\right)$$

$$\frac{ER_1}{R_1+R_3} = \frac{ER_2}{R_2+R_4}$$

$$R_1 R_2 + R_1 R_4 = R_1 R_2 + R_2 R_3$$

$$\boxed{R_1 R_4 = R_2 R_3}$$

or

$$\boxed{R_1 = \frac{R_2 R_3}{R_4}}$$

(d) Ohm-meter.

It is one kind of electronic device mainly used for calculating device electrical resistance of circuit. Unit of resistance is Ohm. Electrical resistance is calculation of how much an object resists allowing the flow of current through it.

There are diff types of meters available with diff sensitivity levels such as micro, mega, & milli Ohmmeters.

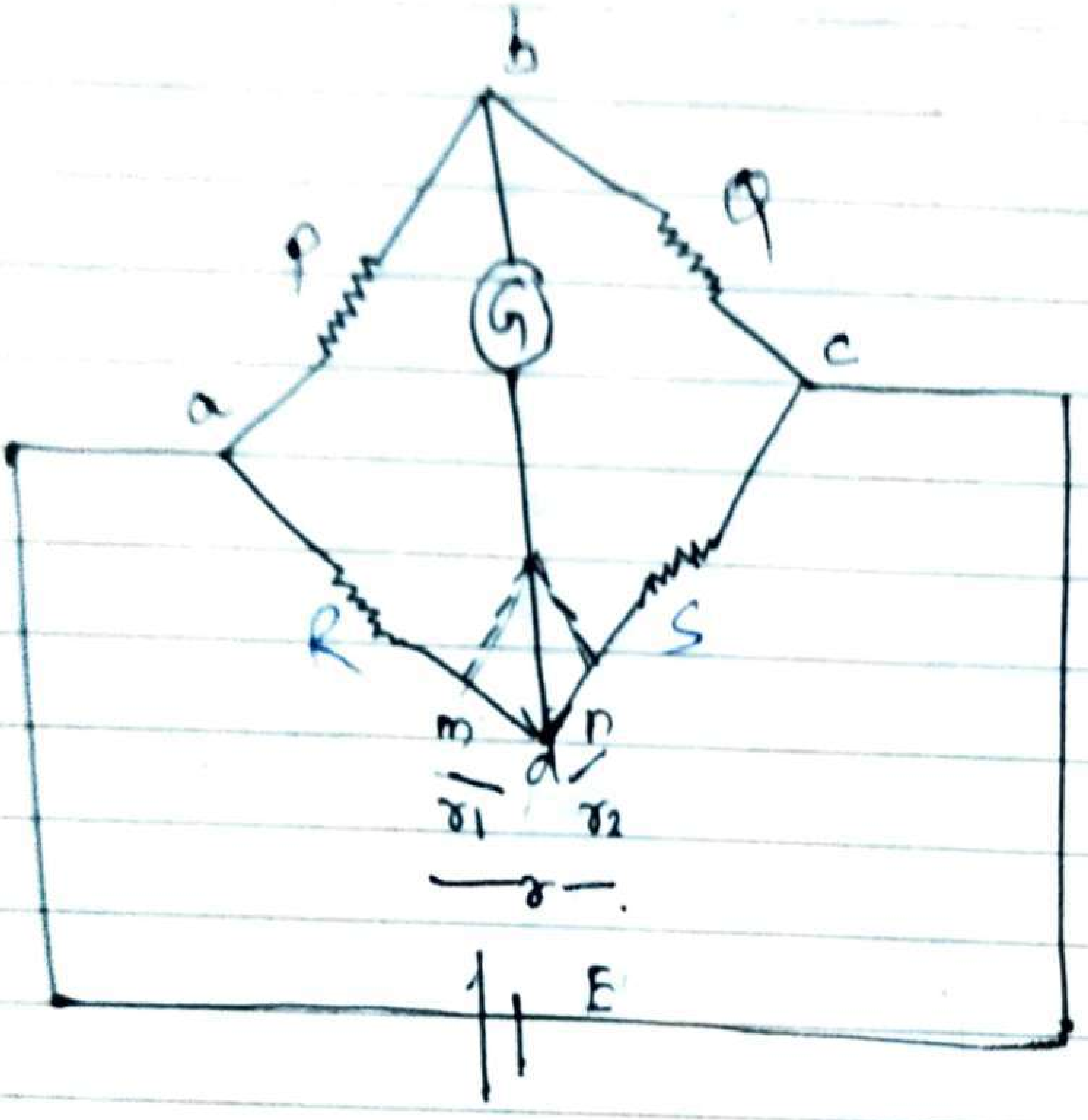
* Types of Ohmmeter-

- Series Ohmmeter
- Shunt Ohm meter
- Multi-range Ohmmeter.

