MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)

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WINTER– 14 EXAMINATION

Subject Code: **17434**   <u>**Model Answer**</u>

<u>**Important Instructions to examiners:**</u>

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: **12 marks**

a. Draw only diagram of capsule.
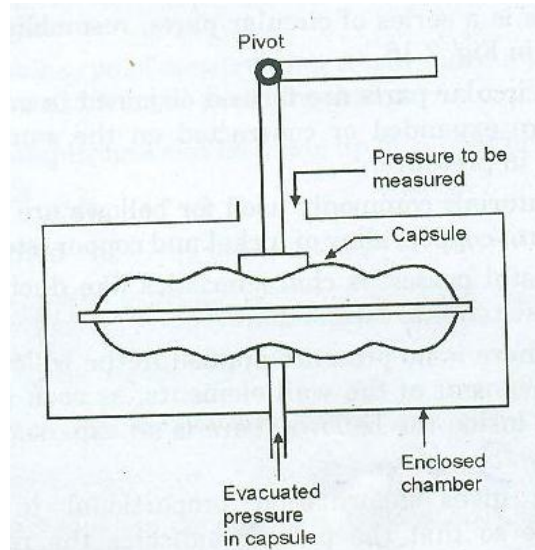
Ans a. **Diagram: 2M**

Fig: Capsule

b. State the necessity of transducer.

Ans b. **Necessity of transducer: 2M**

- In most of the industrial processes and applications electronic instrumentation systems are used to measure and record the results in which transducers are always present.
- Input quantity for most of the instrument systems is non-electrical quantity. To convert there non-electrical quantity like heat, pressure, level, flow rate, humidity, pH, temperature etc. into electrical quantity in order to use electrical methods and techniques for measurements, manipulation and control transducers are required.
- Transducers provide an output signal when stimulated by mechanical or non-mechanical input.
- There are so many advantages of getting electrical signal as output by transducers like wear and tear are absent, amplification, signal conditioning can be possible indication and recording is possible.

c.   List the different temperature scales.

Ans c. **Different temperature scales: 2M**
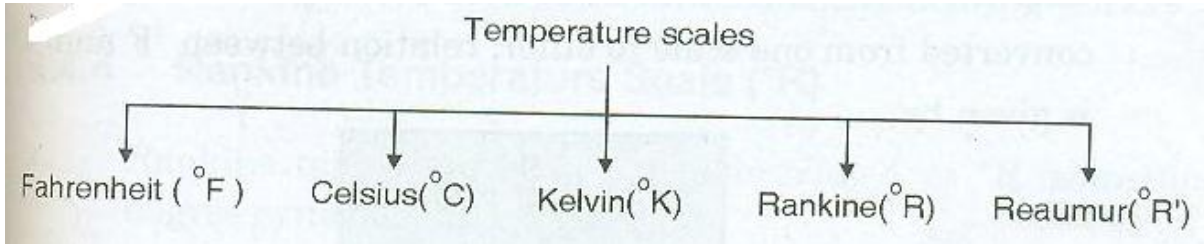
d.   Define laminar flow and turbulent flow.

Ans d. **Laminar Flow: 1M; Turbulent flow:1M**

Laminar Flow: When a fluid flowing through the pipe at different speeds fast at centre and sloe at edge and the fluid particles move in layers with one layer sliding over the adjacent layer, the flow is said to be laminar flow.

Turbulent flow: When the particles of fluid move in disorderly manner occupying different relative positions in successive cross sections, then this flow is called as turbulent flow.

e.   Define Humidity. State its units.

Ans e. **Definition:1M; Unit:1M**

Humidity is defined as it is a measure of water vapour present in the surrounding air.

