



**SUMMER- 15 EXAMINATION**

Subject Code: 17434

**Model Answer**

**Important Instructions 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 principal components indicated in the 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 of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.



1.a) Attempt any SIX of the following:

12 marks

i) List the four different units of pressure.

Ans i. **Each Unit -1M (Any two units)**

The different units of pressure

$1\text{N/m}^2 = 1 \text{ pascal (1 Pa)}$

1 kPa (kilo pascal) = 1000 Pa

1 millibar =  $100 \text{ dyne/cm}^2 = 100\text{Pa}$

1 torr = 1mm Hg= 133.3 Pa

1 atmospheric pressure (atm) = 101.325 kPa

PSI (pound per square inch)

SI unit

$\text{N/m}^2$  (Newtons per square meter)

ii) Define transducer. Give two examples.

Ans ii. **Definition: 1M, Example:1M**

Transducer is defined as a device which converts energy from one form to another i.e. physical to physical, physical to electrical or electrical to physical.

e.g. Strain gauge, Thermistors, Thermocouple, Bourdon tube.



e.g. Temperature

e.g. Thermistor

e.g. Resistance

iii) State Seeback and Peltier effect.

Ans iii. **Seeback: 1M; Peltier: 1M**

**Seeback effect:** Seeback effect states that whenever two dissimilar metals are connected together to form two junctions, out of which, one junction is subjected to high temperature and another junction is subjected to low temperature then emf is induced proportional to the temperature difference between two junctions.

**Peltier effect:** Peltier effect state that two dissimilar metals closed loop, id current forced to flow through the closed loop then one junction will be heated and other will become cool.



iv. Why Rotameter is called variable area meter?

Ans iv. **Correct Explanation:2M**

- It consists of a float which is free to move up or down within the tube. The tube is mounted vertically with small opening at the bottom and its diameter is gradually increasing from bottom to top of tube, therefore it is called as variable area flowmeter.

v. Define:

1. Absolute Humidity **1M**
2. Relative Humidity **1M**

Ans v.

Absolute Humidity: It is defined as it is mass of water vapor present per unit volume.

$$H_A = m/Vg$$

- Its unit is gram per cubic meter ( $g/m^3$ )

Relative Humidity: It is defined as a ratio of moisture content of the gas to the maximum moisture the gas can contain at that temperature.

$$\% H_R = \rho_g \times 100 \rho_s$$

$\rho_g$  = moisture content of gas

$\rho_s$  = fully saturated air

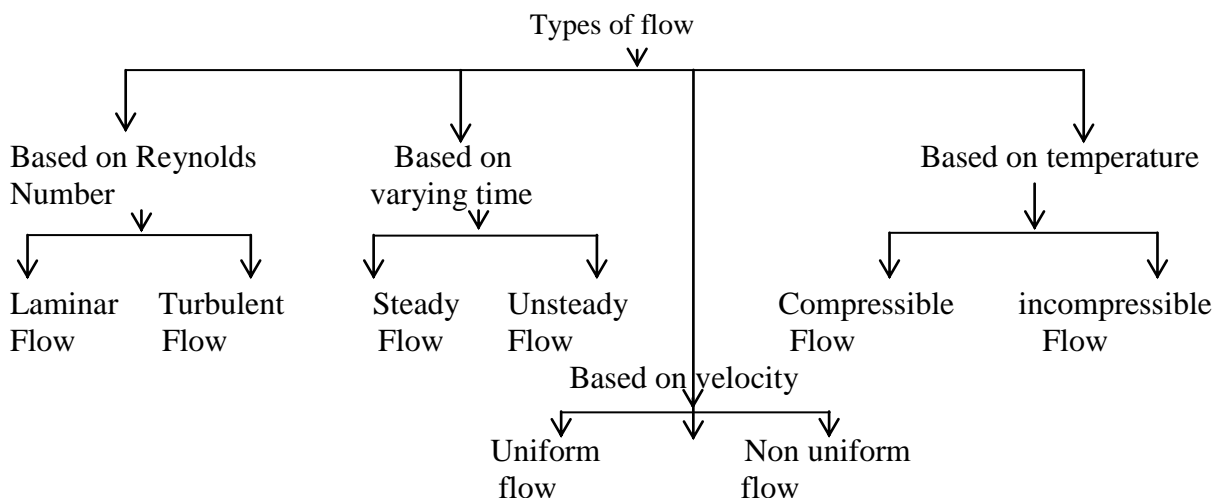
vi. State the working principle of thermocouple.

Ans vi. **Working Principle- 2M**

Thermocouple is a temperature transducer that develops an emf which is a function of temperature between hot junction and cold junction.

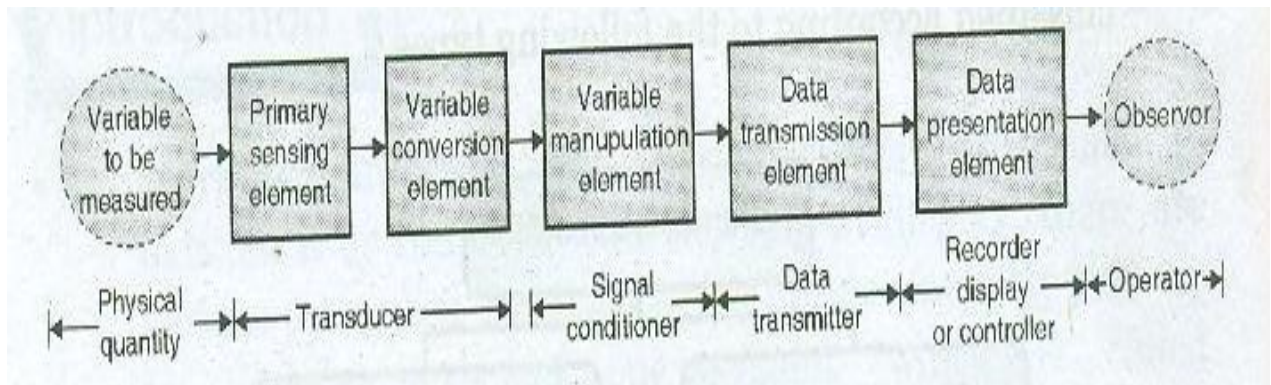
vii. State the different types of flow.

Ans vii. **Correct answer: 2 M**



viii. Draw the block diagram of instrumentation system.

Ans viii. **Diagram:2M**



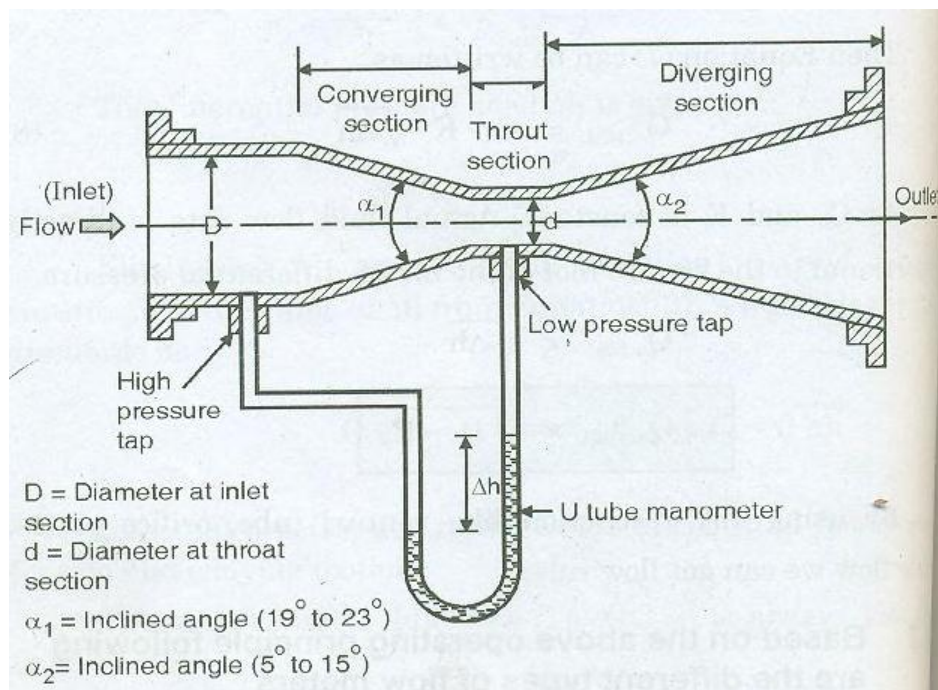
**Fig: Block diagram of instrumentation system.**

**b. Attempt any TWO of the following:**

**8 marks**

i. Describe working of venturimeter with neat sketch

Ans i. **Working:2M, Diagram:2M**



**Fig: venturimeter**

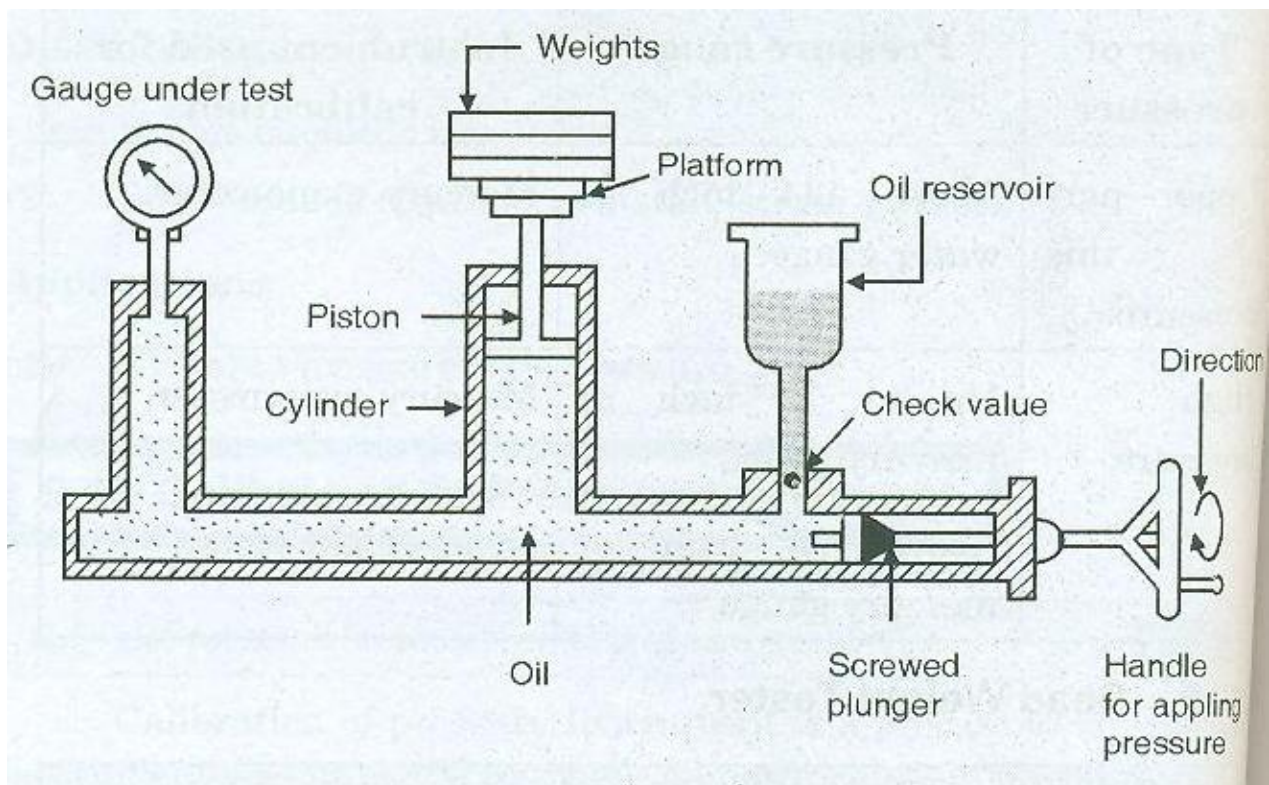
- Venturi meter consists of three sections that is converging section, throat section and diverging section.
- The flow is introduced to the meter through the inlet with diameter 'D'. The inclined angle of converging section is  $\alpha_1$  which may be between  $19^\circ$  to  $23^\circ$
- The flow is then passed through the throat section which have the diameter 'd'