* LOW Resistance measurement $(R < 1\Omega)$

- Voltmeter ammeter method
- Kelvin's double bridge method (V Imp)
- Potentiometer method (chapt. 4)

• Kelvin's Bridge Method- (Imp)



- The Kelvin's Bridge is modification of the wheat stone bridge and provides grately increased accuracy measurement of low resistance.

- Suppose that instead of using of point m, which gives a low result or at point n which makes the result high.

We make the galvanometer connection to any intermediate point 'd' as shown by full-line figure

If at point ~~d~~, the resistance ~~R~~ 'r' is divided into two parts i.e. 'r_1', 'r_2' such that —

$$\boxed{\frac{r_1}{r_2} = \frac{P}{Q}} \text{ —— } (1)$$

Now adding both side 1, then eq (1) becomes -

$$\frac{r_1}{r_2} + 1 = \frac{P}{Q} + 1$$

$$\frac{r_1 + r_2}{r_2} = \frac{P+Q}{Q}$$

$$\frac{r}{r_2} = \frac{P+Q}{Q} \qquad (r = r_1 + r_2)$$

$$\boxed{r_2 = \frac{Q\cancel{R}r}{P+Q}}$$

Now putting r_2 value ~~p~~ in eq (1) then we get -

$$\frac{r_1}{\frac{QR}{P+Q}} = \frac{P}{Q}$$

$$\frac{r_1 (P+Q)}{\cancel{Q}R} = \frac{P}{\cancel{Q}}$$

$$r_1 (P+Q) = RP$$

$$\boxed{r_1 = \frac{PR}{(P+Q)}}$$

Date ___/___/___ Page No

Now, (Wheat stone's bridge)

$$\frac{P}{Q} = \frac{R+r_1}{S+r_2}$$

$$\left(\frac{P}{Q} = \frac{R+\frac{Pr}{P+Q}}{S+\frac{Qr}{P+Q}}\right)$$ solve by this (long method)

or

$$R+r_1 = (S+r_2).\frac{P}{Q}$$

$$R+\left(\frac{Pr}{P+Q}\right) = \left[S+\left(\frac{Qr}{P+Q}\right)\right]\frac{P}{Q}.$$

$$R+\cancel{\frac{Pr}{P+Q}} = \frac{SP}{Q} + \cancel{\frac{QrP}{(P+Q)Q}}$$

$$R = \frac{SP}{Q}$$

$$\boxed{\frac{R}{S} = \frac{P}{Q}}$$

Limitation-

The sensitive galvanometer is used for detecting the balance condition

The high measurement current is required for obtaining the good sensitivity.

EMMI

UNIT-I

PHILOSOPHY OF MEASUREMENT

Notes-

Measurement:-

The measurement of a given quantity is the result of a quantitative comparison between an unknown quantity & a pre-defined standard quantity.

Instrument-

It can be defined as a device for measuring the value of magnitude of a quantity or variable.

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* CLASSIFICATION OF INSTRUMENT-

a) Absolute instrument-

These instrument read the quantity under measurement indirectly. i.e, in terms of deflection degree and metre constant.

ex- Tangent galvanometer, current balanced meter.

The actual value under measurement

can be calculated by using the formula ⇒ $\boxed{\text{meter constant} \times \text{deflection}}$

b) Secondary instrument-

These instrument read the quantity under measurement directly. i.e, If is ammeter it reads directly in amperes.

The instrument commonly used in lab. such as- ammeter, voltmeter, etc.

✱ CLASSIFICATION OF SECONDARY INSTRUMENT-

Secondary Instrument

- Depending upon the principle of operation
  - Magnetic meter
  - Induction meter
  - Electrostatic meter
  - Hot wire
- Depending upon the permissible percentage error
  - Standard meter
  - Sub-standard meter
  - I grade instru.
  - II grade instr.
- Depending upon application
  - Indicati instrum
  - recordi instrum
  - Integrating Instrume

(a) Depending upon permissible % error-

- Standard meter-

These are the most accurate meters which are used for calliberation of meters. The permissible error in this meter is 0.2% and less than 0.2%.

- Sub-Standard meter-

The permissible error is order of 0.2% to 0.5% of full scale deflection

- I-grade instrument-

They are used for testing in lab. The % error in this meter is in the order of full scale deflection.

- II- grade instrument-

It is used for panel. There % error is 2% to 5%

(b) On the basis of application-

- Indicating Instrument-

These Instrument gives the instantaneous value of under measurement with the help of pointer and calliberation scale example - voltmeter, wattmeter, etc.

- Recording instrument-

These instruments gives continous record of quantity under measurement over a certain period of time.

or

It gives graphical representation with the help of pen & paper.

→ Recording ~~line~~ type of ammeter, voltmeter used in generating stations & distribution sub-station.

- Integrating instrument-

These meter gives summissions of the quantity under measurement over a ~~strate~~ certain period of time. The reading of these meters in terms of digits.

ex - Energymeter.

