Important suggestions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1 A	**Attempt any TEN of the following :** **20 Marks**
a)	**State the range for low and medium resistance.**
Ans:	**(Each point 1 Mark)** Low resistances: less than 1 ohm. Medium resistances: 1 ohm to 0.1 Mega ohm.
b)	**List the different methods to produce damping torque.**
Ans:	**(Any one method 1 Mark)** **Methods of providing damping torque in indicating type instruments:** 1) Air friction damping. 2) Fluid friction damping. 3) Eddy current damping.
c)	**List any two applications of CRO.**
Ans:	**(Any one application $^1/_2$ Mark)** **Applications of CRO:** 1) Measurement of phase and frequency. 2) Measurement of inductance and capacitance. 3) Tracing the waveform. 4) Determination of amplitude of variable quantity. 5) In radar & television. 6) For finding B-H curves. 7) For studying the heart beats etc. 8) To detect standing waves in transmission lines 9) To check faulty components in various circuit 10) For tracing transistor curves

d)	**What is meant by energy meter constant?**
Ans:	**Energy Meter Constant** **(2 Mark)** A fixed value which is used when converting **meter** readings to actual energy use, especially when potential transformers and similar types of equipment are used in metering. For example, K=--------rev/Kwh
e)	**Define: (i) Resolution, (ii) Calibration, with reference to electrical measuring systems.**
Ans:	**Resolution** **(1 Mark)** The smallest increment in input (the quantity being measured) which can be detected with certainty by an instrument is called its resolution or discrimination. ***OR*** It is smallest measurable input change of an instrument. ***OR*** it is the least incremental value of the electrical quantity on the scale **Calibration:** **(1 Mark)** Calibration means comparing the measuring instrument with standard instrument to find out the error in the instrument under test.
f)	**State the function of controlling torque in electrical measuring instrument.**
Ans:	**(Each point 1 Mark)** **Function of controlling torque** 1. **The function is to** opposes the deflection force and increases with the increase in the deflection of the moving system, to limit its movement. 2. and brought pointer to set a position where the two opposing forces i.e. deflection and controlling forces are equal.
g)	**State various types of errors in wattmeter.**
Ans:	**(Any one error $^1/_2$ Mark)** **Types of Error in wattmeter:** 1. Errors due to method of connection. 2. Error due to pressure coil inductance. 3. Error due to pressure coil Capacitance. 4. Error due to mutual inductance effect. 5. Error due to stray magnetic fields. 6. Error due to eddy currents. 7. Temperature error. **8.** Error due to vibration of moving system.

h) State any two disadvantages of one wattmeter method of measurement of 3 phase power.

Ans: **(Any one 1 Mark)**

Disadvantages of one wattmeter method:-

1. Only used for balanced load
2. It can not be used for unbalanced load
3. It is used for star connection then neutral point must be available
4. Delta connection must be opened to connect current coil.

i) State the significance of power factor.

Ans: **(Any one point 1 Mark)**

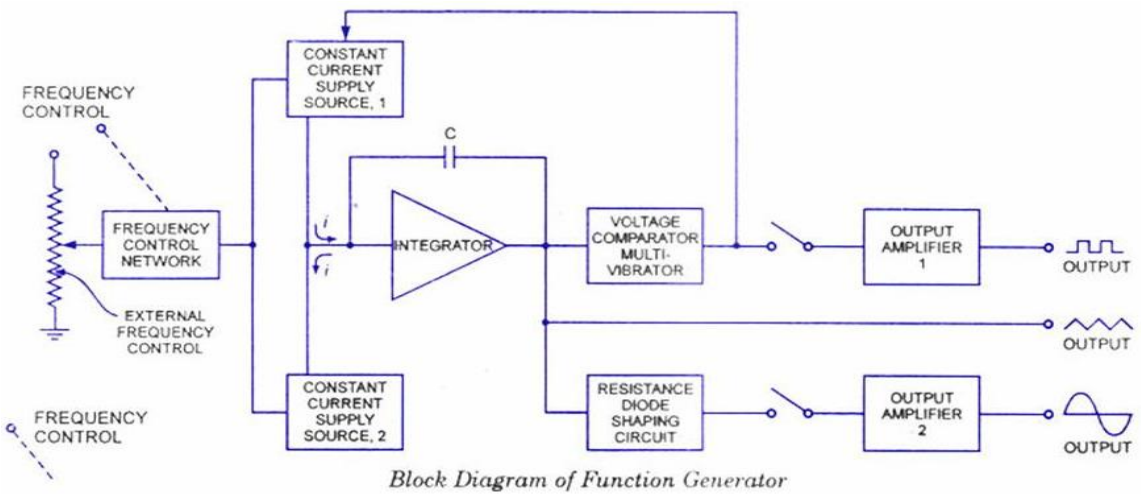
Significance of power factor:-

1. **Cosine of angle between voltage & current in a circuit is called power factor.**
2. **It is a measure of the real power in a circuit.**
3. **Inductive & capacitive circuits causes low PF. Low PF causes increase in current resulting in increase in copper losses in the system.**
4. **Large KVA rating equipment**
5. **Greater conductor size**
6. **CosØ = R/Z CosØ= Active Power/ Apparent Power**

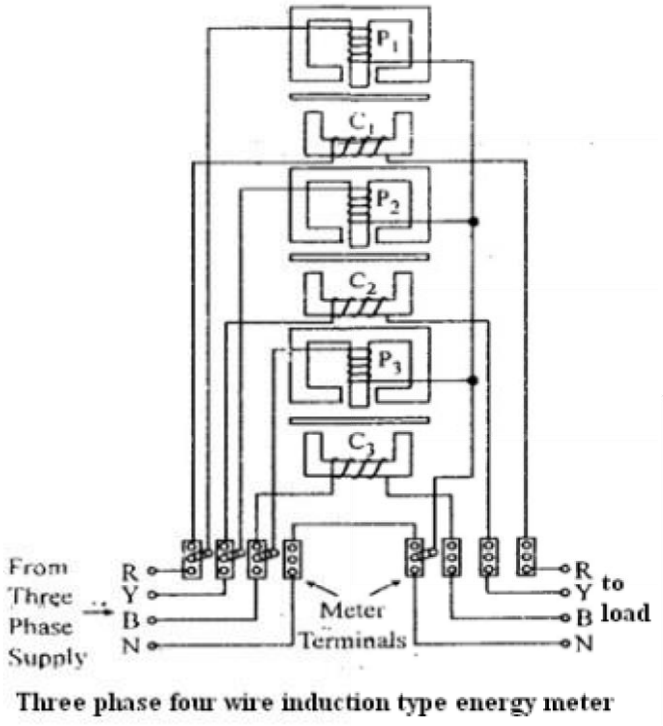
j) Compare primary and secondary instruments (any two points).

Ans: **(Any Two point 1 Mark)**

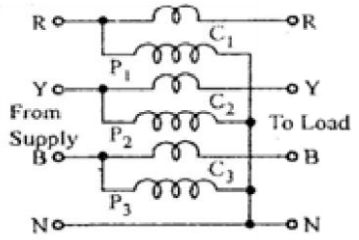
Sr no	Primary instruments	Secondary instruments
1	Gives magnitude of quantity in terms of physical constants of instrument	Gives reading directly of the quantity measured.
2	Need no calibration	Calibrated with respect to absolute instruments
3	Measurement is tedious and time consuming (as indirect) due to calculations needed to be done	Quick method as direct method of reading.
4	Very rarely used.	Very widely used.
5	e.g. tangent galvanometer and current balance galvanometer.	e.g. magnetic meter, induction meter, hotwire meter and electrostatic meter

k)	**Draw block diagram of function generator.**
Ans:	**(Diagram without Labelling: 1 Mark & Neat Labelled diagram: 2 Mark)**  *Block Diagram of Function Generator* **Or equivalent figure**
l)	**Define energy. Write unit of it.**
Ans:	**Energy :-** **(1 Mark)** Electrical energy is defined as the work done in moving electrical charge in electrical fields over specific time duration ***OR*** The total power delivered or consumed by consumer over specific time duration. Electric Energy = Power * Time Energy is the power w.r.t. time **Unit :-** **(1 Mark)** Its Unit in watt sec., WHr., KWHr.
m)	**List the different types of frequency meters.**
Ans:	**(Any one Type 1 Mark)** **Different types of frequency meters** 1. **Reed type [Mechanical type]** 2. **Ferro-dynamic type [Resonances type]** 3. **Weston type** 4. **Ratio-meter type** 5. **Saturable core type** 6. **Digital type**

Q.2	Attempt any FOUR of the following : 16 Marks
a)	Draw a neat sketch of 3-ph induction type energy meter and label the parts.
Ans:	(Fully labeled 4 marks, partial 1 to 3 marks proportional)