- Two pressure taps (one at inlet section and second is at middle of throat section) are provided to measure the pressure difference by using U- tube manometer as shown in the fig.
- The diversion section has inclined angle  $\alpha_2$  which may be between  $5^\circ$  to  $15^\circ$ .
- Flow rate is proportional to the square root of the differential pressure  

$$\text{Flow rate} \propto \sqrt{P_1 - P_2}$$
- Venturi tube made up of cast iron or steel, It is available in different shape like classic Venturi, rectangular Venturi tube, eccentric Venturi tube etc.

ii. Explain the working of dead weight tester with neat diagram.

Ans ii. **Working: 2M; Diagram:2M**



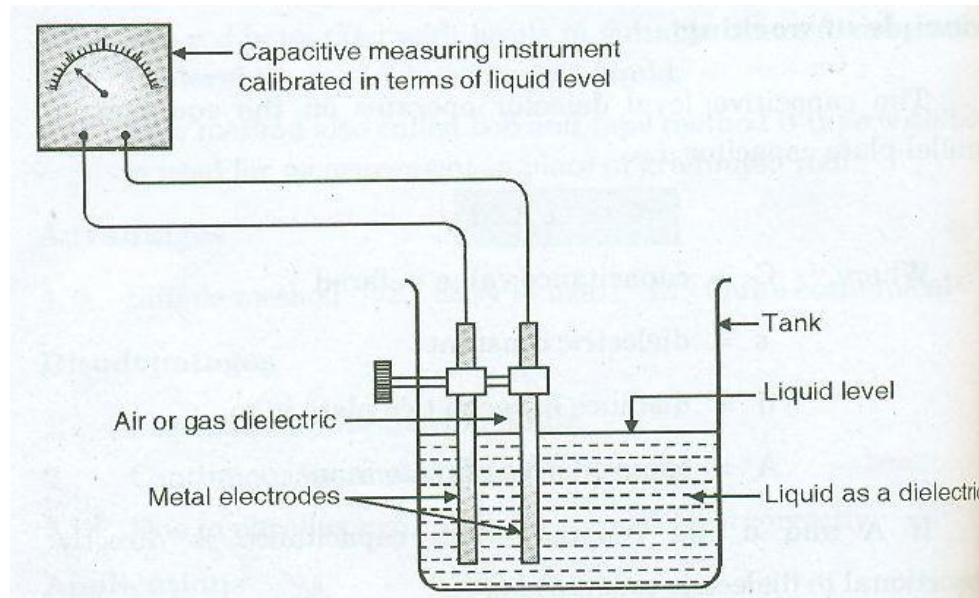
- The handle is fully drawn out and the oil is allowed to enter in the cylinder (i.e. gauge and piston)
- A known accurate weight is placed on the platform. The area of the piston is also known; hence we can calculate the pressure.
- Now the handle is turn to pressure in clockwise direction so that the pressure will buildup on the gauge side as well as platform side.
- Increase the pressure by rotating the handle clockwise until enough pressure is developed inside the cylinder and lifts the platform with weights placed on it and it floats freely within the limit stops.
- Repeat the same procedure for different weights (increase weights in steps). In the same way most of the pressure gauges are calibrated against dead weight testers.



- An error in dead weight testers is less than 0.1%. In order to reduce the friction between the piston and cylinder, the piston is gradually rotated while a reading being taken.

iii. With neat diagram, explain working of capacitance level measurement.

Ans iii. **Diagram: 2M; Working:2M**



**Fig: Capacitance Level Gauge**

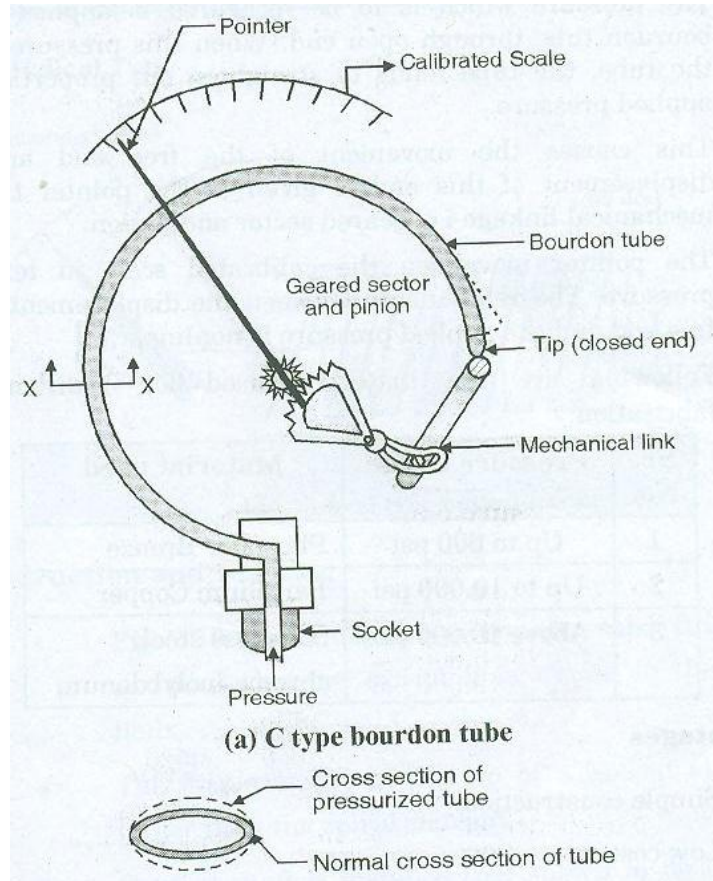
- It consists of two probes firmly fixed parallel to each other and acts as plates of capacitor. This system is used for non-conducting liquid which act as an dielectric material.
- A capacitance measuring instrument is connected to the probes to measure the capacitance and it is calibrated in terms of liquid level in the tank.
- When the liquid in the tank increases, the capacitance also increases and when the liquid level decreases the capacitance decreases.
- This value of capacitance is measures by capacitance measurement instrument and displayed on the indicator calibrated in terms of liquid level.

**2. Attempt any FOUR of the following:**

**16 marks**

**a. Draw the constructional detail of C type Bourdon tube and explain its working.**

**Ans a. Diagram: 2M; Working:2M**



**Fig: Bourdon Tube**

- C type bourdon tube is made up of an elliptically flattened tube bent in such a way as to produce the C shape as shown in the fig. One end free end of this tube is closed or sealed and the other end (fixed end) opened for the pressure to enter.
- The free end connected to the pointer with the help of geared sector and pinion. Calibrated scale and pointer is provided to indicate the pressure.
- The cross section view of C type bourdon tube under normal condition and pressurized condition is as shown in figure.
- The pressure which is to be measured is applied to the bourdon tube through open end. When this pressure enters the tube, the tube tends to straighten out proportional to applied pressure.
- This causes the movement of the free end and the displacement of this end is given to the pointer through mechanical linkage i.e. geared sector and pinion.
- The pointer moves on the calibrated scale in terms of pressure. The relationship between the displacement of the free end and the applied pressure is nonlinear.

b. Write application of following transducer.

- |                                       |    |
|---------------------------------------|----|
| i. Venturi tube                       | 1M |
| ii. Orifice plate                     | 1M |
| iii. Ultrasonic flow meter            | 1M |
| iv. Positive displacement flow meter. | 1M |

Ans b.

**i. Venturi tube:**

- The venturi tube is used to handle the slurries and dirty fluids.

**ii. Orifice plate:**

- Quadrant edge orifice plate is used for more viscous fluid.
- Segmental or eccentric type plates are used for fluid containing solids.

**iii. Ultrasonic flow meter**

- Mostly used for liquids without any pressure loss.
- Mainly used for liquid flow.

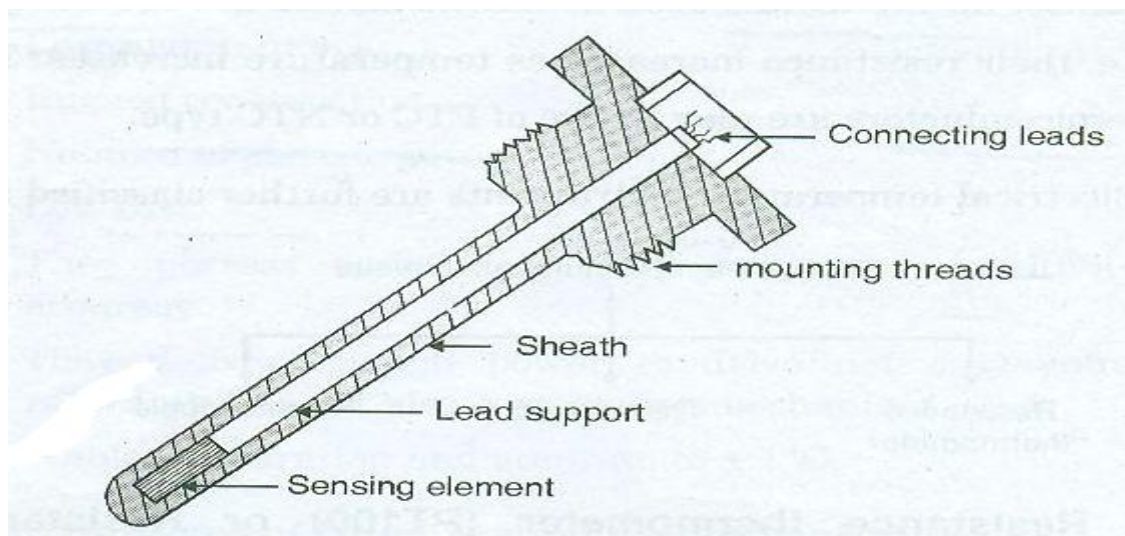
**iv. Positive displacement flow meter:**

- Used in laboratories
- Used in testing and production lines.

c. Give construction, working principle of RTD with a neat sketch.