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* CLASSIFICATION OF INSTRUMENTS-

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* CHARACTERSTICS OF INSTRUMENTS-

- Static characterstics
- Dynamic characterstics.

(a) Static characterstics -

They are defined as for the instrumen which measure quantities which do not vary with the time.

→ **Accuracy** - The accuracy of measurement indicates the nearness to the true value or actual value of the quantity.

→ **Precision** - It is the measure of reproducibility of the measurement i.e. given a fixed vale of variable. It is a measure of degree to which successive difference from each other.

Example- consider an instrument on which reading can be we taken upto 1/100 of unit. The instrument has zero adjustment error so when we take the reading the instrument is highly precise. but -

- however as the instrument has a zero adjusment error the reading obtained a precise, but they are not accurate.

Date ___/___/___

Questions-

(1) The following table gives a set of ten measurement that when record in a lab. Calculate the precision of fifth measurement.

Measurement	Measurement Voltage
1	98
2	101
3	102
4	97
5	101
6	100
7	103
8	98
9	106
10	99

(1) Precision $= 1 - \left[\frac{X_n - \bar{X}_n}{\bar{X}_n}\right]$

where $\vec{X_n}$ = average value of an measurement

Now, $\vec{X_n} = \frac{98 + 101 + 102 + 97 + 101 + 100 + 103 \cdots 99}{10}$

$\boxed{\vec{X}_n = 100.5}$

where X_n is the value of n^{th} measurement, $X_5 = 101$

Now,

Precision $= 1 - \left[\frac{101 - 100.5}{100.5}\right]$

$= 0.995$

% Precision $= 99.5\%$ Ans

→ Error - It is also called as static error
- It is the deviation from the true value of the measured variable
- Static error may be either absolute error or % error

- Absolute error-

This is the result of comparison b/w the expected value of variable and the observed value of the error.

$$\boxed{e = Ae - Am}$$

$\boxed{e = Ae - Am}$

$\frac{\text{absolute error}}{\text{expected value}} \times 100$

$Ae \rightarrow$ absolute ~~error~~ value

$Am \rightarrow$ measured value

$e \rightarrow$ error

- Percentage error-

It is the ratio of absolute error to the expected value of the variable

$$\boxed{\% \text{ error} = \frac{\text{absolute error}}{\text{expected value}} \times 100}$$

or

$$\% \text{ error} = \frac{e}{Ae} \times 100$$

$$\% \text{ error} = \frac{Ae - Am}{Ae} \times 100$$

- Note:-

error can be also be expressed as a % of the full scale reading

$$\boxed{\% \text{ error} = \frac{A_e - A_m}{\text{full scale deflection}} \times 100}$$

② The expected value of voltage across the resistor is 80 V however the measurement gives a value of 79 V Calculate –

a) absolute error
b) % error
c) Relative accuracy
d) % accuracy
e) error expressed as a % of the full scale reading if the full scale deflection case is 0– 100 V

② Given

(a) $A_e = 80V$

$A_m = 79V$

$e = (80-79)V$

$= 1$

(b) $\% \text{ error} = \cancel{\frac{1}{80} \times 100}$ $\frac{80-79}{80} = \frac{1}{80} \times 100$

$= \cancel{1.25\%}$ $= 1.25\%$

(c) Relative/ accuracy $= 1 - 1.25$

$= -0.25$

(c) $1 - \frac{A_e - A_m}{A_e}$

$= 1 - 0.0125$

$= 0.9875$

(d) % accuracy $= 0.9875 \times 100$

$= 98.75\%$

(v) $\% e = \frac{A_e - A_m}{\text{full scale defle}} \times 100$

$= \frac{80 - 79}{100} \times 100$

$= \frac{1}{100} \times 100$

$= 1\%$ Ans

→ Scale range / Scale Span (length)

The scale range or scale span of an instrument is defined as the difference b/w the largest and the smallest reading of the instrument.

Related numericals -

A voltmeter is caliberated from 100V to 200V. The accuracy is specified within ±0.25% of the instrument span. What is mass error.

Solution,

Given = Range is 100V to 200V.

Range of scale = $(200 - 100)V$
$= 100V$

Maximum error = $\pm \frac{0.25 \times 100}{100}$

Max error = $\pm 0.25 V$ Ans

→ Reproducibility :-

- It is defined as the degree of closeness by which a given value can be repeatedly measured
- The reproducibility is specified for a period of time

→ Drift -

The drift is defined as the gradual shift in the indication over a period of time where ~~in~~ is the input variable doesn't change.

- It is an undesirable quality and it can't be compansionate

- It may be caused becoz of environmental factors like stray magnetic field, Thermal EMFs, change in temperature, mechanical vibrations, etc.