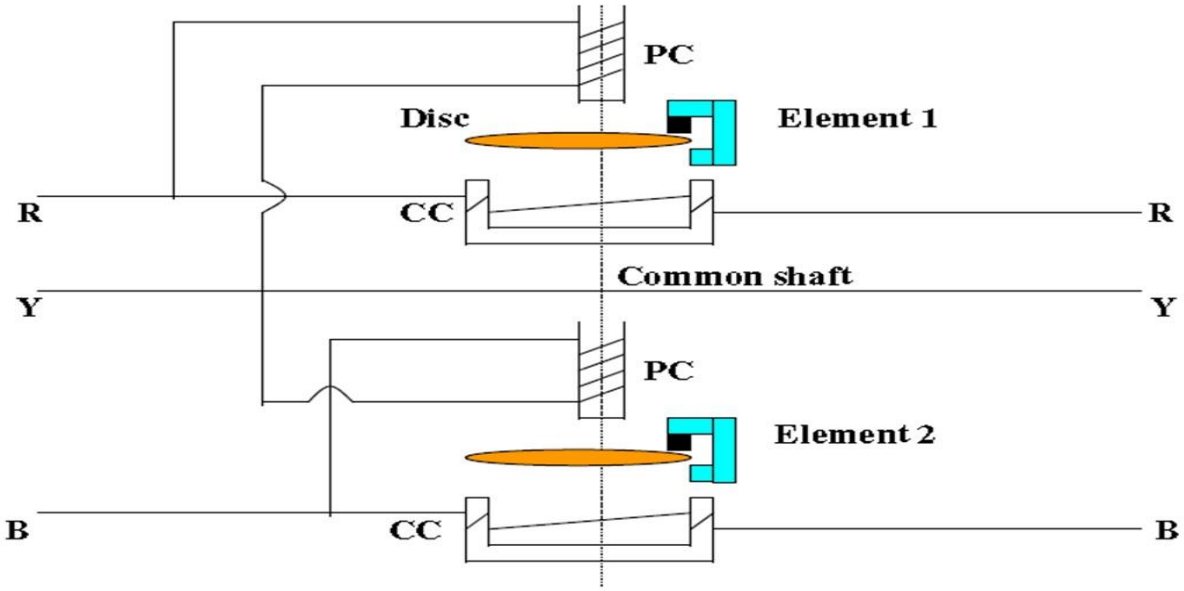


Three phase four wire induction type energy meter



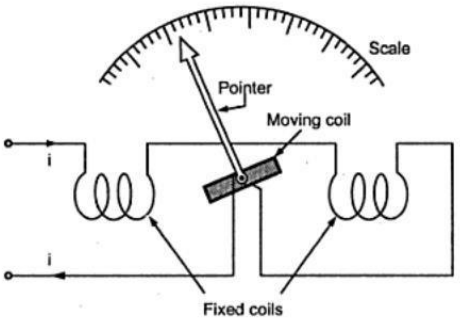
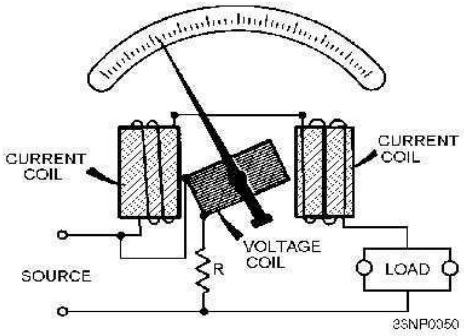
Connection diagram

OR



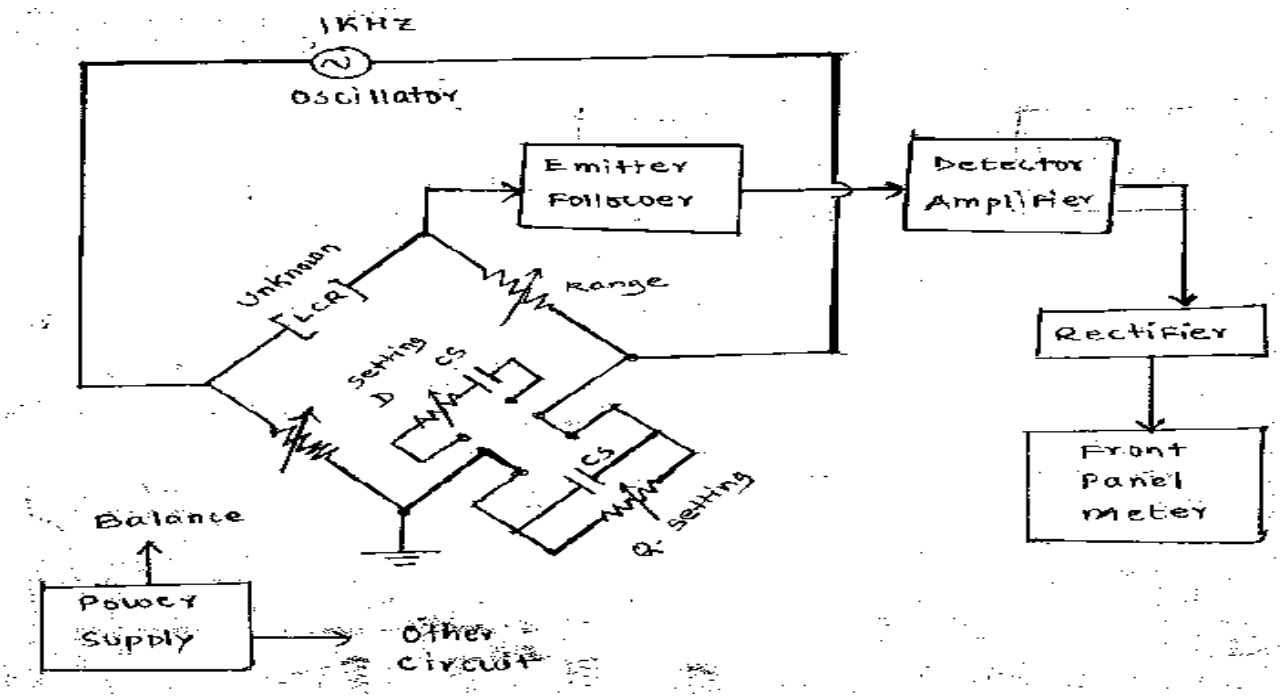
Three Phase Energy Meter

Or equivalent figure

b)	**Describe systematic errors in measuring instruments.**
Ans:	**(Instrumental Error 2 marks, Environmental Error 1 mark , Observational Error 1 marks)** **Systematic errors: -** ➢ Instrumental Error: These errors are caused due to the mechanical structure of measuring instrument. a) Inherent shortcomings of instruments: Instrument may read too low or too high. b) Improper use of instruments: Improper handling e.g. overloading, overheating, failure to adjust zero, use of high resistance leads. c) Loading effect: cause distortion in original signal. ➢ Environmental Error: These are because of surrounding conditions such as temperature, pressure, humidity, dust, vibrations, or external magnetic fields or electrostatic fields. ➢ Observational Error: Parallax errors, incorrect multiplying factor.
c)	**With neat diagram explain constructional details of dynamometer type wattmeter.**
Ans:	**(Diagram 2 marks, constructional details 2 mark)**  ***OR***  **Or equivalent figure** ➢ **Constructional details of dynamometer type wattmeter:-** • **Fixed Coils [F1 & F2].** : fixed coil is divided into two sections to give a uniform field near the center [F1 & F2]. The operating field is produced by the fixed coil • **Moving coil [M]:-**The moving system consists of a coil mounted on the spindle which is free to rotate in the space between the two fixed coils. The coil is made up of thin copper wire and is air cored to avoid hysteresis. • **Control torque** provided by two spiral springs. They also act as connecting leads for the moving coil. Pointer is mounted on the spindle. • Mirror is provided to avoid parallax error. • **Damping** is provided by air friction damping

d) Describe with working of LCR meter for measurement of inductance.

Ans: **(Diagram 2 marks, Working 2 mark)**

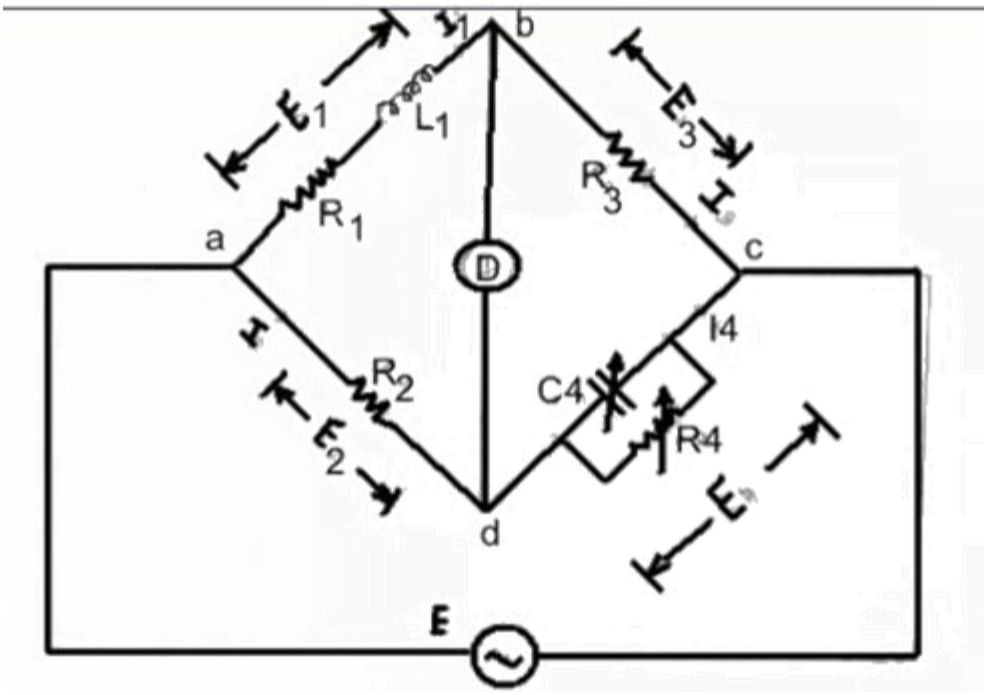


Or equivalent figure

working of LCR:-

- A LCR meter (Inductance (L), Capacitance (C), and Resistance (R) test equipment used to measure the inductance, capacitance and, resistance of a component.
- It works on the principle of impedance measurement
- LCR Meter works on principals of AC & DC Bridges
- The device under test is subjected to an AC voltage source.
- The LCR meter detects the voltage over and the current through the device under test.
- From the ratio of these, the meter can determine the magnitude of the impedance.
- The phase angle between the voltage and current is also detected
- in case of L-R or inductances measurements have the elements in series (as would be encountered in an inductor coil) [D setting]
- That C-R capacitances measurements have the elements in parallel (as would be encountered in measuring a capacitor with a leaky dielectric) [Q setting]