Ans c. **Diagram:2M; Working principle:2M**

- A pure metallic element or wire with large positive temperature co-efficient (PTC) changes its resistance with changes in temperature. The element is used as resistance thermometer.



**Fig: Industrial platinum resistance thermometer**



d. List the advantages and disadvantages of float type's level gauges.

Ans d. **Advantages: 2M, Disadvantages:2M**

**Advantages of float types level gauges:**

1. Continuous and direct measurement is possible.
2. Low cost and reliable design
3. If the tank is kept below the ground level. It is possible to read the liquid in a tank from the ground level.
4. Large temperature range liquid can be handled by this method.

**Disadvantages of float types level gauges:**

1. Operation is limited to moderate pressure.
2. They are tailored to tank geometry.

e. State the selection criteria for transducer (any eight points)

Ans e. **Any 8 points: 4M**

1. Operating range
2. Operating principle
3. Sensitivity
4. Accuracy
5. Frequency response and resonant frequency
6. Errors
7. Environmental compatibility
8. Usage and ruggedness.
9. Electrical aspect.
10. Stability and Reliability
11. Loading effect
12. Static characteristics
13. General selection criteria

f. Describe how humidity is measured by using hair type hygrometer.

Ans f.

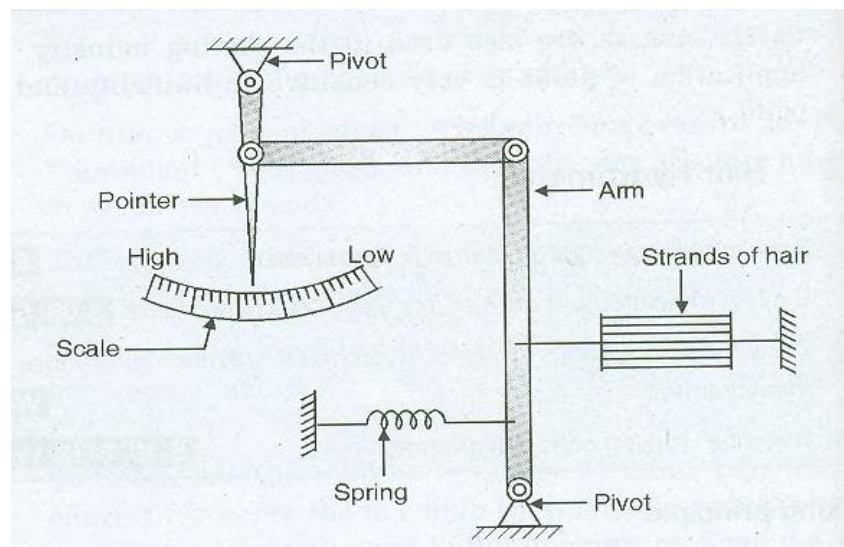


Fig: Hair Hygrometer

- It consists of bunch of human hair which increases mechanical strength of the instrument, arm with pivot joints and points scale assembly.
- The element is maintained at slight tension by a spring. The hair strands are generally arranged parallel to each other with sufficient space between them for giving free access to the air sample whose humidity is to be measured.
- The indicator scale is directly calibrated to give a direct indication of humidity. The pointer or recording pen is operated through mechanical linkage.
- As the relative humidity surrounding to that of hygrometer increases, length of hair strands increases, which move the pointer on the calibrated scale for maximum value.

**3. Attempt any FOUR of the following:**

**16 marks**

a. Draw construction diagram of LVDT with label. Also state the application of LVDT.

Ans a. **Diagram: 2M; Application:2M (any one diagram should be considered)**

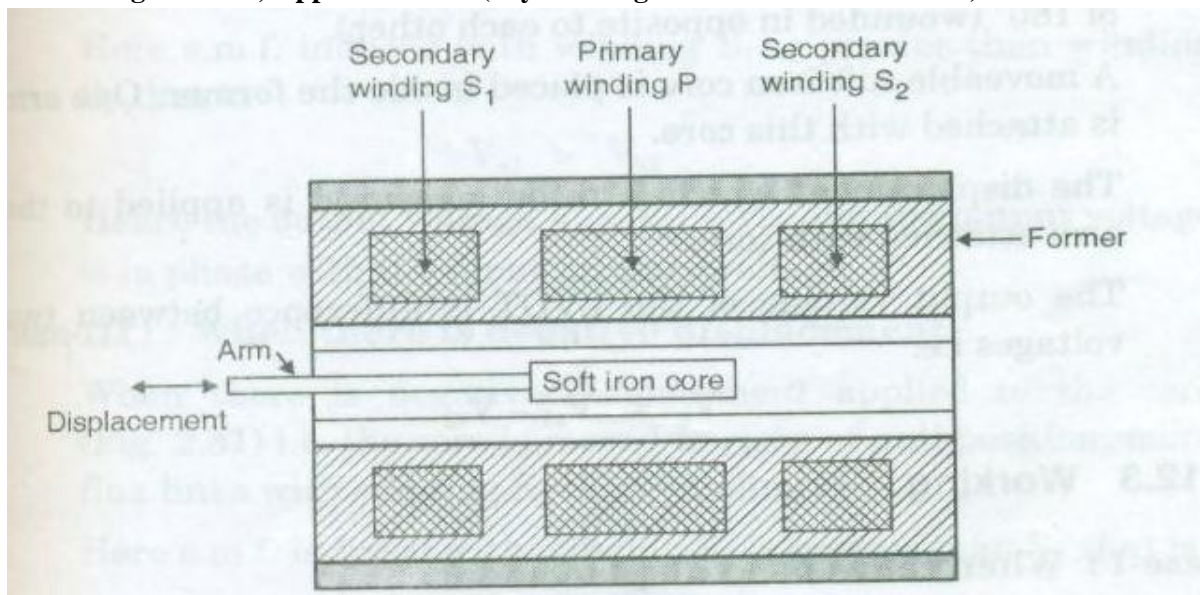


Fig: Cross section view of LVDT

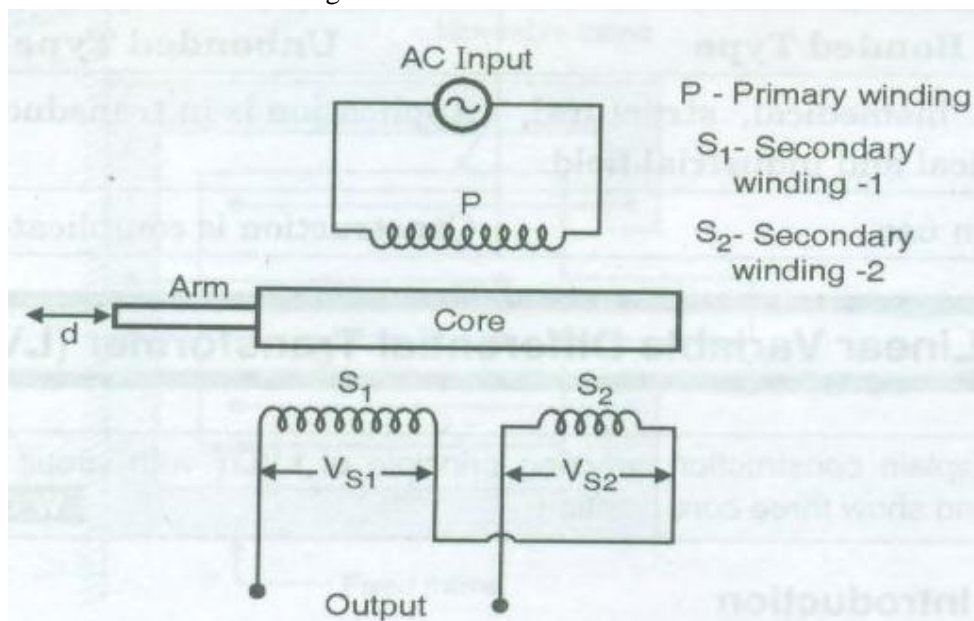


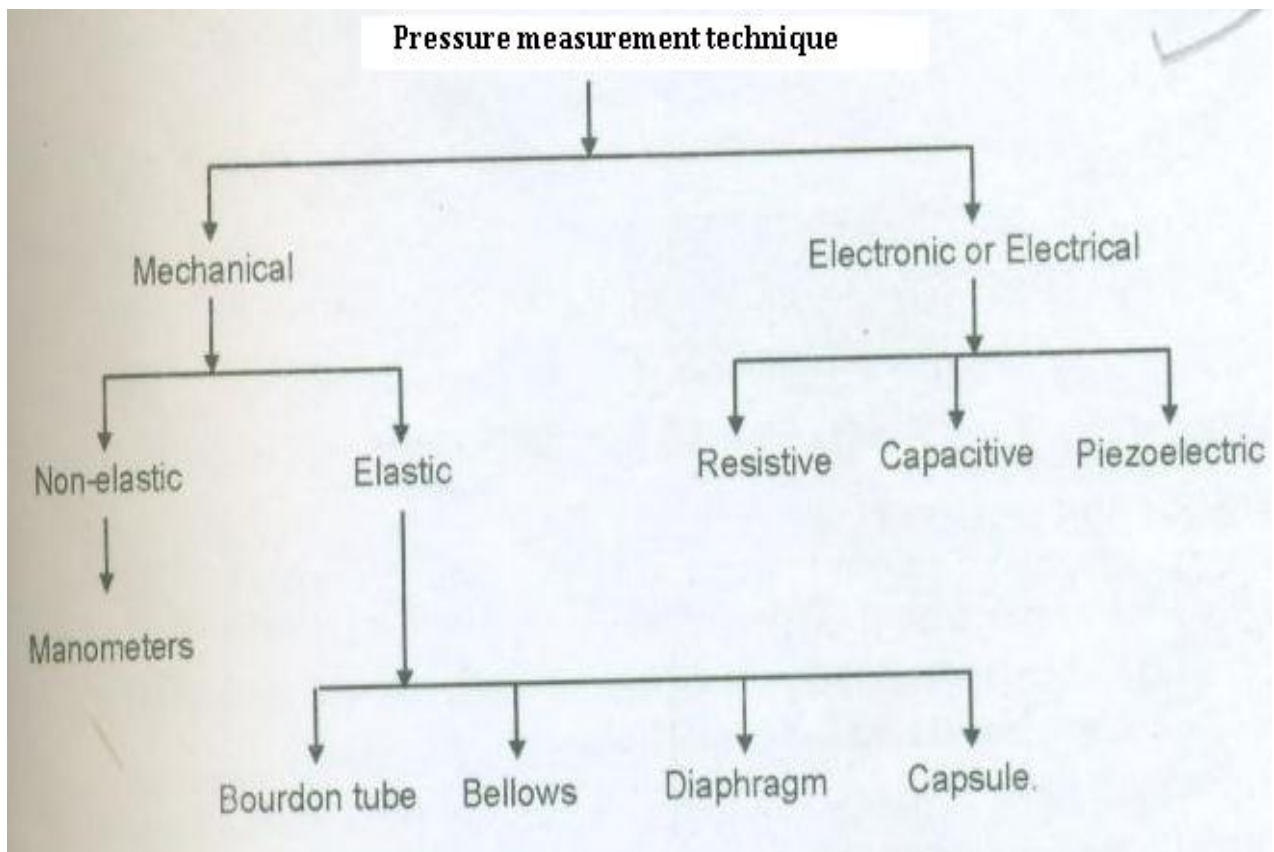
Fig: Basic Circuit diagram of LVDT

**Applications:**

1. LVDT is used to measure the linear displacement.
2. Useful in force, pressure and weight measurement as a secondary transducer.
3. Useful for measurement and control of thickness of metal sheet.
4. Useful for measurement of tension in cord.
5. Useful for measurement weight or pressure exerted by liquid in the tank.

b. What is the different pressure measurement method? State the working principle of U- tube manometer.