→ Repeatibility -

- It is the measure degree of closeness with which a given input can be measured over and over again.
- It is random in nature

→ Sensitivity -

- It is the ratio of output of the instrument to the change in input of the instrument

$$\boxed{\text{Sensitivity} = \frac{\text{Change in O/P}}{\text{Change in I/P}}}$$

★ $\boxed{\text{Inverse sensitivity / deflection vector} = \frac{\text{change in I/P}}{\text{Change in O/P}}}$

(3) A wheatstone bridge is required a change of 8Ω in the ~~to~~ unknown arm of the bridge to produce a change in deflection of 4mm of galvanometer. Determine the sensitivity and also determine the deflection factor.

Solution

Given - magnitude of I/p = 8Ω
change in O/p = 4mm

(i) $\text{sensitivity} = \dfrac{\text{change in O/p}}{\text{change in I/p}}$

$= \dfrac{4\text{mm}}{8\Omega}$

$= 0.5\ \text{mm}/\Omega$ Ans.

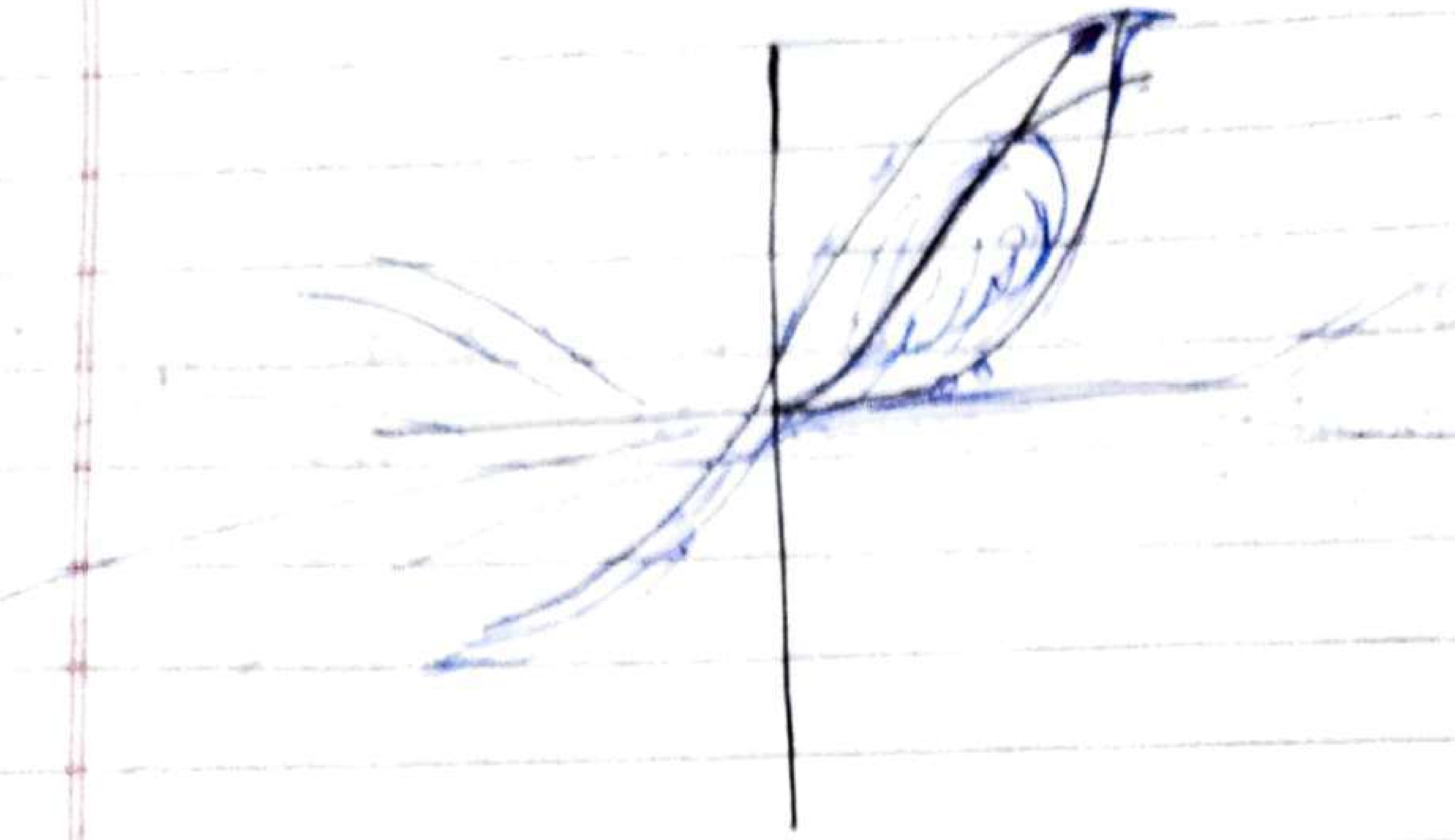
(ii) $\text{Deflection factor} = \dfrac{\text{change in I/p}}{\text{change in O/p}}$