OR



Or equivalent figure

L1-R1 is unknown inductance under test

At balances condition

$$(R_1 + jwL_1)\left(\frac{R_4}{1 + jwC_4R_4}\right) = R_2R_3$$

$$R_1R_4 + jwL_1R_4 = R_2R_3 + jwR_2R_3C_4R_4$$

Solving to find out L1 and R1

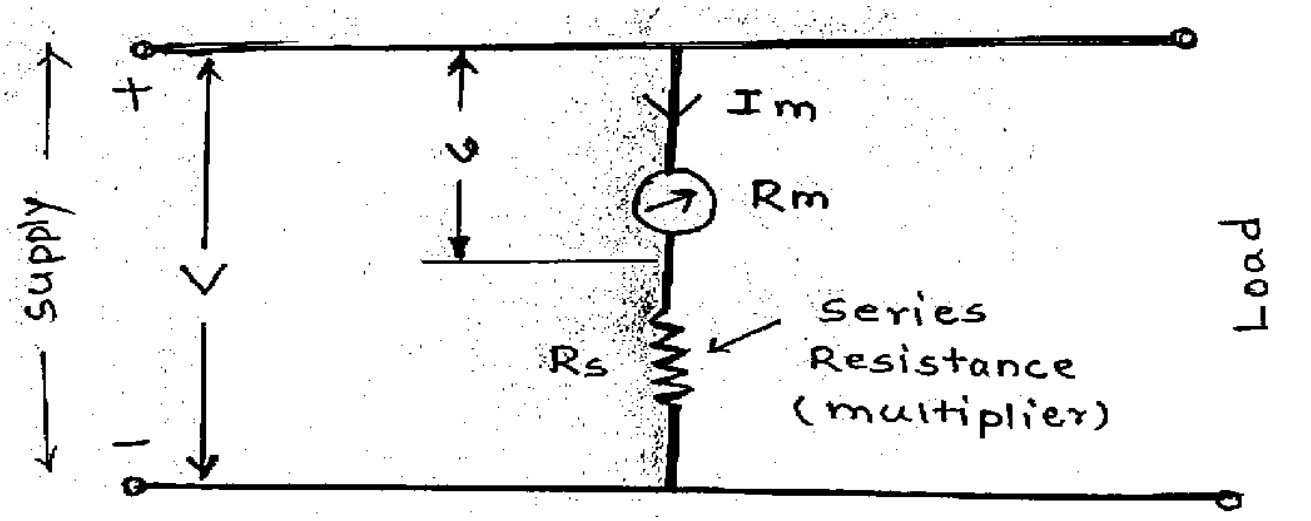
$$R_1 = \frac{R_2R_3}{R_4} \quad L_1 = R_2R_3C_4$$

$$Q = \frac{wL_1}{R_1} = wC_4R_4$$

e) How the range of voltmeter is extended using multiplier'

Ans:

(Diagram 2 marks)



Or equivalent figure

Let Im=Ifs= full scale deflection current of meter. Rm= internal resistance of meter coil.
Rs= multiplier resistance. v = voltage across the meter coil for current I
V= full range voltage of instrument.

$v = I_m * R_m$----------(1) **(1/2 mark)**

$V = I_m * (R_m + R_S)$----------(2) **(1/2 mark)**

From eq (1) & (2)

$$V = I_m * R_m + I_m * R_S)$$

$$V = v + I_m * R_S)$$

$$R_S = \frac{V}{I_m} - R_m$$

or

Divide eq (1) & (2) *we get*

$$\frac{V}{v} = \frac{I_m * R_m}{I_m * (R_m + R_S)}$$

$$m = \frac{V}{v} = 1 + \frac{R_S}{R_m}$$

$$R_s = (m-1) * R_S$$ **(1 mark)**

f) If the readings on two Wattmeters are 5 kW and 0.5 Kw, the latter reading being obtained after reversal of the current coil, calculate the power and power factor of the load.

Ans:

(Note:- student may solve this example considering any one of case give marks accordingly)

Case:1 current coil of second wattmeter get reverse

$W_1 = 5KW$, $W_2 = -0.5KW$

Total power $W_T = W_1 + W_2$ **(1 mark)**

$= 5KW + (-0.5KW) = 4.5KW$ **(1 mark)**

$$\text{P.F of Load} = \cos\left\{\tan^{-1}\frac{\sqrt{3}\,(W1-W2)}{(W1+W2)}\right\}$$ **(1 mark)**

$$= \cos\left\{\tan^{-1}\frac{\sqrt{3}\,(5.5)kw}{(4.5)kw}\right\}$$

$= 0.42$ **(1 mark)**

OR

Case:2 current coil of first wattmeter get reverse

$W_1 = -5KW$, $W_2 = 0.5KW$

Total power $W_T = W_1 + W_2$ **(1 mark)**

$= -5KW + 0.5KW = -4.5KW$ **(1 mark)**

$$\text{P.F of Load} = \cos\left\{\tan^{-1}\frac{\sqrt{3}\,(W1-W2)}{(W1+W2)}\right\}$$

$$= \cos\left\{\tan^{-1}\frac{\sqrt{3}\,(-5.5)kw}{(-4.5)kw}\right\}$$ **(1 mark)**

$= 0.42$ **(1 mark)**

OR

Case:3 current coil of Both the wattmeter get reverse

$W_1 = -5KW$, $W_2 = -0.5KW$

Total power $W_T = W_1 + W_2$ **(1 mark)**

$= -5KW + (-0.5KW) = -5.5\ KW$ **(1 mark)**

$$\text{P.F of Load} = \cos\left\{\tan^{-1}\frac{\sqrt{3}\,(W1-W2)}{(W1+W2)}\right\}$$ **(1 mark)**

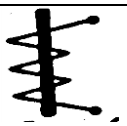
$$= \cos\left\{\tan^{-1}\frac{\sqrt{3}\,(-4.5)kw}{(-5.5)kw}\right\}$$

$$= 0.57$$ **(1 mark)**

Q.3 **Attempt any FOUR of the following :** **16 Marks**

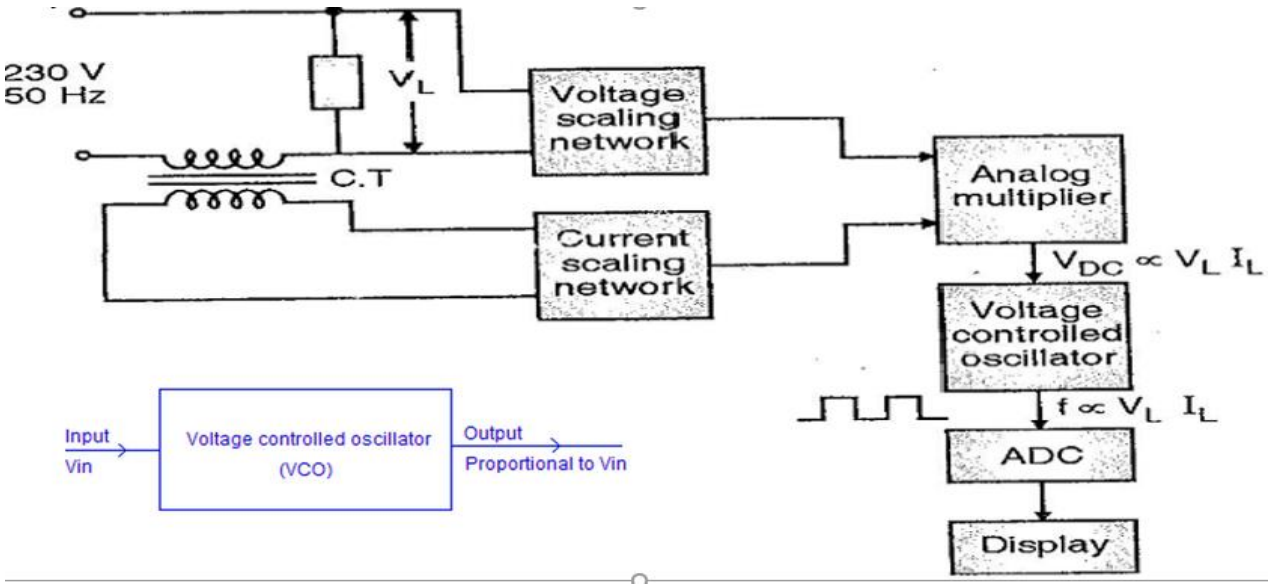
a) **Compare PMMC and MI instruments on the following basis : (i) Construction (ii) Symbol (iii) Working principle (iv) Application**

Ans: **(Each point 1 mark)**

Points	PMMC instruments	MI instruments
Constriction	Delicate in nature	Robust
Symbol		
Working principal	When current carrying conductor is placed in a magnetic field, it experiences a force	Piece of iron is attracted /repelled by magnet or magnetic field.
Application	Used for only DC measurements	Used for DC as well as AC measurements