Ans b. **Methods 2M, Working principle 2M**

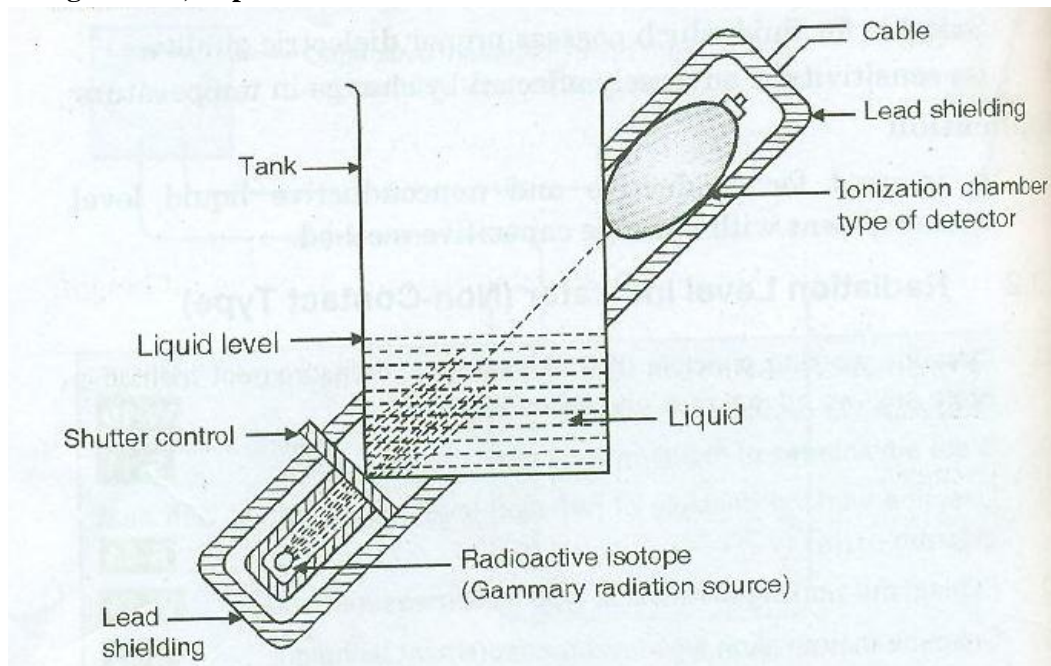


When two pressures  $p_1$  and  $p_2$  are equal the liquid height in the manometer tube is at equal level in both limbs.

If there is a pressure difference at two ends of tube, the liquid goes down on one side and goes up on the other side.

c. Describe the radiation type level measurement technique.

Ans c. **Diagram 2M, Explanation 2M**



The working principle of nucleonic gauge or gamma ray liquid level gauge is that the absorption of gamma rays varies with the thickness of the absorbing material (i.e. height of liquid column) between the source and detector.

Construction & working

- Construction of gamma ray liquid level gauge is as shown in fig. the instrument consists of a radioactive isotope encapsulated in the lead shielding, which may be either Ce-137, Am -241 or Co-60 and radiate gamma rays.
- The amount of radiated rays is controlled by a shutter. The gamma rays pass through the liquid towards the detector.
- A radiator detector is of ionization chamber type. The detector and electronics circuits incorporating the amplifiers and read out instruments or recorder controller.
- As the gamma rays are passed through the liquid, the liquid area absorbs the gamma rays, higher the height of liquid column higher is the absorption of gamma rays and consequently lower is the detector output.
- The output is measured and correlated with the level of liquid in the tank using the following exponential type of expression applicable in such an arrangement:

$$I = I_0 e^{-\mu \rho x}$$

where I is the intensity of radiation falling on detector

$I_0$  is the intensity of radiation at the detector with absorbing material not present.

$\mu$  is mass absorption coefficient in  $\text{m}^2/\text{kg}$

$\rho$  is the mass density of test material in  $\text{kg}/\text{m}^3$

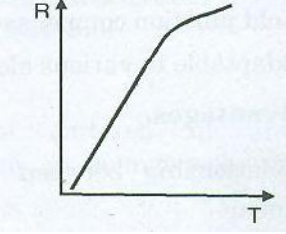
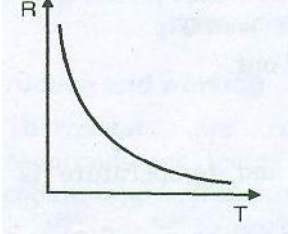
x is the thickness of absorbing material in m (liquid height in this case)

- From above equation the intensity of radiation falling on detector depends on the height of liquid.



d. Compare NTC and PTC w.r.t. thermistor (any four points)

Ans d. **Each point: 1 M**

Sr.No	PTC	NTC
1	It is positive temperature coefficient	It is negative temperature coefficient
2	As temperature increases resistance also increases $R \propto T$	As temperature increases resistance also decreases $R \propto 1/T$
3	PTC manufactured from barium titanate, titanium oxide, and powdered barium carbonate.	NTC composed of metal oxides such as manganese, nickel, cobalt, copper, iron and uranium.
4		

e. Describe how speed is measured by photoelectric method with neat diagram.

Ans e. **Diagram: 2M; Explanation: 2M**

- The light passes through the holes available on the rotating disc with a specific interval, depends on the angular speed of the disc having equidistant holes. The frequency of this light pulses is measure of the angular speed of the disc.

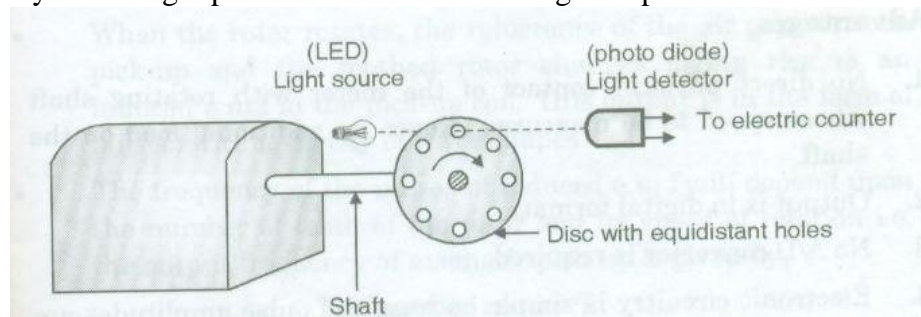


Fig: Photoelectric Tachometer

**OR**

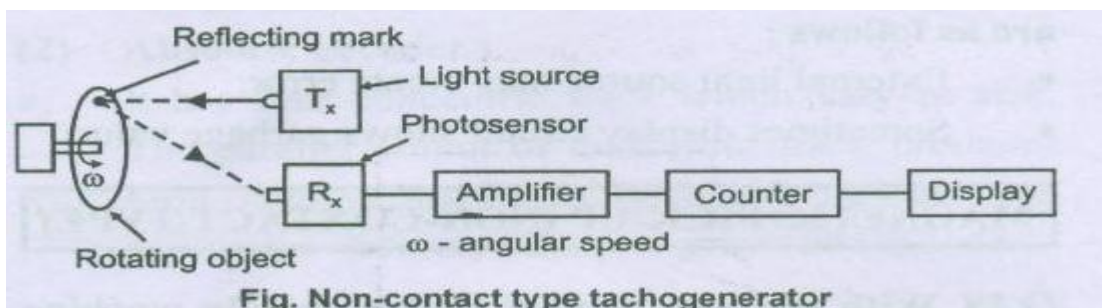


Fig. Non-contact type tachogenerator



### Working:

This method of measuring speed of rotation consists of mounting an opaque disc on the rotating shaft.

The disc has a number of equidistant holes on its periphery. At one side of the disc a light source is fixed like Led and on other side of the disc and in the line of the light source, a light sensor like phototube or some photosensitive semi conducting device is placed.

When the opaque portion of the disc is between the light source and the light sensor, the later unilluminated and produces no output.

But when a hole appears between the two , the light following upon the sensor produces an output pulse.

The frequency at which the pulses are produced depends upon the number of holes in the disc and its speed of rotation. Hence the speed is given by,

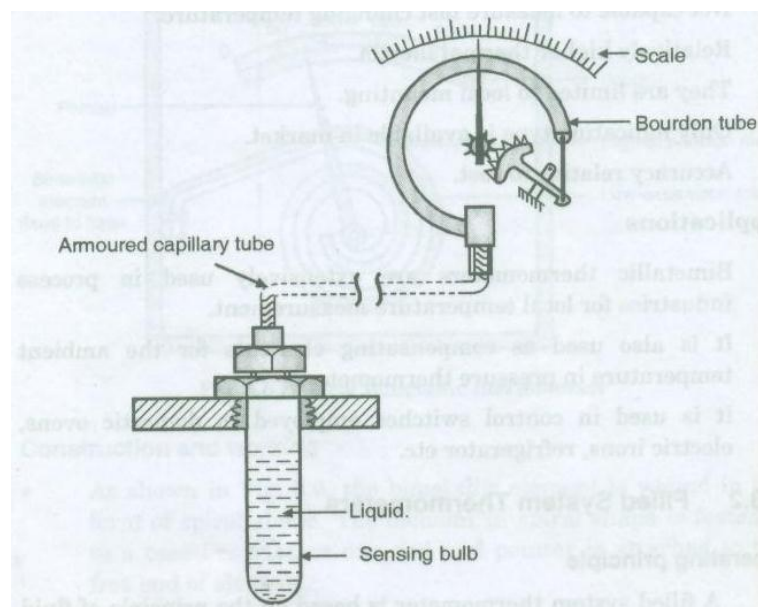
$$N = f / H_N$$

Where  $f$ = frequency,  $H_N$ = Number of holes on disc,  $N$ = speed

- Since the number of holes on the disc is fixed, the speed is a function of pulse rate.
- the pulse rate can be measured by electronic counter which can be directly calibrated in terms of speed in rpm.

f. Describe with neat diagram how temperature is measured by liquid filled thermometer.