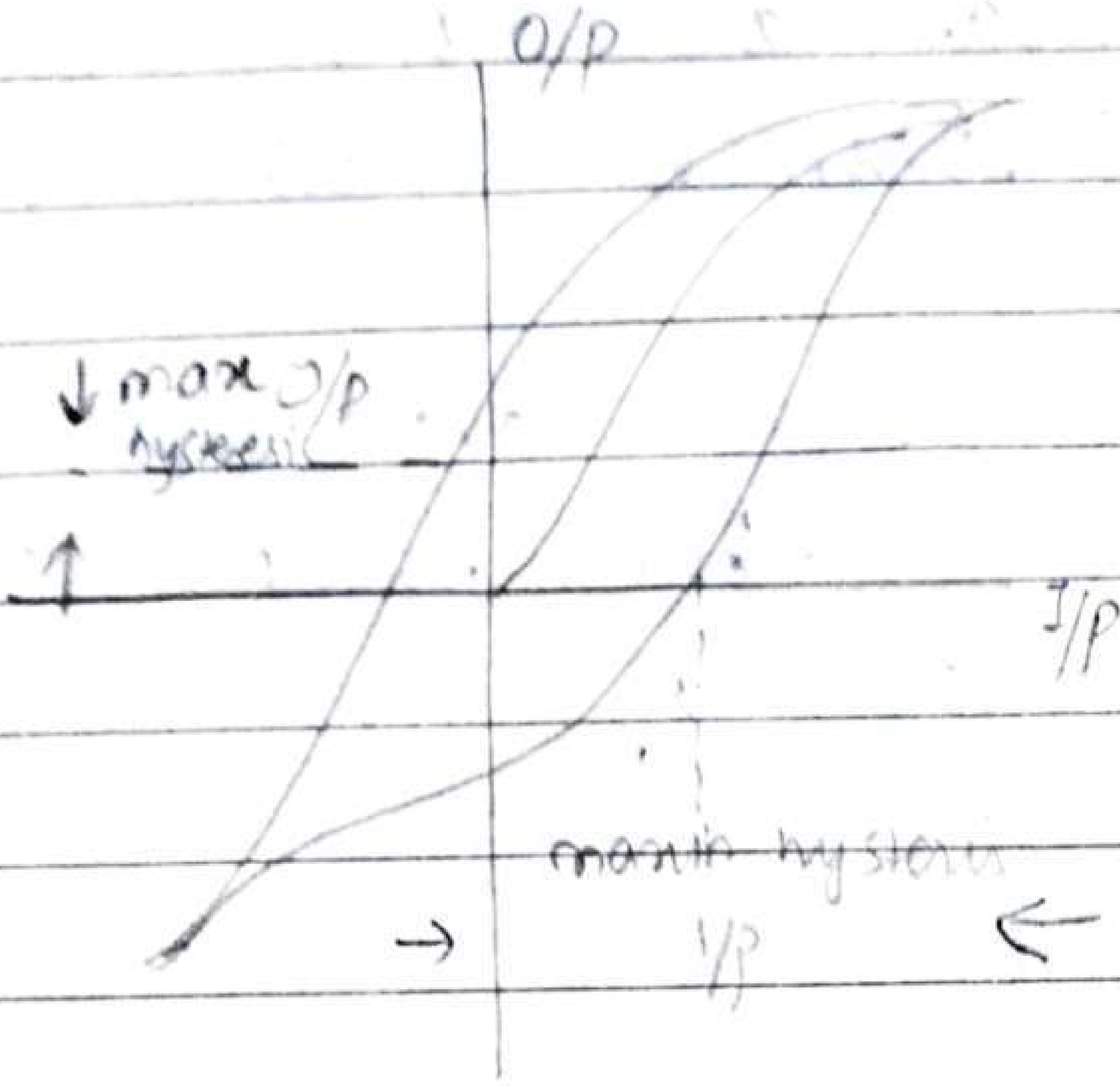
$= \dfrac{8\Omega}{4\text{mm}}$

$= 2\ \Omega/\text{mm}$ Ans

→ Hysteresis :-

- This is a phenomenon which depicts different output effect while loading and unloading.
- The difference b/w 2 curve is called hysteresis.





→ Threshold-

Threshold is the smallest measarable I/P, below which no output change can be identified.

→ Dead time-

It is the time before which the instrument starts to respond after the output has been changed.

→ Dead zone -

It is the largest change of I/P quantity for which there is no O/P.

→ Resolution -

- It is the smallest change in the measured value to which the instrument will respond.

- It is the smallest increment in the input value that can be detected by the instrument.

(4) The moving coil galvanometer Voltmeter has the uniform scale with 100 division. The full scale ~~reao di~~ reading is 200V and 1/10 of a scale division can be estimated with a fair degree of certainty. Determine the resolution of the instrument.