b) **Draw and describe working of electronic energy meter.**

Ans: **(Diagram 2 marks, Working 2 mark)**



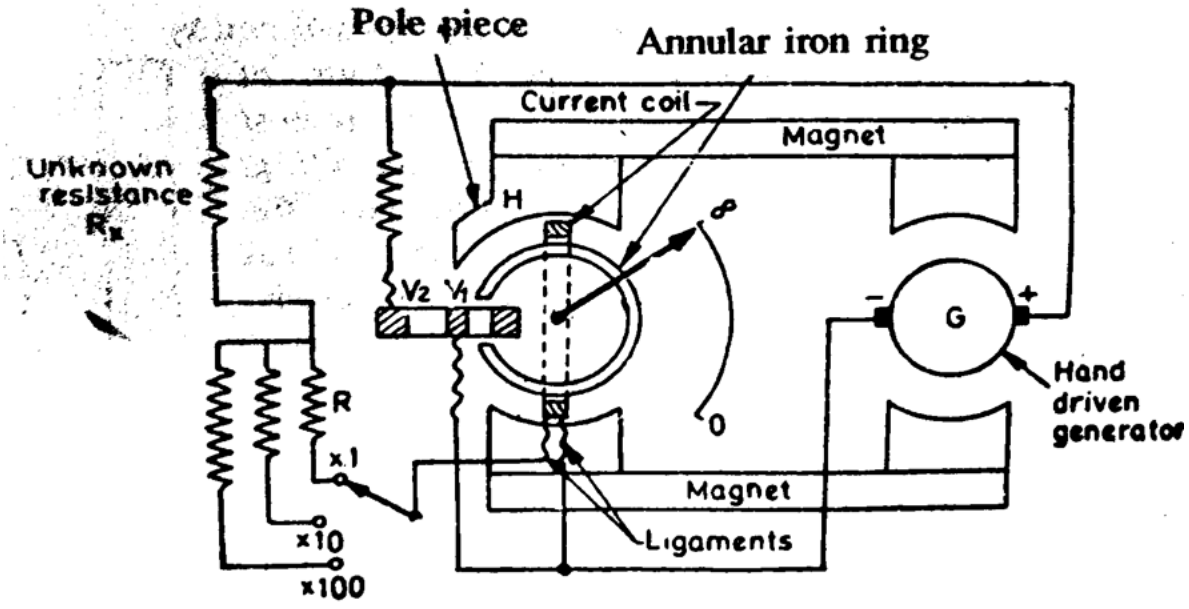
Or equivalent figure

working of electronic energy meter:-

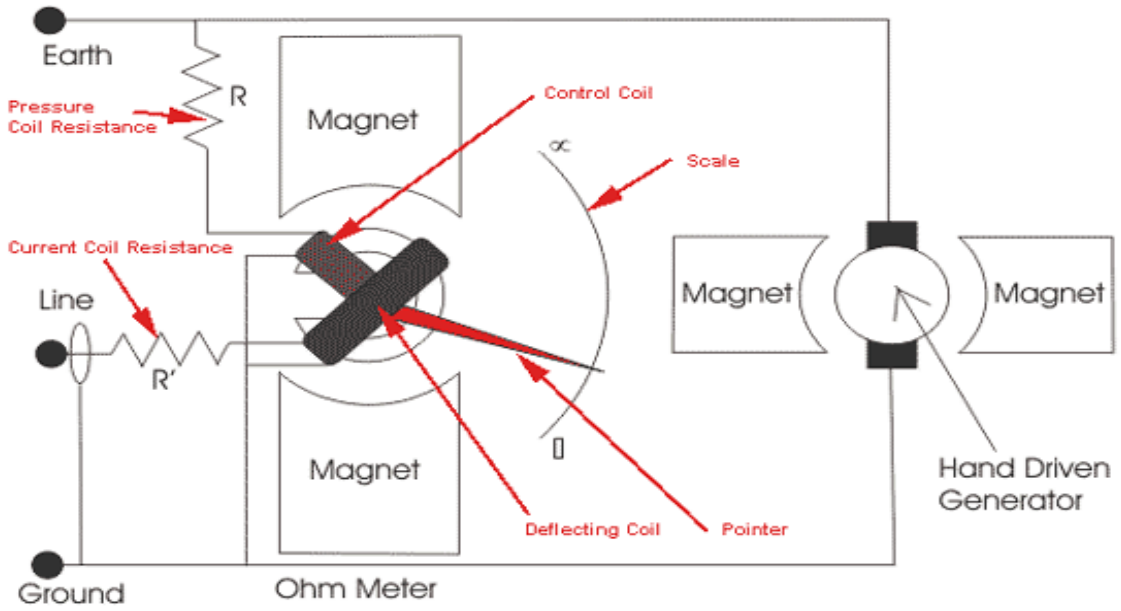
1. CT reduces current to reasonable value for current scaling network.
2. Voltage & current scaling networks reduce proportionally the voltage & current to values suitable for the analog multiplier.
3. Analog multiplier gives a dc voltage proportional to the product of the voltage and current drawn from supply that is the power drawn.
4. The voltage controlled oscillator gives a frequency proportional to its input (which is proportional to the power).
5. The ADC converts the square wave frequency analog output to display the energy in watthour.

c) Draw construction of Megger and write operating principle of it.

Ans: **(Diagram 2 marks, Operating principal 2 mark)**



OR



Or equivalent figure

Operating principle of Meager:-

1. **Deflecting[CC] & Control coil [PC]**: both coils mounted at right angle to each other and maintain polarities in such a way to produced torque in opposite direction. And Deflecting coil or current coil connected in series and allows flowing the electric current taken by the circuit being tested. The control coil also known as pressure coil is connected across the circuit.
2. **Permanent Magnets:** Produce magnetic field to deflect pointer with North South pole magnet.
3. **D.C generator or Battery connection:** Testing voltage is produced by hand operated D.C generator for manual operated Megger. Battery / electronic voltage charger is provided for automatic type Megger for same purpose.
4. **Pressure coil resistance (PCR) and Current coil resistance (CCR) :** Current limiting resistor (CCR & PCR) connected in series with control & deflecting coil to protect damage in case of very low resistance in external circuit.
5. Voltage for testing produced by hand operated megger by rotation of crank in case of hand operated type, a battery is used for electronic tester.
6. **Torque of the megger varies in ration with V/I, (Ohm's Law :V= IR or R=V/I). Electrical resistance to be measured is connected across the generator & in series with deflecting coil.**
7. As the voltage increases in external circuit the deflection of pointer increases and deflection of pointer decreases with a increases of current Hence, resultant torque is directly proportional to voltage & inversely proportional to current.
8. When resistances under test is open, torque due to voltage coil will be maximum & pointer shows ‘infinity’
9. If resistances under test is short circuit pointer shows ‘zero’, which means ‘NO’ resistance

d) **A 4 mA meter movement with an internal resistance of 1 ohm is to be converted into 0-100 mA ammeter. Calculate the value of shunt resistance.**

Ans:

$R_m = 1\Omega$, $R_{Sh} = ?$, $I_m or\ I_{FSD} = 4\ ma$ = Full scale deflection of ammeter

For 100 ma shunt resistance required is,

$$R_S = \frac{I_m * R_m}{(I - I_m)} \quad or \quad R_S = \frac{R_m}{(M-1)},\ M = \frac{I}{I_m} \quad \textbf{(2 mark)}$$

$$R_S = \frac{I_m * R_m}{(I - I_m)} \qquad R_S = \frac{R_m}{(M-1)},\ M = \frac{I}{I_m}$$

$$M = \frac{I}{I_m} = \frac{100\ ma}{4\ ma}$$

$$R_S = \frac{4 * 1}{(100 - 4)}$$

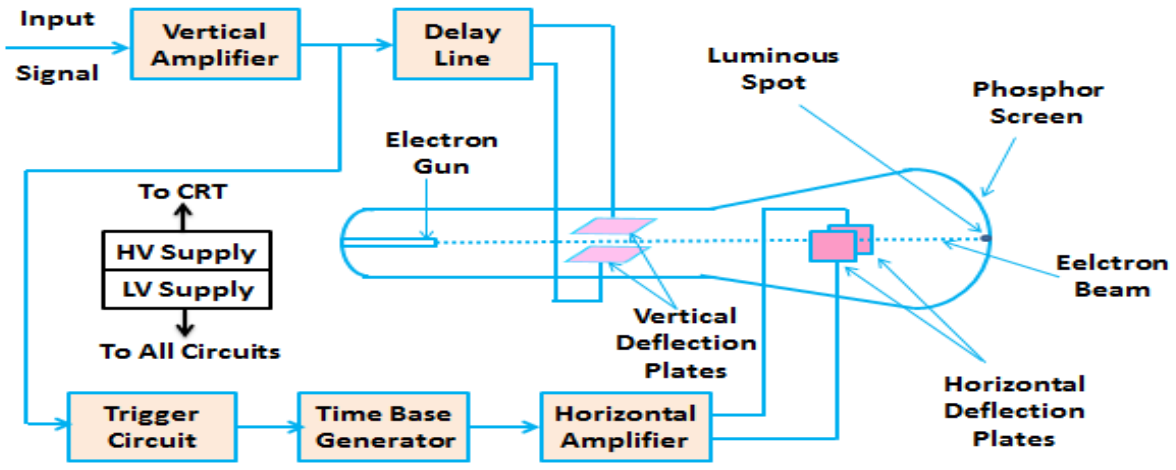
$$M = 25$$

$$R_S = \frac{4}{96} \qquad R_S = \frac{1}{(25-1)}$$

$$R_S = 0.0416\ \Omega \qquad R_S = 0.0416\ \Omega \quad \textbf{(2 mark)}$$

e) **(e) Draw block diagram of CRO. Write the function of each block.**

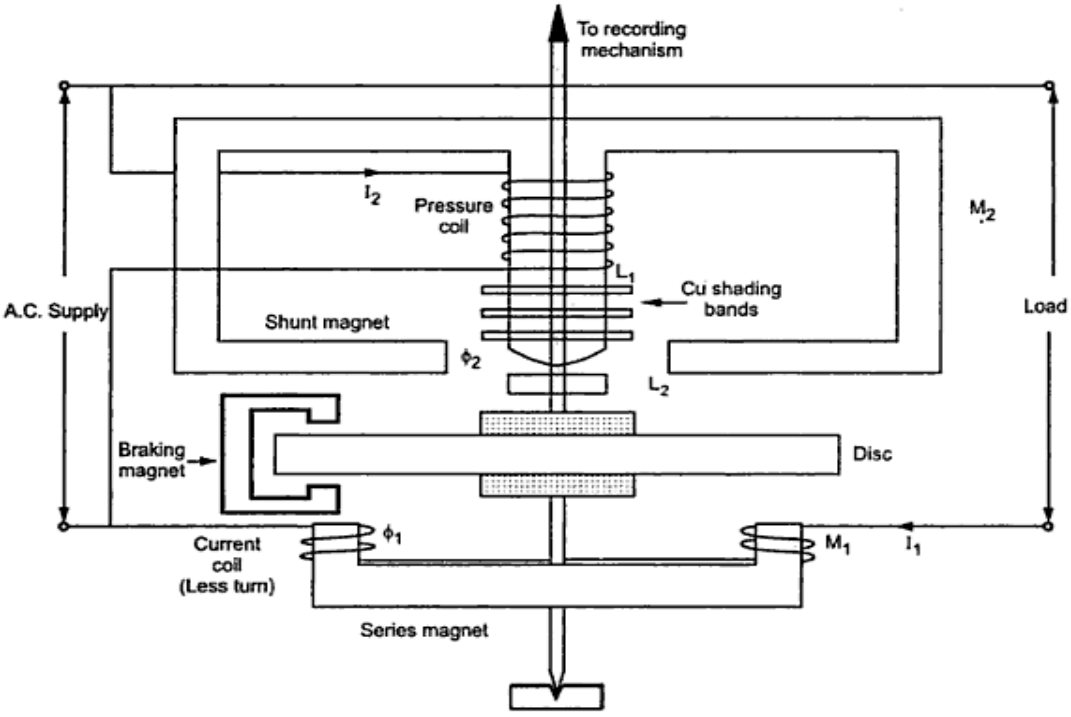
Ans: **(Diagram 2 marks, function of each block carrying 1 mark)**



Block Diagram of Cathode Ray Oscilloscope (CRO)

Or equivalent figure

1. Vertical amplifier strengthens the input signal applied to vertical depleting plates
2. Trigger circuit gives input to time base circuit
3. The output of time base generator is amplified by horizontal amplifier and then applied to horizontal deflecting plates of CRT
4. CRT consists of electron gun assembly which include thermally heated cathode, accelerating anode, focusing anode

	5. The electron beam coming out from electron gun assembly enters to deflecting plates. **6.** The screen of CRT internally coated with Phosphors material on which we observe waveform of the input signal.
f)	**Explain magnetic effect employed in measuring instrument.**
Ans:	**(Any Two Point Expected Each Carrying 2 Mark)** **Magnetic Effect:** **I) In PMMC meters:** ➢ When a current is passed through a conductor, magnetic field is produced round the conductor. Due to this field when current carrying conductor is placed in a magnetic field it experiences a mechanical force. Examples: PMMC, galvanometer **II) In Moving Iron Type meters:** ➢ When we bring one permanent magnet near to another electromagnet then there is a force of attraction or repulsion depending on the direction of current in the coil of electromagnet. ➢ Examples: Moving iron type instruments, Moving coil type instruments **III) In Electrodynamic meters:** When a current is passed through a conductor, magnetic field is produced round the conductor. Due to this field when current carrying conductor is placed in a magnetic field it experiences a mechanical force. Examples: Electrodynamometer type instruments, Induction type instrument.
.4	**Attempt any FOUR of the following : 16 Marks**
a)	**Draw a neat sketch of 1-ph induction type energy meter and write operating principle of it.**
Ans:	**(Diagram 2 marks, Operating principal 2 mark)**  **Or equivalent figure**

Operating Principal:-

The disc is placed between the two-flux due to pressure coil and flux due to current coil, which will set up torque on the disc which is proportional to power causing the disc to rotate.