Ans f. **Diagram:2M; Explanation:2M**



**Fig: Liquid filled thermometers**

- It consists of sensing bulb, capillary tube and bourdon tube interconnected with each other.

- Liquid is filled in sensing bulb at a pressure at normal ambient temperature. Mercury, ethyl alcohol, xylene and toluene are commonly using liquid.
- During operation the thermometer bulb is installed inside the substance whose temperature is to be measured. This causes the liquid inside the bulb to heat or cool until its temperature matches the temperature of the measured substances.
- This change in temperature causes the filling liquid to expand or contract and thus the bourdon tube moves.
- As the temperature increases the liquid expands and this expansion forces the bourdon tube to uncoil, with decrease in temperature the liquid contracts and it forces the tube to coil.
- The free end of the bourdon tube is used to drive a pointer for indicating temperature or to drive a pen on a strip chart.

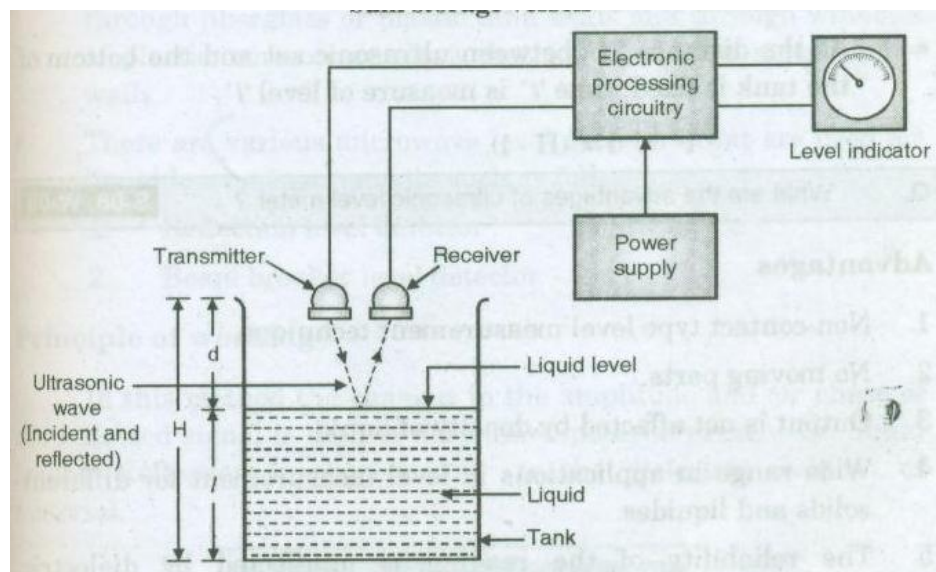
**4. Attempt any FOUR of the following:**

**16 marks**

a. Describe the working principle of ultrasonic level measurement with neat diagram.

Ans a. **Diagram: 2M; Explanation:2M**

- Working principle:- It operates by generating an ultrasonic wave or pulse and measuring a time it takes for the echo to return.



b. What is piezoelectric effect? Name two piezoelectric materials.

Ans b. **Effect 2M, Material 2M**

- Piezoelectric effect state that “ when a pressure or force or vibration applied to the crystalline material like quartz crystal or crystalline substances then an e.m.f. is generated across the material or vice versa”.

- Piezoelectric materials

**Natural crystals**

\* Quartz crystal,

**Synthetic crystals**

\* Barium, titanate

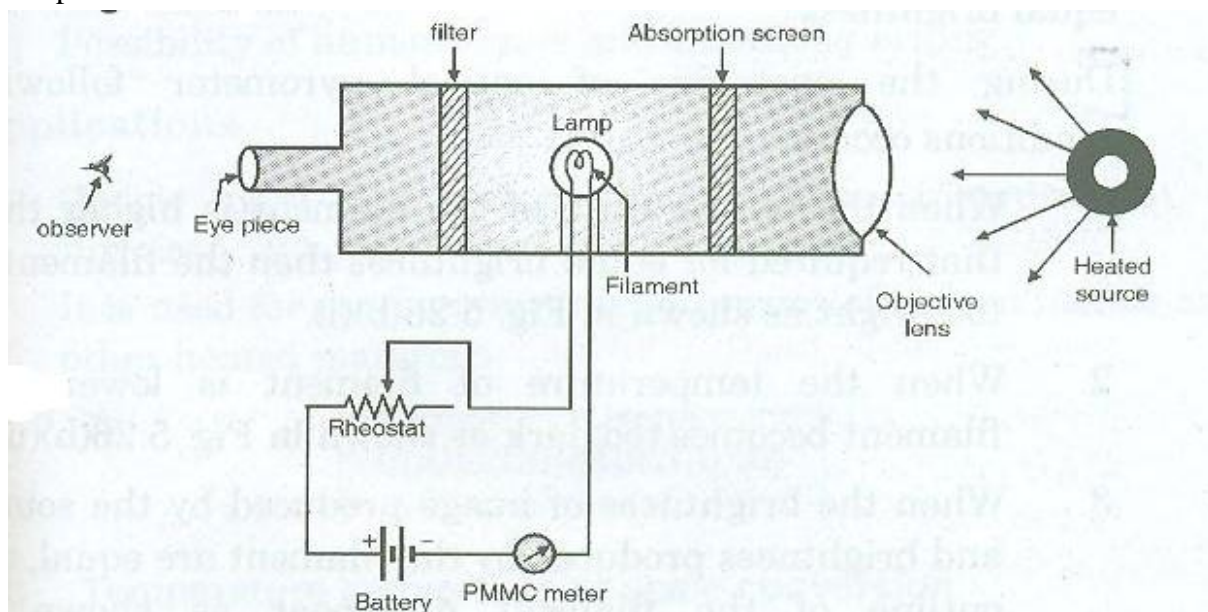
\* Rochelle salt

\* Lithium sulphate

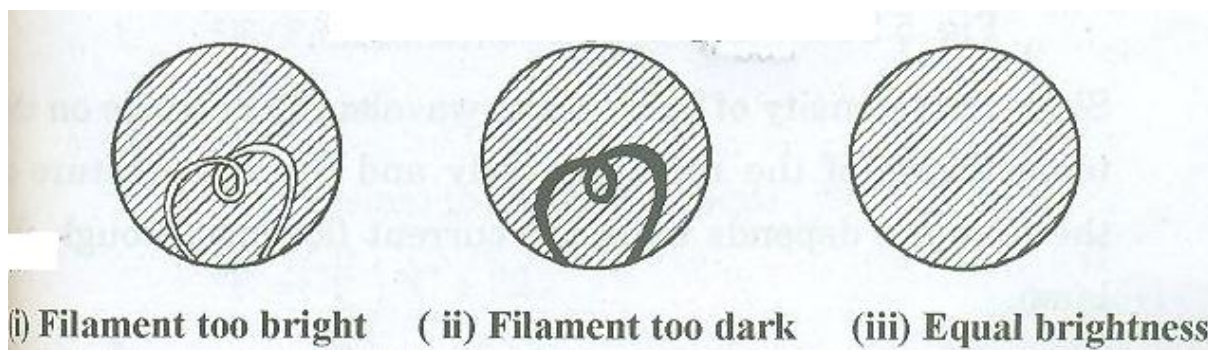
c. What is pyrometry? Describe working of optical pyrometer with neat diagram.

Ans c. **Pyrometer 1M, diagram & explanation 3M**

- Pyrometer:- When physical contact with the medium to be measured is not possible or impractical due to very high temperature (above 1400°C) pyrometers are used for temperature measurement.



**Fig: Optical pyrometer**



The working principle of optical pyrometer state that the brightness of light of a given color emitted by a hot source, gives an indication of temperature.

Working:

- It consists of a tube, one end of this tube has objective lens and other end has a sighting eye piece to observe the filament.
- The filament is viewed through filter and eye piece. The lens side of tube is projected towards the hot body whose temperature is to be measured.
- An image of radiating source is produced by a lens and made to coincide with the filament of an electric lamp.

- The current through the lamp filament is made variable so that lamp intensity can be adjusted. The current through filament is adjusted until the filament and the image are of equal brightness.

During the operation of optical pyrometer following conditions occurs.

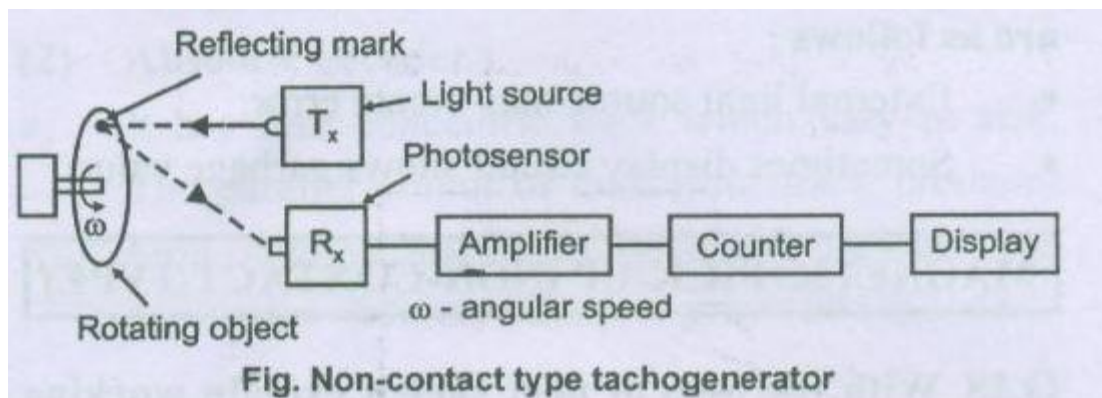
- When the temperature of the filament is higher than that required for equal brightness then the filament is too bright as shown in the figure.
- When the temperature of filament is lower, the filament becomes too dark as shown in fig.

When the brightness of image produced by the source and brightness produced by the filament are equal, the outline of the filament disappear

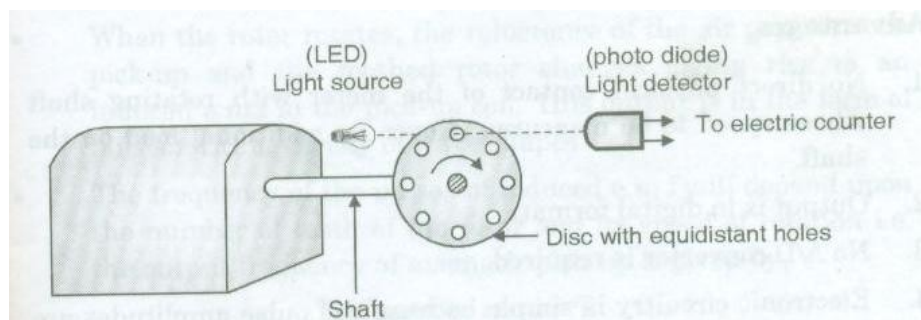
d. What is tachometer? Explain photo- electric pickup.