(4) Solution

Given -

Full scale reading = 200V

No. of divisions = 100

Scale division $= \frac{200\,V}{100}$

$= 2\,V$

$$\boxed{\text{Scale division} = \frac{\text{Full scale Reading}}{\text{No. of division}}}$$

$$\text{Resolution} = \frac{1}{10} \times 2$$

$$\boxed{= 0.2V} \text{ Ans.}$$

(5) A digital voltmeter has a read out range from 0 – 9999 counts. Determine the resolution of the instrument in when full scale reading is 9.999V.

(5) <u>Solution,</u>

<u>Given</u>

Full scale reading = 9.999V.

$$\text{Resolution} = \frac{1}{9999} \text{ counts}$$

$$= \frac{1}{9999} \times 9.999$$

$$= 0.001$$

Resolution = 1mV Ans//

→ Stability –

The ability of an instrument to retain its performance throughout its specify storage life and operating life is called as stability.

Tolerance-

It is the maximum allowable error i.e. specified in terms of certain value while measurement is called as tolerance.

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Continue here-

* Calculation of Phase angle & P.F of Two wattmeter

$W_1 = V_L I_L \cos(30-\phi)$ — 1

$W_2 = V_L I_L \cos(30+\phi)$ — 2

$W_1+W_2 = V_L I_L [\cos(30-\phi) + \cos(30+\phi)]$

$W_1+W_2 = 2 V_L I_L \cos 30^\circ \cos\phi$

$W_1+W_2 = \sqrt{3} V_L I_L \cos\phi$ — 3

Now,

$W_1-W_2 = V_L I_L \sin\phi$ — 4

Now 4 / 3

$$\frac{W_1-W_2}{W_1+W_2} = \frac{\sin\phi}{\sqrt{3}\cos\phi}$$

$$\boxed{\tan\phi = \sqrt{3}\left[\frac{W_1-W_2}{W_1+W_2}\right]}$$

→ $\boxed{\text{Phase angle } \phi = \tan^{-1}\left[\sqrt{3}\left(\frac{W_1-W_2}{W_1+W_2}\right)\right]}$

* ERROR-

The error of an instrument is the algebric difference b/w observed value and true value of the quantity being measured.

* Types of errors-

- Gross error - Human made error.
- Systematic error
- Schematic error
- Random error.

(a) Gross error-

These errors are mainly human made errors due to mistakes in taking readings or ~~hammering~~ handling instruments, Ea incorrect setting and adjustment, improper use and application of instrument.

These error are also called personal error.

By taking a careful observation of the reading and recording. the error can be minimized.

(b) Systematic error-

Instrumental error   environmental error   Observational error.

These errors are due to short comings of the instruments such as defective components or parts and the effects of surrounding environment on the instrument or by the user due to improper setting conditions or incorrect proceeder of measurement

They are classified as-

- Instrumentational error
- Environmental error
- Observational error.

→ Instrumentational error-

These are inherant error due to the tolerances in the component value due to the incorrect setting faulty assembling and their mechanical structure.

→ Observational error-

These errors are introduce by the observer. These errors may be introduce due to parall an error while reading ~~amm~~ a meter, improper scale selection, etc

→ Environmental error-

Environmental or surrounding atmosphere external to the measuring devices such as effect of humidity, atm pressure, temperature, electrostat field surrounded the instrument gives rise to these type of errors.

(C) Schematic error-

- These errors are due to unknown causes
* These errors are of two types-
- Static error
- Dynamic error

→ Static error-

These errors are due to limitation of instrument or ~~loss~~ laws governing its observation.

→ Dynamic error-

These errors are due to slow in response of the instrument to follow the changes in reading

(d) Random errors-

- These errors are due to unknown causes.
- These errors are small and follow the laws of probability

The expected value of the voltage across a resistor is 50 V. However error the measurement gives the value of 49 mm. Calculate

- absolute error
- % error
- Relative accuracy
- % accuracy.
- Error expressed as a % after full scale reading, if the full scale deflection is 0 - 100 V.

(a) Given -

$Ae = 50V$

$Am = 49mm$

$e = Ae - Am$

$= 50 - 49$

$= 1 \ V/mm$

(b) % error - $\frac{Ae - Am}{Ae} \times 100$

$= \frac{1}{50} \times 100 = 2\%$

(c) Relative accuracy -

$$\Rightarrow 1 - \frac{A_e - A_m}{A_e}$$

$$\Rightarrow 1 - \frac{50 - 49}{50}$$

$$= 0.98$$

(d) % accuracy $= 0.98 \times 100$
$= 98\%$

(e) $\% e = \frac{A_e - A_m}{\text{full scale deflection}} \times 100$

$$= \frac{50 - 49}{100} \times 100$$

$$= \frac{1}{100} \times 100$$

$$= 1\% \text{ Ans}$$

STANDARDS-

- A standard is a physical representation of unit of measurements.
- It is used for calliberation in order to verify the accuracy of measuring devices

TYPES OF STANDARDS-

(1) International Standards-

- These are those standards maintained ~~measured~~ at international beaurea weights & measured in France

- The standards are periodically evaluated and checked by absolute measurement ~~in France~~ in terms of fundamental units

- They are highest most possible accuracy and absolute quality

- They are not available in the ordinary users for caliberation purpose.