As shown in the diagram electromagnets, eddy currents will be induced on the disc by two fluxes

OR

An aluminum disc is placed inside a magnetic core with two limbs. One carries a voltage coil so its flux is proportional to voltage, the second carries a current coil so its flux is proportional to current.

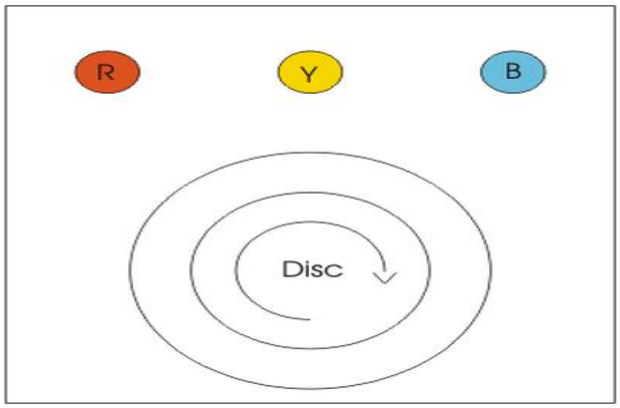
b) Describe with neat diagram phase sequence indicator.

Ans: **Note:- student may write any one of type (Diagram 2 marks, Operation 2 mark)**

There are two types of **phase sequence indicators** and they are:

(a) Rotating type (b) Static type.

- **Rotating type**

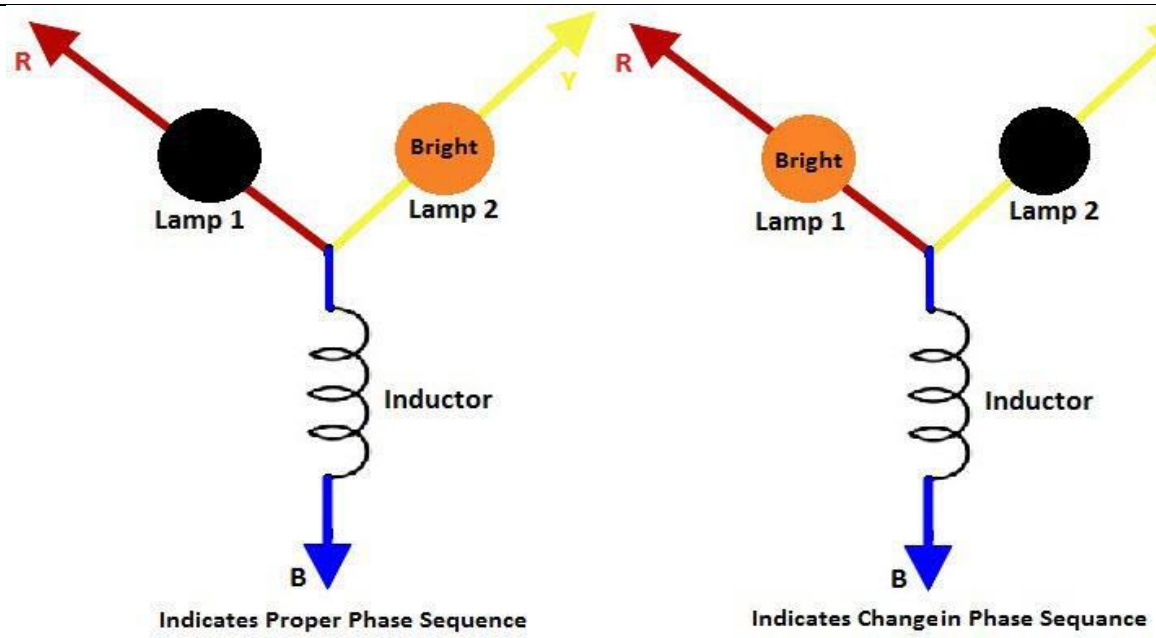


Or equivalent figure

1. It works on the principle of induction motors.
2. The arrow marked on the disc represents the direction of rotation.
3. If the phase sequence of supply is same as that of the terminals marked on the indicator the disc will rotate in the direction of rotation(RYB)
4. If the disc moves in the clockwise direction then chosen sequence is RYB and if the direction of rotation is in anticlockwise the sequence is reversed(RBY).

OR

- **Static type.**
- Connect two lamps, lamp1 to R-phase, lamp2 to Y-phase and inductor to B-phase as shown in the below figure. Resistors are connected in series with the lamps for protecting the lamps from over currents and breakdown voltages.



Or equivalent figure

- If the sequence of supply is RYB, then the lamp 2 will glow brighter than lamp 1; if the sequence of the supply is reversed or altered, then the lamp 1 will glow brighter than the lamp

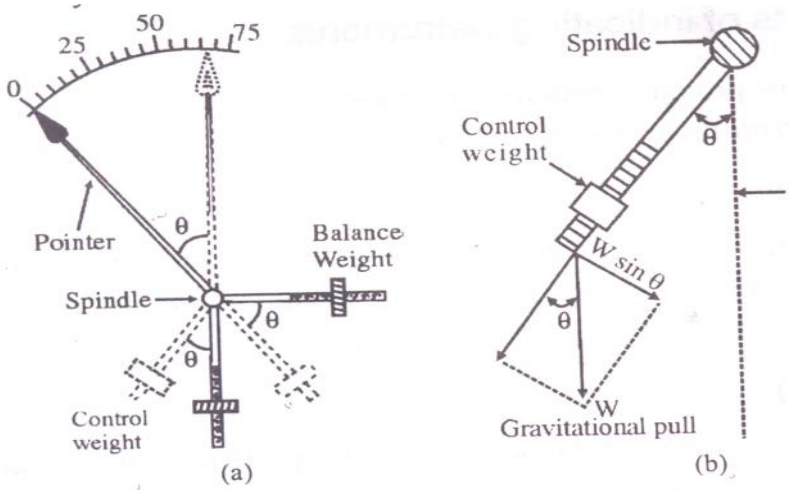
c) Compare analog and digital multimeter

Ans: **(Each point 1 mark)**

Sr No.	Analog multi-meter	DMM
1	Power supply is not required	Power supply is required
2	Less suffered from electric noise	More suffered from electric Noise
3	Less isolation problems.	More isolation problems.
4	Less accuracy	High accuracy is obtained.
5	Simple construction	Complicated construction
6	Bigger in size	Smaller in size
7	Many times O/P is ambiguous	An unambiguous reading is obtained.
8	Better visual indication	Visual indication is not that much better.
9	Less cost	More cost

d) With neat diagram describe gravity control method to obtain controlling torque.

Ans: **(Diagram 2 marks, Operation 2 mark)**



Or equivalent figure

1. In gravity control method, a small weight is attached to the spindle of the moving system.
2. Weight W1 provides the controlling torque, W2 is for balancing the weight of the pointer.
3. Due to the gravitational pull, a control torque (acting in opposite direction to the deflecting torque) is produced whenever the pointer tends to move away from its initial position.
4. In this case, Td is directly proportional to current I and Tc is directly proportional to sine of the deflection angle,

$$Tc = W1 \sin\Theta \times L = W1L \sin\Theta$$

$$\text{Thus} \quad Tc \alpha \sin\Theta$$

$$\text{As} \quad Td \alpha I$$

$$Tc \alpha \sin\Theta$$

At steady state position deflection torque=controlling torque

$$I \alpha \sin\Theta$$

Thus the scale of the gravity control type instruments is non-uniform

e) Why CT is never operated with an open secondary ?

Ans: **(Any four points Expected: 1 mark each)**

1. If any reason CT secondary is kept open the very high load current is passing through the primary winding of CT which will create the Strong magnetic field
2. This Strong magnetic field will be link to the Secondary winding of the CT
3. If no current flows in secondary, no ampere turns are produced by the secondary circuit.

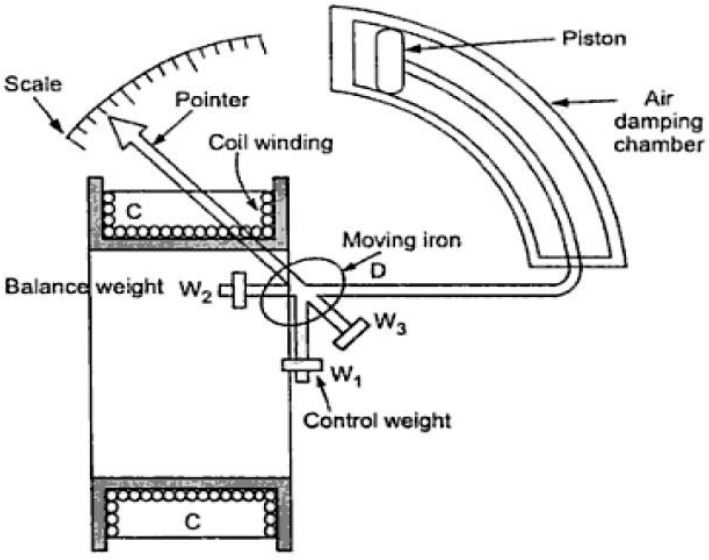
4. For CT Secondary there are large no of turns, magnetic field also strong So as per faradays law the very high voltage will be induced in CT.