Ans d. **Tachometer:1M; Photo- electric pickup:3M**

Tachometer is an instrument which is used to measure angular speed. It is measured per minutes (rpm).



OR



- Optical tachogenerator or tachometer is non contact type device which is used to measure speed in rpm.
- It consists of a source light which directs the light beam towards rotating object.
- A reflecting mark is affixed to the rotating object. The photosensor is focused on the area toward the mark.



- When the object rotates, it modulate light by reflecting mark, producing a tray of pulses, whose frequency is proportional to the speed.
- The number of pulses counts the number of revolutions of object. The output of photosensor is amplified. The counter is used to count the number of pulses.
- A display device is used to read out the output. It may be CRO or seven segment display or analog meter.
- The external light may produce error if simple LED and photosensor is used. Therefore to avoid this, IR (Infra-Red), LED and photosensor is used.

e. State two advantages and two drawbacks of liquid filled and gas filled thermometer.

Ans e.

**Advantages of liquid filled thermometer: 1M**

1. Linear response is given
2. Sensitivity is good.
3. Low cost
4. Accuracy is moderate
5. Easy to operate.

**Drawbacks of liquid filled thermometer 1M**

1. Possible breakage of glass tube
2. Calibration may be disturbed in pressurized thermometer
3. Long time constant.

**Advantages of Gas filled thermometer: 1M**

1. Accuracy is about  $\pm 1$  of FSD (Full scale deflection)
2. Available in wide range
3. Over range protection upto 120% of FSD
4. Linear response
5. Rugged construction

**Drawbacks of Gas filled thermometer: 1M**

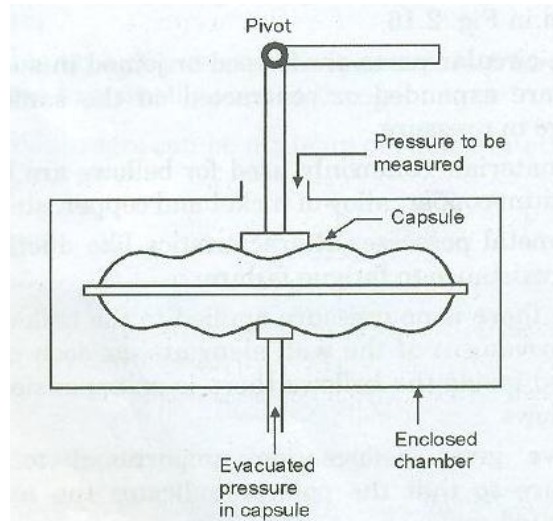
1. Bulky in nature
2. Range can be limited due to size of capillary and bulb.



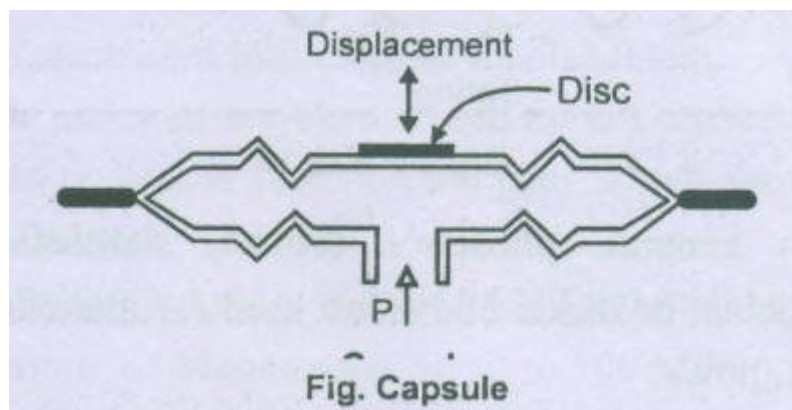
f. What is capsule? How it is used for pressure measurement?

Ans f. **Capsule: 2M; Use for pressure measurement:2M**

Capsule:



OR



- A capsule is made up of two identical corrugated diaphragms so as to form a leak- proof chamber and also referred to as an aneroid.
- The fluid under measurement is entered in to the chamber.
- One diaphragm is rigidly held while other deflects and results in twice the displacement of single diaphragm.
- The central part of diaphragm consists of a round disc which serves on one side to communicate the displacement. The opening is provided in other diaphragm to apply the pressure.

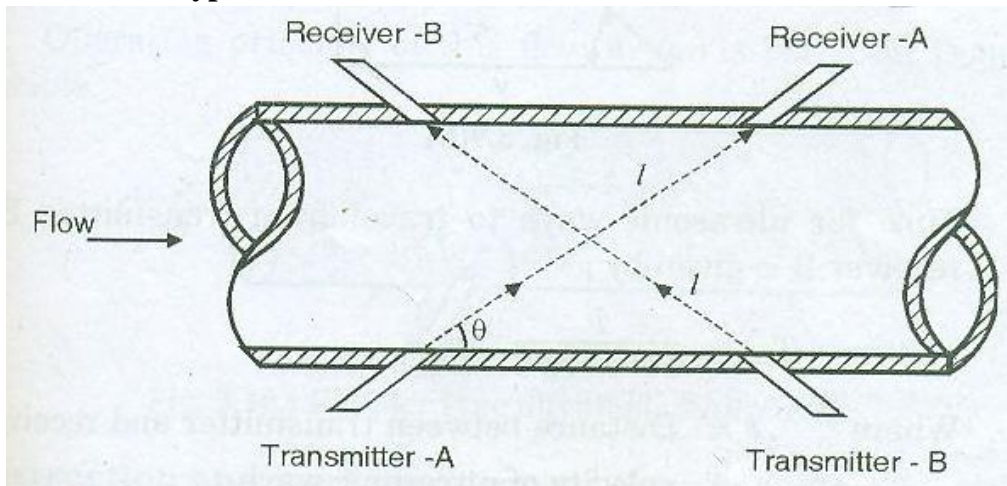
5) Attempt any FOUR of the following:

16 marks

a. Explain any one type of ultrasonic flow meter with neat diagram.

Ans a. Any one type: 4M

• **Time difference type:-**



- The operating principle of this flow meter is based on the apparent change in the velocity of propagation of ultrasonic wave pulses in a fluid with a change in velocity of fluid flow.
- This flowmeter consists of two transmitters and two receivers. These are separated by distance  $l$  and mounted.
- Transmitter A transmits the waves pulsed of short duration in the direction of receiver A, this favor the wave as it is in direction of low.
- Transmitter B transmits the wave pulsed of short duration in the direction of receiver B, this do not favor the wave as it is opposite to the direction of low.
- The velocity of ultrasonic waves increased or decreased by the fluid velocity depending upon the direction of fluid.
- The detector measures the transit time from upstream to downstream and vice versa. The time for ultrasonic wave to travel from transmitter A to receiver A is given by

$$T_A = l / (c + v \cos \theta)$$

- Time for ultrasonic wave to travel from transmitter B to receiver B is given by,

$$T_B = l / (c - v \cos \theta)$$

where  $l$  = distance between transmitter and receiver

$c$  = velocity of ultrasonic wave

$\theta$  = angle of path with respect to pipe axis.

$v$  = velocity of fluid flowing through pipe.

- The difference in time between  $T_A$  and  $T_B$  is given by,

$$\Delta T = T_A - T_B$$

$$\Delta T = (l / (c + v \cos \theta)) - (l / (c - v \cos \theta))$$

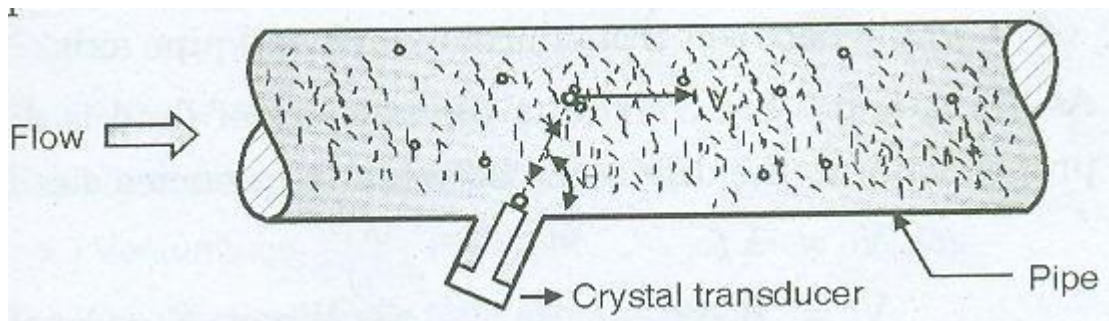
$$\Delta T = l / 2v \cos \theta$$

$$\text{Therefore } v = l / 2\Delta T \cos \theta$$

The measurement is independent of velocity of ultrasonic wave (c )

- By measuring the difference in reception frequency, and knowing the value of  $\Theta$  and  $l$ , the velocity of fluid can be counted.

**OR**



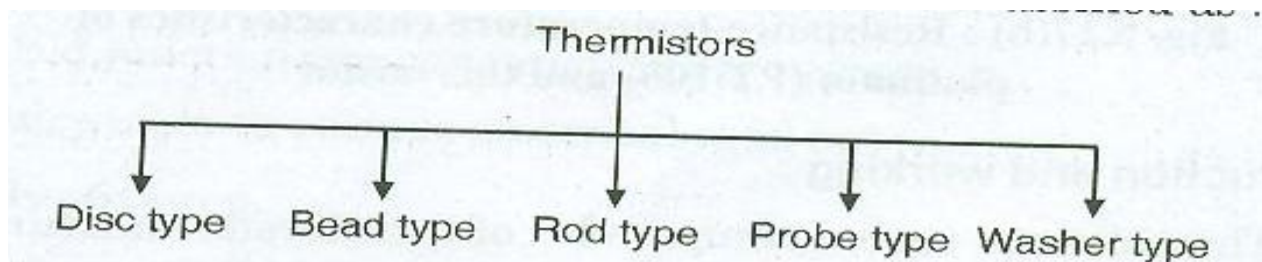
- One crystal transducer is mounted outside the pipe. This transducer emits an ultrasonic wave and the wave is projected at an angle through the pipe wall into the liquid.
- The transducer is basically piezoelectric crystal with a heavy backing to attenuate the unwanted rear movement.
- Some parts of the ultrasonic wave are reflected by the liquid particles and bubbles in the liquid and it is returned through the pipe wall towards the transducer.
- As the liquid flows through the pipe the particles and bubbles in the liquid also moves these particles acts as reflectors for the ultrasonic wave.
- The particles and bubbles moving with the velocity of the fluid, the frequency of the reflected wave is shifted according to particle velocity, it is given by Doppler principle.

b. What is thermistor? Discuss its different types with proper diagram.