(2) Primary Standards-

- These standards are maintained by the NBSCE (national bureau of standards) in different parts of the world.

- They are not available outside the national laboratories

- The main function of the primary standard is the varification & the caliberation of secondary standards

(3) Secondary standards-

- These are basic reference standards used in the laboratories
- Each industry has its own standards. The particular industry that maintained the secondary standards is responsible for the calberation of these standards.
- The secondary standards are periodically send to the national standard laboratories for calliberation and comparison again primary standard.

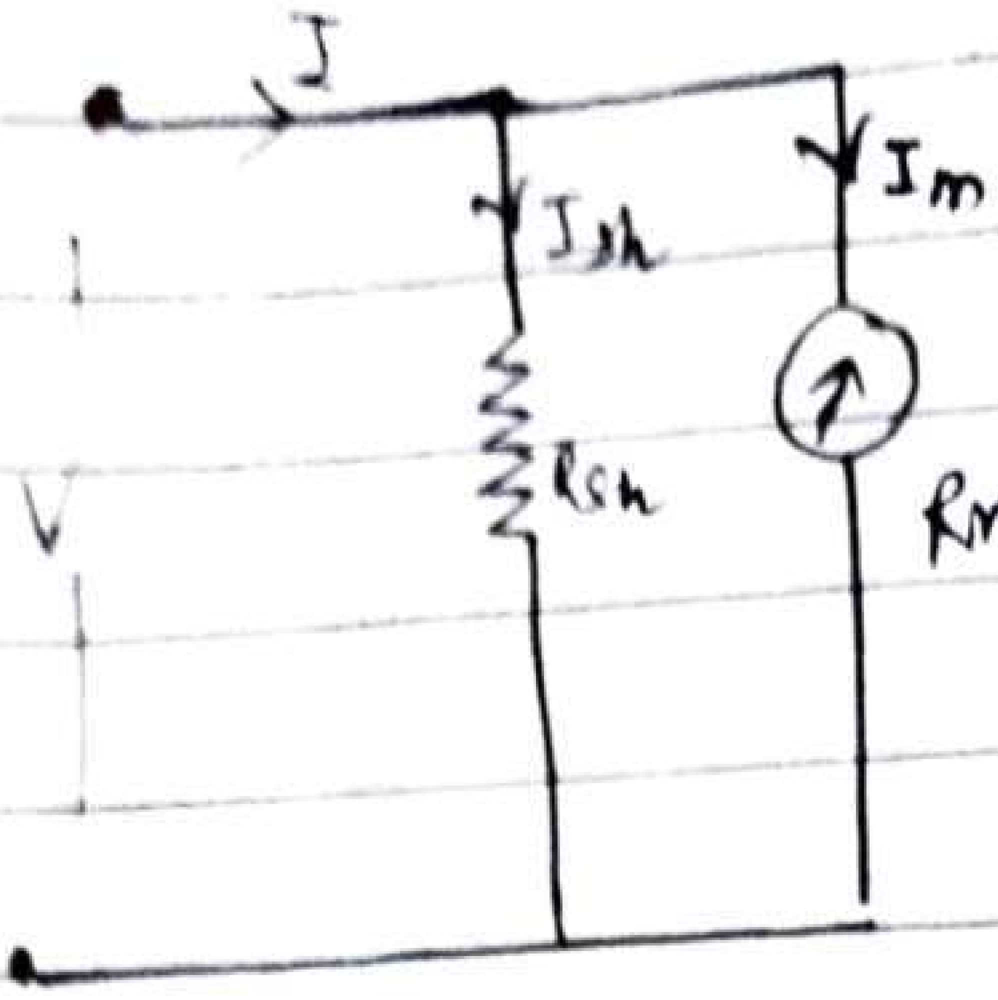
(4) Working Standards-

- Working standards are used in laboratories in in the day to day proces of caliberating instrument
- For eg- A manufacture of precision resistance may use a standard resistance for checking the value of resistance that are manufactured These are accurate then primary standards

* POWER MEASUREMENT IN 3-ø system -

- One wattmeter method (P= 3W)
- Two wattmeter method ← Star connection, Della connection
- Three wattmeter method $(P = W_1 + W_2 + W_3)$