At the same time

- The operator can get electrical shock of that voltage
- The CT insulation may Failure
- The ratio error and phase angle errors are likely to be much increased by such misconnection.

f) Describe with neat diagram working principle of attracted type MI instruments.

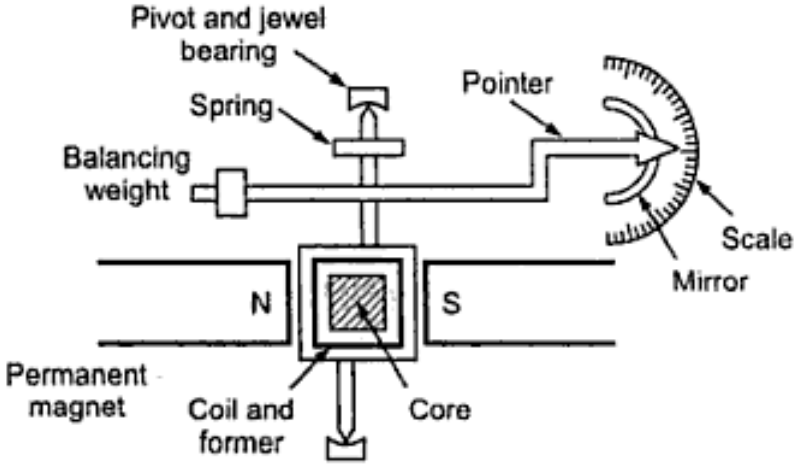
Ans: **(Diagram 2 marks, working principle 2 mark)**



Or equivalent figure

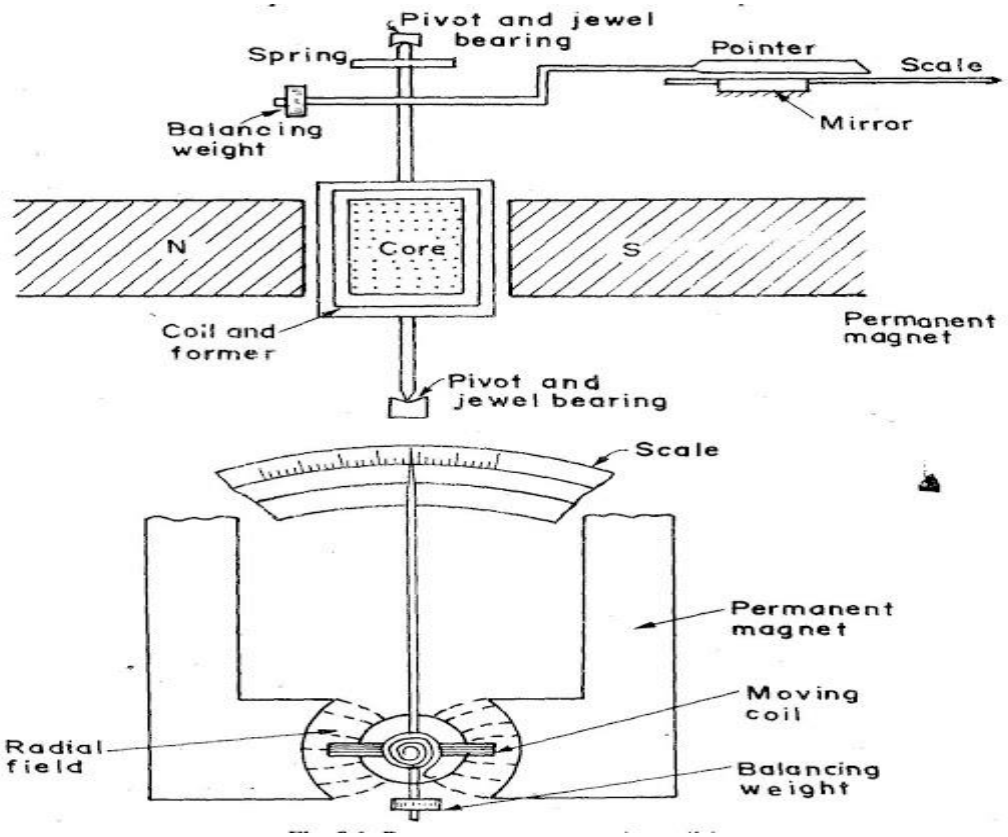
1. **Moving element:** a small piece of soft iron in the form of a vane or rod.
2. **In Attracted type** a cylindrical coil or solenoid which is kept fixed. An oval-shaped soft-iron piece are used
3. **Control torque** is provided by spring or weight (gravity).
4. **Damping torque** the damping device consisting of an air chamber and a moving vane attached to the instrument spindle.
5. **Deflecting torque** produces a movement on an aluminum pointer over a graduated scale.
6. The electrical quantity which is to be measure is provided to the input of meter coil so, that current will circulate through the meter coil
7. The current to be measured is flowing in the coil, produces a magnetic field. Iron piece gets attracted towards center of the magnetic field and pointer deflects on the scale.
8. The scale is non-linear. Mirror is provided to avoid parallax error.
9. When $T_d = T_c$ the pointer will be stable & we can get correct reading of the electrical quantity

Q.5	Attempt any FOUR of the following : 16 Marks
a)	Draw a neat labelled diagram of PMMC type of measuring instrument.
Ans:	(Fully labeled 4 marks, partial 1 to 3 marks proportional) (Diagram:labeled 4 marks, unlabeled 1 mark, partially labeled 2 marks.)



OR

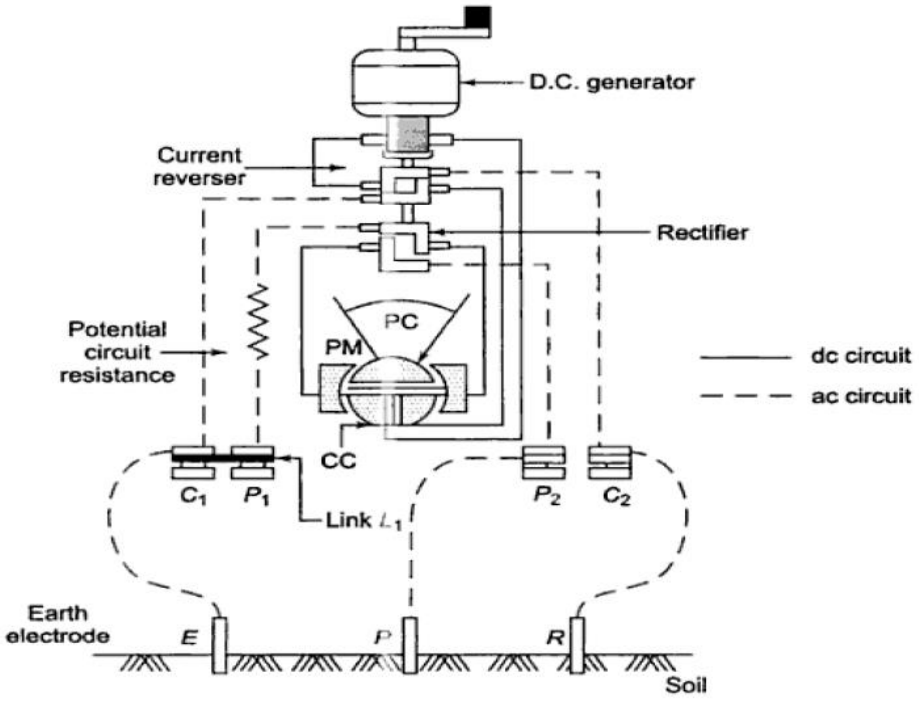
Or equivalent figure



b)	**Explain significance and purpose of electrical measurement system.**
Ans:	**(Significance 2 marks and purpose 2 marks)** ➢ **Significance of Electrical Measurement System** **1. The measurement is required for measurement of all physical quantities for e.g speed, velocity, temperature, pressure etc.** **2. All electrical quantities also for e.g. voltage, current, wattage, energy** **3. The measurement is required for treading & dealing purpose in our society** **4. For controlling & feedback purpose the measurement is essential** **5. In every nation for their military application there is need of measurement and control** **6. In industry or in government organization there is R & D Department The measurement is widely required in various industries and in various educational institutes for the training purpose** ➢ **Purpose Of Electrical Measurement System** **1. The measurement is the sciences or process in which we are measuring the physical quantities to fulfill the need of human kind** **2. For treading & dealing purpose or any other** **3. Measurement is basic need of human kind that's why all standards and references designed by the human kind** **4. These standards and references may changes time to time, area to area person to person**
c)	**State the advantages of instrument transformer in using for extension of range of meters.**
Ans:	**(Any four advantages Expected: 1 mark each)** **Advantages of instrument transformer:** **1. Extension of instrument range is possible.** **2. Isolation of instruments from high voltage side.** **3. Power loss is less as compared to shunts and multipliers.** **4. Same instrument transformers can be used for different quantity measurement.** **5. It is economical method of range extension.** **6. Increases in safety of operator.**

d) Draw earth tester. What is the necessity of measuring earth resistance?