Ans b. (definition – 1mark, different types – 3 marks)

Thermistor:

- Thermistors are nothing but Thermal resistors which are generally temperature sensitive semiconductors. These are variable resistors whose varies as temperature varies.



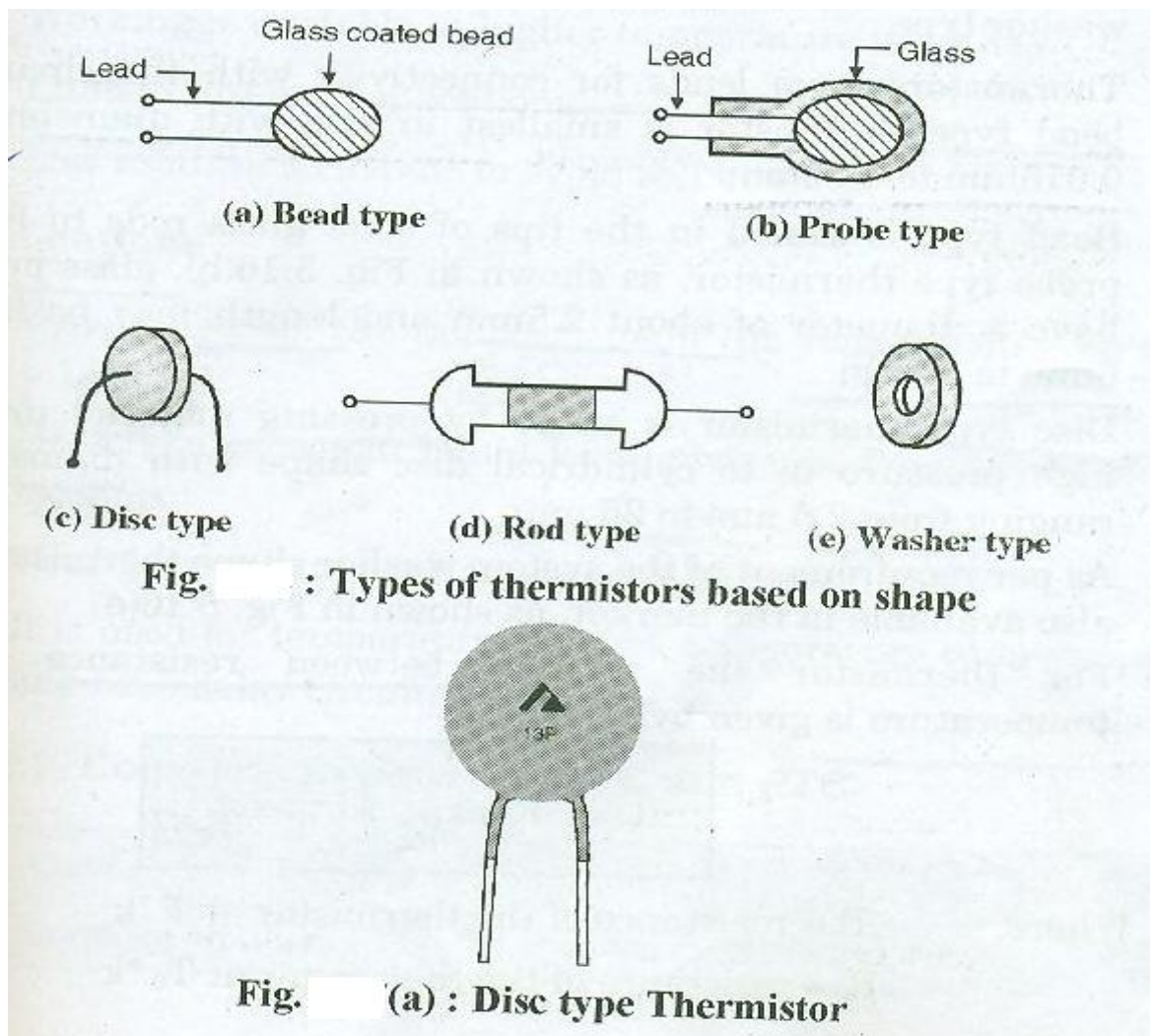
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- Thermistors have leads for connectivity with the circuits; bead type thermistors is smallest in size with diameter of 0.015mm to 1.25mm.

- Bead type is sealed in the tips of solid glass rods to form probe type thermistors as shown, glass probe have a diameter of about 2.5 mm and length may be from 6mm to 50mm.
- Disc type thermistor is made by pressing material under high pressure in to cylindrical disc shape with diameters ranging from 2.5mm to 25mm.
- As per requirements of the systems washer shape thermistors is also available in the market.
- For thermistors the relation between resistance and temperature is given by;

$$R = R_0 \exp \left[ \beta \left( \frac{1}{T} - \frac{1}{T_0} \right) \right]$$

- R= resistance of the thermistor at T°k
- R<sub>0</sub>=resistance of the thermistor at T<sub>0</sub>°k
- β= constant depending on material of thermistor.
- Typical value of β is between 3500 to 4500°k



c. Classify each of the following transducer in two different categories.

- |                  |                    |
|------------------|--------------------|
| (i) Thermocouple | (iii) Bourdon tube |
| (ii) LVDT        | (iv) Strain guage. |

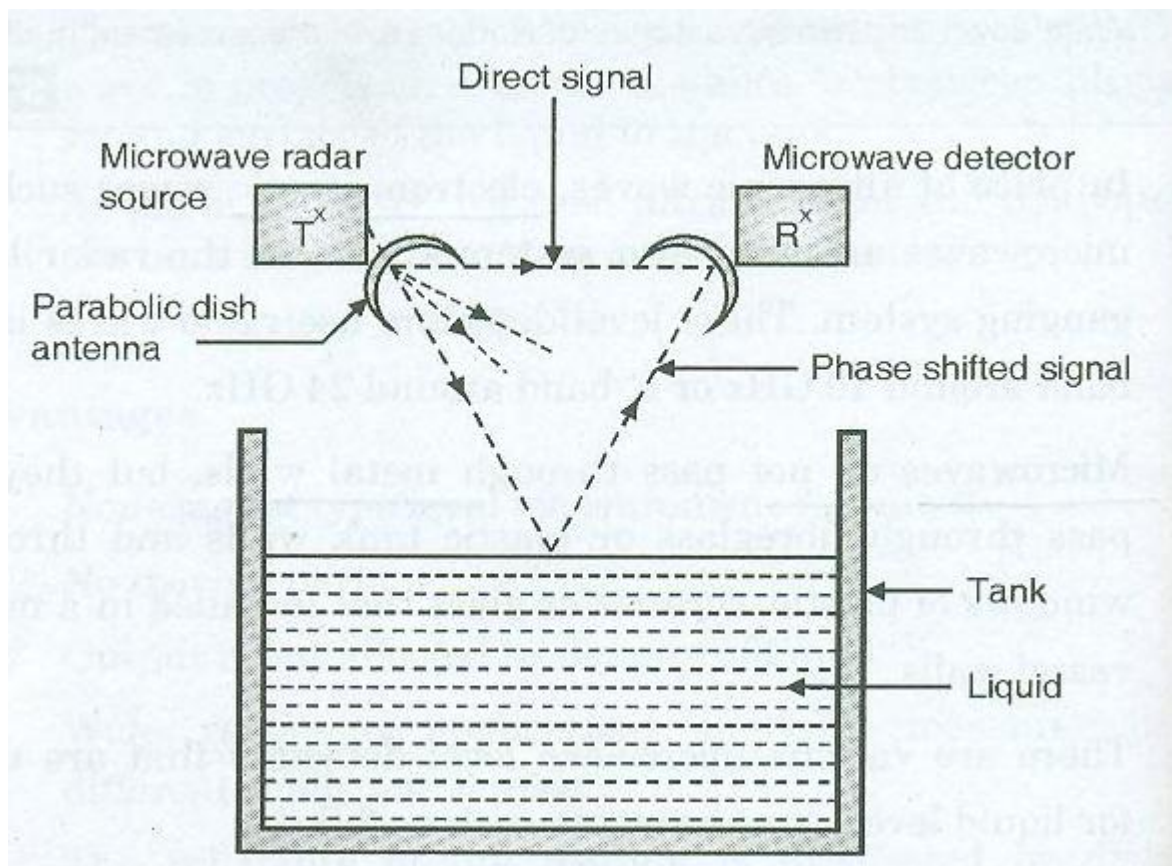


Ans c. (Note: Any other correct category of transducer classification should be considered) 4M

Sr. No	Active	Passive
1	Thermocouple	LVDT
2	Bourdon Tube	Strain gauge

d. Draw a diagram of radar level measurement. Write an advantages and disadvantages of it.

Ans d. **Diagram: 2M; Advantages:1M, Disadvantages:1M**



**Fig: Radar Level Detector**

**Advantages:**

1. This is non- contact technology
2. High accuracy for measurements in storage tanks and some process vessels.

**Disadvantage:**

1. Fairly expensive technology.



e. State the advantages and disadvantages of photoelectric tachometer.

Ans e. **Advantages: 2M ; Disadvantages:2M**

**Advantages of photoelectric tachometer:**

1. No direct physical contact of the meter with rotating shaft whose speed to be measured. Hence no additional load on the shaft.
2. Output is in digital format.
3. No A/D converter is required.
4. Electronic circuitry is simple because the pulse amplitudes are constant.
5. Continuous measurement is possible.

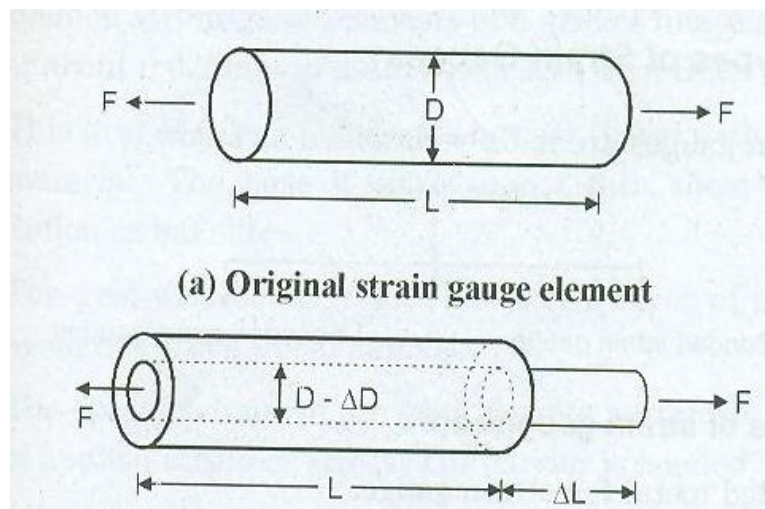
**Disadvantages of photoelectric tachometer:**

1. Life span of light source is limited (typically 50,000 hours).
2. The accuracy of meter is depends on the error represented by one pulse.

f. Define guage factor. How strain guage is suitable for pressure measurement.