EXTENSION OF RANGE OF AMMETER-



In || voltage is always same i.e

$$I_{sh} R_{sh} = I_m R_m$$

$$R_{sh} = \frac{I_m R_m}{I_{sh}} \quad \text{—— (1)}$$

But,

$$I = I_{sh} + I_m \quad \text{—— (2)}$$

$$I_{sh} = I - I_m$$

Now put eq (2) in eq (1), then,

$$R_{sh} = \frac{I_m R_m}{I - I_m}$$

$$\boxed{R_{sh} = \frac{R_m}{\frac{I}{I_m} - 1}}$$

Multiplying factor $(m) = \frac{I}{I_m}$

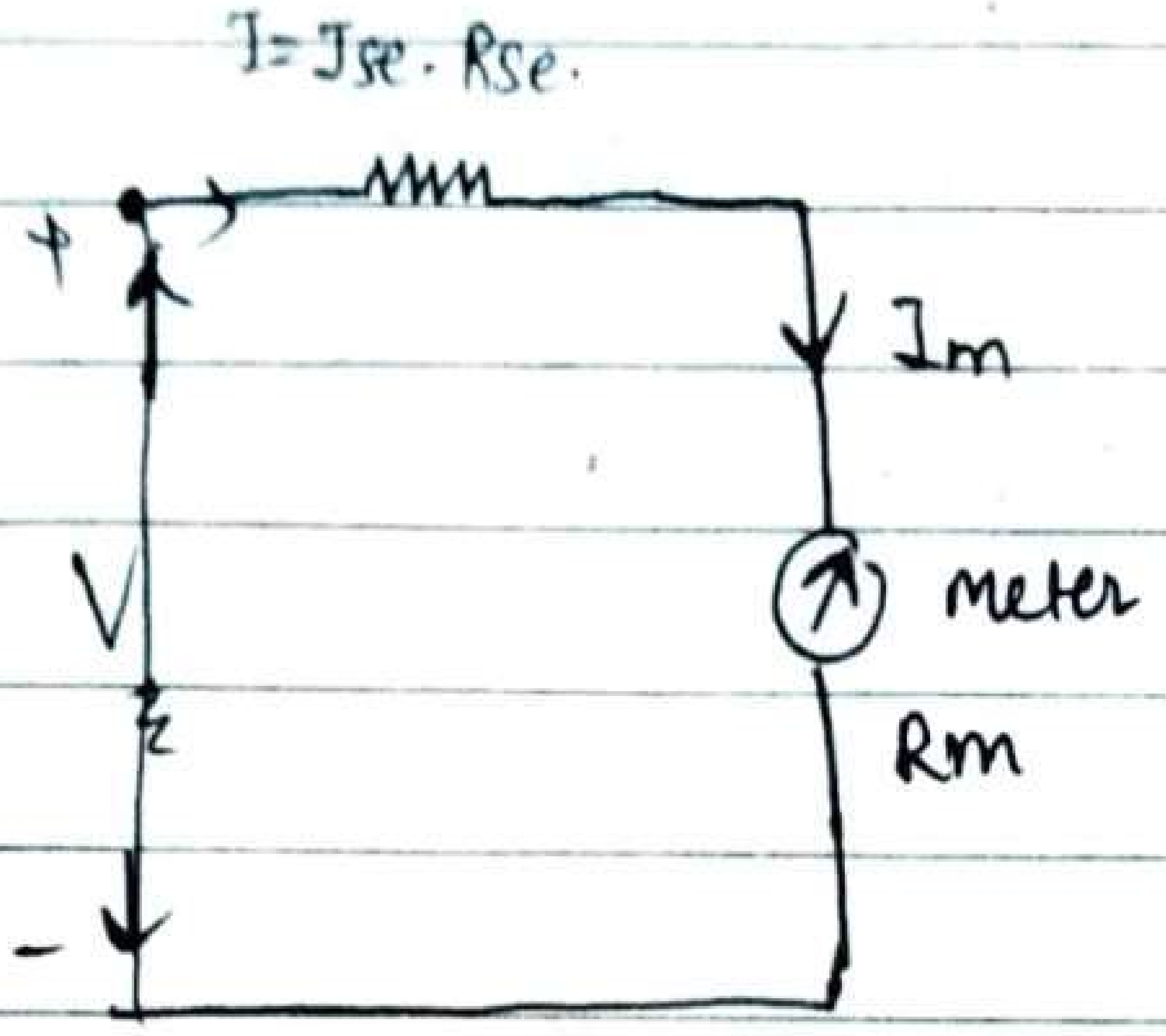
Then,

$$\boxed{R_{sh} = \frac{R_m}{m-1}}$$

where, R_{sh} = shunt resistance

I_{sh} = shunt current
R_m = meter resistance
m : multiplying factor
I = total current
I_m = meter current

EXTENSION OF RANGE OF VOLTMETER–



Now, applying KVL in loop (1)

$$I_m (R_{se} + R_m) = V$$
$$I R_{se} = V - I R_m$$
$$\boxed{R_{se} = \frac{V}{I} - R_m}$$

Where,

R_{se} = series resistance
I = total current
I_m = meter current
I_{se} = Series current
R_m = Voltmeter resistance