Ans: **(Diagram 2 marks, necessity of measuring earth resistance 2 mark)**



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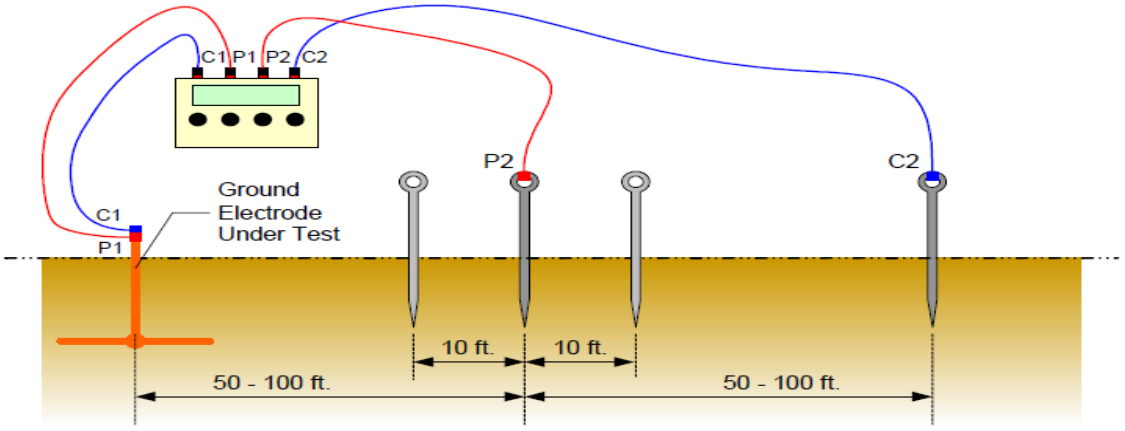


Or equivalent figure

Necessity of measuring earth resistance:-

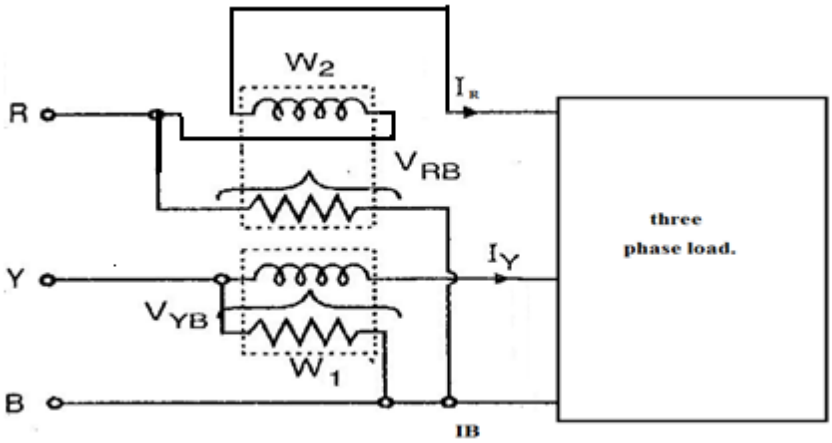
To maintain the value of earth resistance which is highly required for

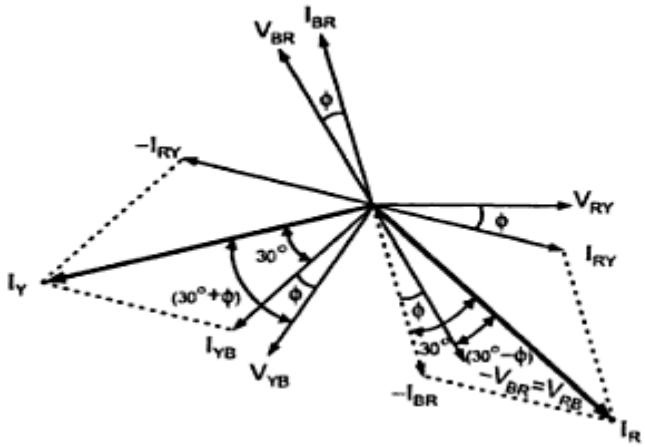
1. To avoid electrical shock to operator from ground fault.
2. Protection from lightning surge.
3. Smooth operation of relay and CB in power system
4. For measurement purpose by using CT and PT

e) **Derive the formula for calculating P.F. of a 3 phase star connected balanced load where power is measured by two wattmeter method.**

Ans: **Note Student may draw different connecton diagram and respected phaser diagram**

(Diagram 2 marks)





$I_R \hat{} V_{RB} = I_R \hat{} (-V_{BR})$
$= 30 - \phi$
$I_Y \hat{} V_{YB} = 30 + \phi$

Or equivalent figure

$V_L = V_{RB} = V_{YB}$, $I_L = I_R = I_Y$
Ø = phase angle between voltage and current of the phases.

For connection 1 [W_1]	For connection 2 [W_2]
$W_1 = V_{PC} * I_{CC} * \cos(V_{PC} \hat{} I_{CC})$	$W_2 = V_{PC} * I_{CC} * \cos(V_{PC} \hat{} I_{CC})$
$W_1 = V_{RB} * I_R * cos(V_{RY} \hat{} I_R)$	$W_2 = V_{YB} * I_Y * cos(V_{RB} \hat{} I_R)$
$W_1 = V_{RB} * I_R * cos(30 - \emptyset)$	$W_2 = V_{YB} * I_Y * cos(30 + \emptyset)$
$W_1 = V_L * I_L * cos(30 - \emptyset)$	$W_2 = V_L * I_L * cos(30 + \emptyset)$

Active power

$$P = W_1 + W_2$$
$$= V_L * I_L * cos(30 - \emptyset) + V_L * I_L * cos(30 + \emptyset)$$
$$= V_L * I_L[cos(30 - \emptyset) + cos(30 + \emptyset)]$$
$$cos\,A + cos\,B = 2 * cos\frac{A+B}{2} * cos\frac{A-B}{2}$$
$$= V_L * I_L * 2\ \cos 30 * \cos\emptyset$$
$$= V_L * I_L * 2 * \frac{\sqrt{3}}{2} * \cos\emptyset$$
$$P = \sqrt{3} * V_L * I_L * cos\emptyset$$ **(1/2 mark)**

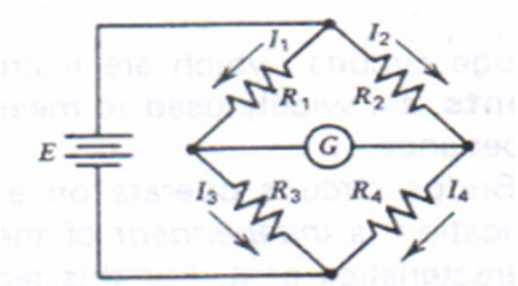
Rective power

$$W_1 - W_2 = V_L * I_L * cos(30 - \emptyset) - V_L * I_L * cos(30 + \emptyset)$$
$$= V_L * I_L[cos(30 - \emptyset) - cos(30 + \emptyset)]$$
$$cos\,A - cos\,B = 2 * sin\frac{A+B}{2} * sin\frac{B-A}{2}$$
$$= V_L * I_L * 2\ \text{Sin}\,30 * Sin\,\emptyset$$
$$W_1 - W_2 = V_L * I_L * Sin\,\emptyset$$ **(1/2 mark)**

Multiply by $\sqrt{3}$

$$Q = \sqrt{3}\ * V_L * I_L * Sin\,\emptyset$$
$$Q = \sqrt{3}(W_1 - W_2)$$
$$P = W_1 + W_2 = \sqrt{3}\ * V_L * I_L * cos\emptyset$$
$$Q = \sqrt{3}(W_1 - W_2) = \sqrt{3}\ * V_L * I_L * \sin\emptyset$$
$$\frac{Q}{P} = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2} = \frac{\sqrt{3}\ * V_L * I_L * \sin\emptyset}{\sqrt{3}\ * V_L * I_L * cos\emptyset}$$
$$\frac{Q}{P} = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2} = \frac{\sin\emptyset}{cos\emptyset}$$
$$\frac{Q}{P} = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2} = \tan\emptyset$$
$$\emptyset = \tan^{-1}\left[\frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}\right] = \tan^{-1}\frac{Q}{P}$$ **(1 mark)**

f)	**Draw the circuit diagram of Whetstone's bridge and derive the formula for balanced load.**
Ans:	**(Diagram 2 marks)**



Or equivalent figure

When the bridge is in balance condition (no current flows through galvanometer G), we obtain;
voltage drop across R1 and R2 is equal,

$$I_1 * R_1 = I_2 * R_2 \text{----------(1)}$$

voltage drop across R3 and R4 is equal,

$$I_3 * R_3 = I_4 * R_4 \text{----------(2)}$$ **(1 mark)**

In this point of balance, we also obtain;

$$I_1 = I_3 \quad \text{and} \quad I_2 = I_4$$

Divide eq. 1 & 2 we get

$$\frac{I_1 * R_1}{I_3 * R_3} = \frac{I_2 * R_2}{I_4 * R_4}$$

$$\frac{R_1}{R_3} = \frac{R_2}{R_4}$$ **(1 mark)**

Q.6	**Attempt any FOUR of the following : 16 Marks**
a)	**What arc the errors occurring in measuring devices due to stray magnetic field and temp '? Explain how to compensate them.**
Ans:	**1. Error due to stray magnetic fields-** **(1 mark)**

Main magnetic field gets disturbed by external magnetic fields known as stray magnetic fields.

2. Compensation technique **(1 mark)**

To avoid this error, magnetic shield made up of magnetic material is placed over CC & PC.

3. Error due to Temperature **(1 mark)**

Change in room temp. changes the value of resistance of pressure coil and the stiffness of the springs.

4. Compensation technique **(1 mark)**

Using low temp. coefficient materials for coils and components this can be minimized.

	Using copper and resistance alloy having a negligible resistance temp coefficient in the ratio of 1:10 for pressure coil
b)	**Describe the following errors and their compensation: (i) Phase error (ii) Speed error**
Ans:	**(I) Phase error** **(1 mark)** 1. In the phase error the phase difference angle between $\emptyset_1$ & $\emptyset_2$is kept $\mathbf{90^o}$by using the shading band/ring 2. If the design and location of Shading band/ring is not proper then the phase difference angle between $\emptyset_1$ & $\emptyset_2$ will not be exact $\mathbf{90^o}$, So that, the speed of the aluminum disc may change 3. This type of error is called as a phase angle error **Compensation** **(1 mark)** • To minimize the phase error the design quality and location of shading band/ring should be proper **(II) Speed error** **(1 mark)** Sometimes speed of the disc is more or less than the rated speed due to wrong positioning of braking magnet. Hence meter gives error. **Compensation –** **(1 mark)** Proper setting up of brake magnet. By changing the position of the brake magnet speed of the rotating disc can be controlled.
c)	**Power supplied to three phase load was measured by two wattmeter method. The readings were 4 kW & —2.55 kW. The supply voltage being 400 V. Determine (i) load P.F., (ii) total power supplied.**
Ans:	$W_1 = 4\ KW$, $W_2 = -2.55KW$ Total power $W_T = W_1 + W_2$ **(1 mark)** $= 4KW + (-2.55KW) = 1.45\ KW$ **(1 mark)** P.F of Load = $\cos\left\{\tan^{-1}\frac{\sqrt{3}\,(W1-W2)}{(W1+W2)}\right\}$ **(1 mark)** $= \cos\left\{\tan^{-1}\frac{\sqrt{3}\,(6.55)kw}{(1.45)kw}\right\}$ = 0.1267 **(1 mark)**

d) Explain the effect of power factor on the wattmeter measurements.