Ans f. **Define: 1M; Explanation & diagram: 3M**

Guage Factor: Guage Factor is defined as the ratio of per unit change in resistance to per unit change in length.



**Fig: Strain Guage**

- Strain guage is a passive transducer which uses the variation in resistance in conducting wire to sense the strain produced by produced by the pressure or force on the wire.
- The strain guages are used for measurement of strain and associated stress.
- Operation of the strain guage is based on the familiar equation of metal conductor i.e.

$$R = \rho \cdot l/A$$

where,  $\rho$  = resistivity of conductor material.

$l$  = length of conductor

$A$  = cross section area of conductor

If the wire is stretched or compressed, its resistance changes due to change in dimension of the wire.

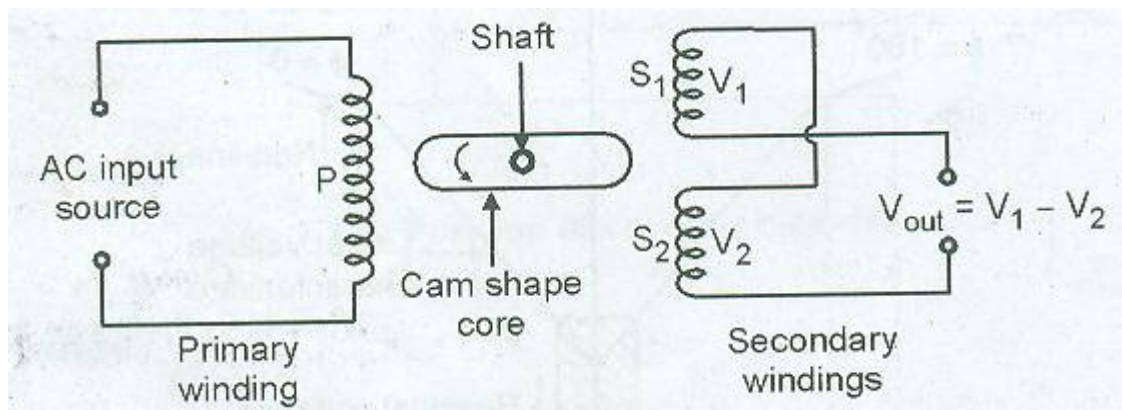
- When pressure is applied to the gauge it produces a positive strain due to which the length of gauge increases and diameter decreases.
- The change in length and change in diameter change resistance of the gauge. Thus resistance of gauge is depending on dimension of gauge which depends in applied force or strain.

**6. Attempt any FOUR of the following:**

**16 marks**

- a. Explain working principle of RVDT with figure.

Ans a. **Working Principle- 2M, Diagram-2M**



**Fig: Circuit Diagram of RVDT**

- RVDT is inductive transducer, which converts the angular displacement into electrical signal.
- If there is no angular displacement to the core i.e. null position, the output voltage of secondary windings  $S_1$  and  $S_2$  are equal and in opposition. Hence output voltage is zero.
- If the core rotates in anticlockwise direction produces more voltage in winding  $S_1$  than  $S_2$ . Hence output is  

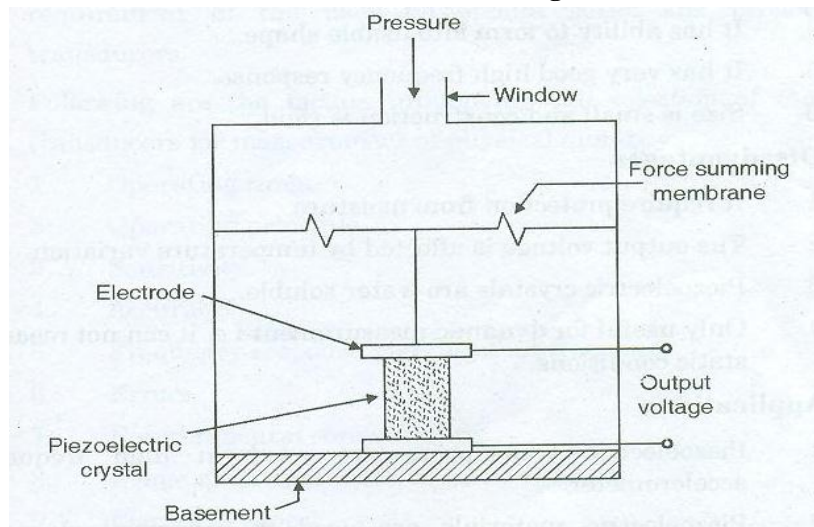
$$V_o = V_{s1} - V_{s2}$$
- If the core rotates in clockwise direction it produces more voltage in windings  $S_2$  than  $S_1$ . Hence output is,  

$$V_o = V_{s2} - V_{s1}$$
- Thus by using RVDT one can determine the angular displacement and its direction.

b. Draw the experimental setup to measure pressure in terms of voltage. And also discuss which types of transducer used in it.

Ans b. **Type 1M, Diagram 3M (NOTE: Consider any relevant transducer example.)**

**Piezoelectric transducer use to convert Pressure in to voltage.**



**Fig: Pressure measurement using piezoelectric transducer**

c. Compare orifice plate and ventury tube with reference to:

- |                       |                        |
|-----------------------|------------------------|
| (i) Working principle | (iii) Maintenance cost |
| (ii) Construction     | (iv) Use               |

Ans c. **Each parameter- 1M**

Sr.No	Parameter	Orifice plate	Ventury tube
1	Working principle	It works on the principle of restriction with known size plate having very small opening.	It works in the principle of restriction with change in diameter of flow pipe.
2	Construction		<p style="font-size: small;"> <math>D =</math> Diameter at inlet section  <math>d =</math> Diameter at throat section  <math>\alpha_1 =</math> Inclined angle (<math>19^\circ</math> to <math>23^\circ</math>)  <math>\alpha_2 =</math> Inclined angle (<math>5^\circ</math> to <math>15^\circ</math>)         </p>
3	Maintenance Cost	High	Less
4	Use	Useful in chemical, feed, milling mineral, paint industries.	Used to measure volume flow of blood through vessels. Also used in waste application.

- d. Compare ultrasonic and radar level measurement with respect to working principle and constructions.

Ans d. **Working principle- 2 Marks and Constructions- 2Marks.**

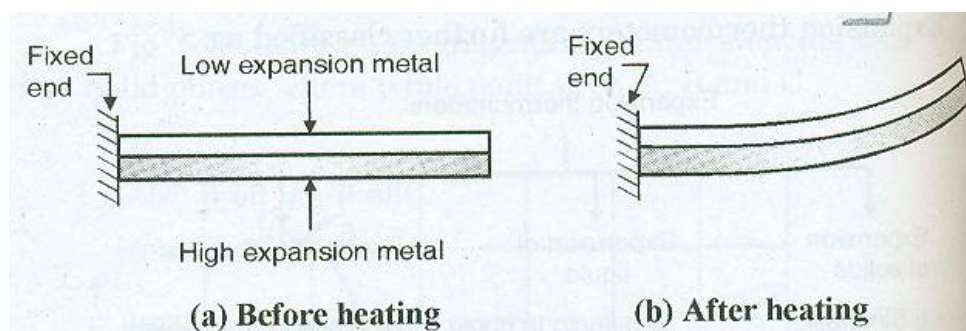
Sr. No	Parameter	Ultrasonic level measurement	Radar level measurement
1	Working principle	It operates by generating an ultrasonic wave or pulse and measuring a time it takes for the echo to return.	In this method, the changes in the amplitude and /or phase of the reflected signal is used to determine material present i.e. liquid height.
2	Construction	This guage consists of an ultrasonic transducer which has a set of transmitter and receiver.	The microwave signal is generated by the source which is directing constant amplitude/ frequency modulated microwave signal.

- e. Explain working principle of bimetallic thermometer.

Ans e. **Working principle: 2M; Diagram: 2M**

Bimetallic thermometers are two fundamental principles:

1. All metals expand or contracts with change in temperature.
2. The temperature co- efficient of expansion is not same for all metals therefore their rate of expansion or contraction is not same. The difference in thermal expansion rate produces deflections proportional to the change in temperature.

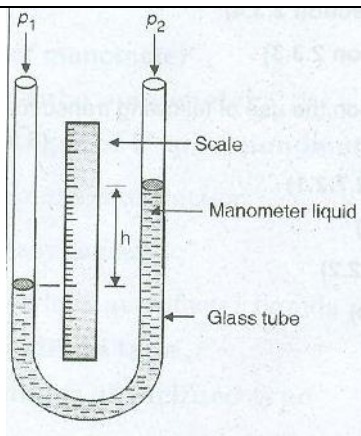
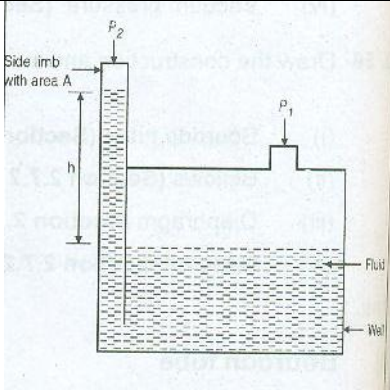


- It consists of bimetallic strip usually in the form of a cantilever beam, which is prepared from two thin strips of different metals having different coefficient of thermal expansion.
- The bonding of two strips is done by welding such that they can not move relative to each other.
- Brass is used as a high expansion metal and Invar (alloy of iron nickel) is used as low expansion metal.
- As the temperature applied to the strip increases, there is deflection of the free end of the strip. The length of metal will change according to the individual expansion rate.



- As one end of bimetallic strip is fixed, the strip will bends at free end towards the side that to low coefficient of thermal expansion metal.
  - The deflection of the free end is directly proportional to the square of the length of the metal strip, as well as to the total change in temperature, and inversely proportional to the thickness of the metal.
  - Pointer is attached to the free end to indicate the temperature.
- f. Compare between U tube and well type manometers. (any four points)

Ans f. **Four points- 4 marks**

Sr.No	U tube manometer	Well type manometer
1	 <p><b>Fig: U- Tube manometer</b></p> <p><math>P_1</math> = High pressure</p> <p><math>P_2</math> = Low pressure</p> <p><math>h</math> = Difference in level liquid.</p>	 <p><b>Fig: Well- type manometer</b></p>
2	U shape tube	Well shape with small capillary
3	It has two limb	It has only one limb
4	$P_2 = \rho h$	$P_2 - P_1 = d (1 + A_1/A_2)H$