Ans:

In two wattmeter method the readings of two wattmeter's are given by eq.

$W_1 = V_L * I_L * cos(30 + \emptyset) \& W_2 = V_L * I_L * cos(30 - \emptyset)$

We will consider different cases of power factors

1. **If power factor is unity i.e. p.f.=1 (ø=0)** **(1 mark)**

For connection $[W_1]$	For connection $[W_2]$
$W_1 = V_L * I_L * cos(30 + \emptyset)$	$W_2 = V_L * I_L * cos(30 - \emptyset)$
$W_1 = V_L * I_L * cos(30 + 0)$	$W_2 = V_L * I_L * cos(30 - 0)$
$W_1 = V_L * I_L * cos(30)$	$W_2 = V_L * I_L * cos(30)$

Thus, both the watt meters read equal readings.

2. **If power factor is 0.5 lagging i.e.ø =60** **(1 mark)**

For connection 1 $[W_1]$	For connection 2 $[W_2]$
$W_1 = V_L * I_L * cos(30 + \emptyset)$	$W_2 = V_L * I_L * cos(30 - \emptyset)$
$W_1 = V_L * I_L * cos(30 + 60)$	$W_2 = V_L * I_L * cos(30 - 60)$
$W_1 = V_L * I_L * cos(90)$	$W_2 = V_L * I_L * cos(-30)$
$W_1 = 0$	$W_2 = V_L * I_L * \frac{3}{2}$

Thus it is observed that one of the wattmeter reads zero and all the power is measured by second wattmeter.

3. **If power factor is between 0.5 and 0.** **(1 mark)**
   i.e. angle of lag is greater than 60 & less than 90 in this case one of the wattmeter gives positive reading and second wattmeter give negative reading

   Hence for taking reading of second wattmeter its pressure coil connections or current coil connections is to be interchanged

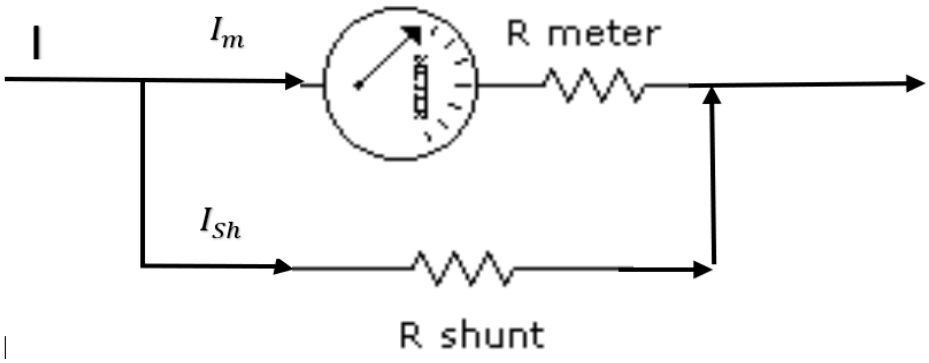
4. **If power factor is 0 i.e. ø =90** **(1 mark)**

For connection 1 $[W_1]$	For connection 2 $[W_2]$
$W_1 = V_L * I_L * cos(30 + \emptyset)$	$W_2 = V_L * I_L * cos(30 - \emptyset)$
$W_1 = V_L * I_L * cos(30 + 90)$	$W_2 = V_L * I_L * cos(30 - 90)$
$W_1 = V_L * I_L * -Sin(30)$	$W_2 = V_L * I_L * Sin(30)$

Therefore, with zero power factor, the readings· of the two Wattmeter's are equal but of opposite sign.

e) Explain how range of ammeter is extended using shunt.

Ans: **(Diagram 2 marks)**



Or equivalent figure

Ammeter shunt:

Let , R_m = ammeter resistance, R_{Sh} = Shunt resistance, I_m = Full scale deflection of ammeter

I_{Sh} = Shunt current

$I = I_{Sh} + , I_m$

$I_{Sh} = I - I_m$

As voltage across shunt and ammeter is same, hence

$I_{Sh} * R_{Sh}h = I_m * R_m$ **(1 mark)**

$(I - I_m) * RS = I_m * R_m$

$$R_S = \frac{I_m * R_m}{(I - I_m)}$$ **(1 mark)**

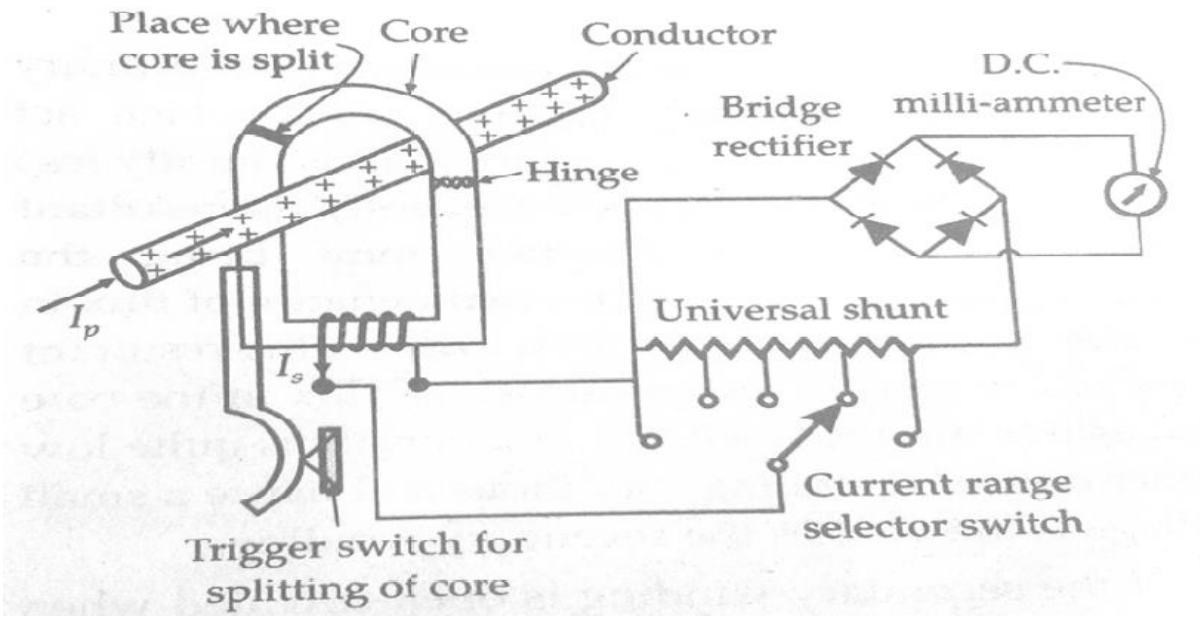
$$R_S = \frac{R_m}{(\frac{I}{I_m} - 1)}$$

$$Here\ M = \frac{I}{I_m}$$

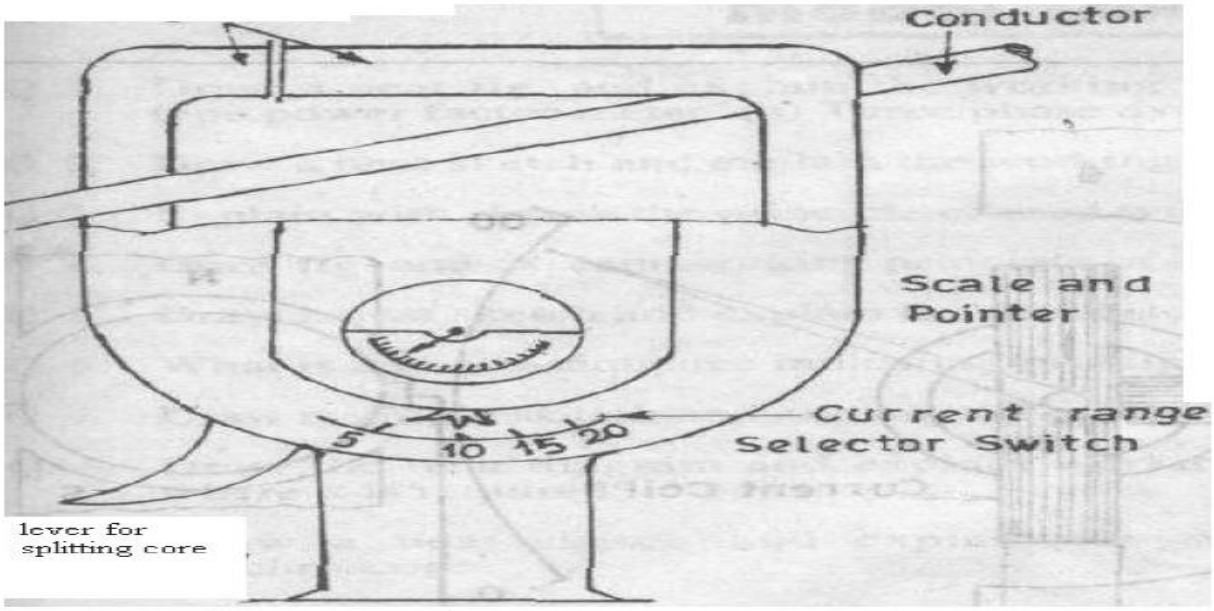
$$R_S = \frac{R_m}{(M - 1)}$$

f)	**With neat diagram, explain the working of clip-on ammeter.**

Ans: **(Diagram 2 marks, working 2 mark)**



splitting core



Or equivalent figure

working of clip-on ammeter:-

	1. Clip on ammeters are used to measure the high current flowing through bus bar, cable or fuse holders carrying currents. **2. They consist of split core current transformer whose secondary winding is connected to rectifier type moving coil instrument.** **3. The primary become conductor, whose current is to be measured. The split core gets aligned by the force of a spring tension.** **4. While the core is covered with insulating material. Hence higher current through conductors can be measured.** **5. A selector switch is provided to select secondary number of turns which ultimately changes the current range.** **6. For measuring current the core is opened by pressing trigger shown and then clipped over the conductor carrying current. The dial will record the current directly.**

----------END----------