Unit: $H_A = m/Vg$

*   Its unit is grams per cubic meter (g/m^3)

f.   Draw circuit diagram of two system RTD connection.
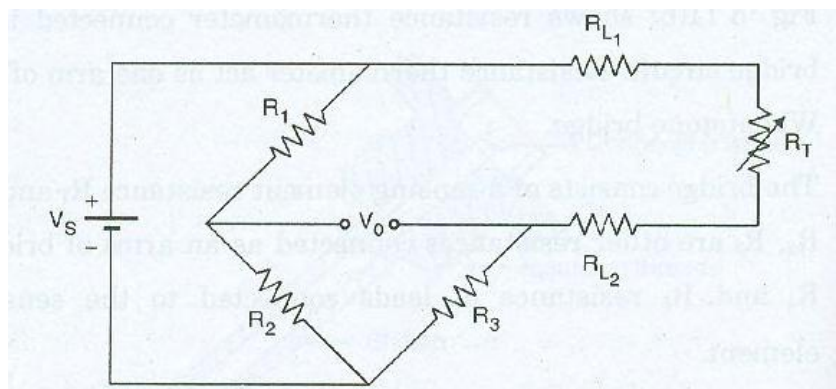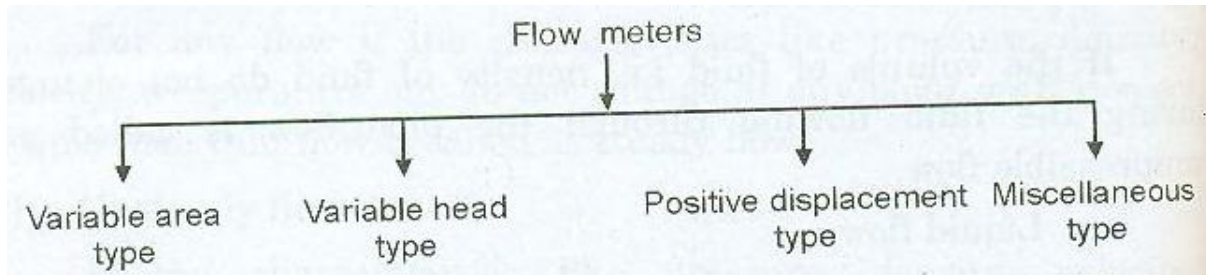
Ans f. **correct diagram: 2M**

Fig: Two system RTD connection

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g. State the classification of flow meters.

Ans g. **Classification of flow meters: 2M**

h. Classify Electrical transducers

Ans h. **Classification Electrical transducer: 2M**
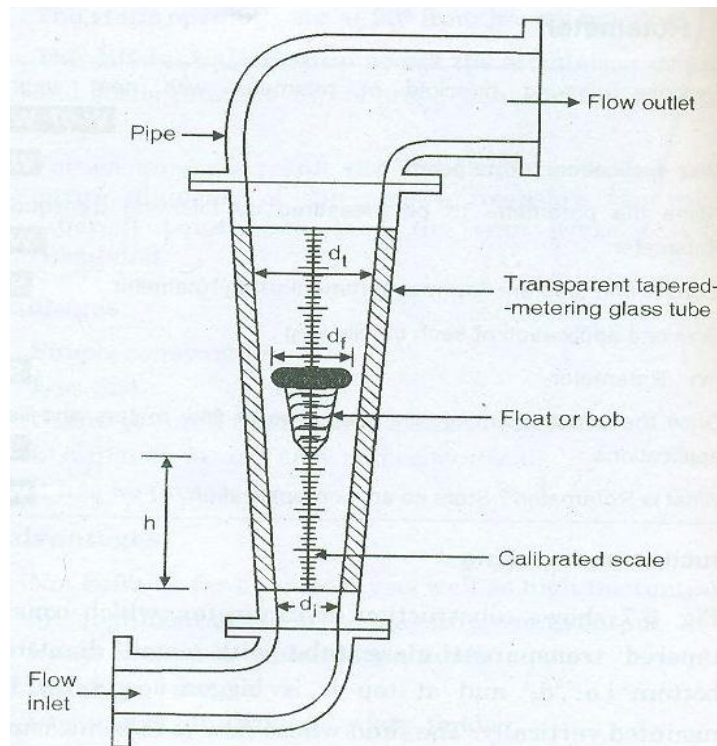
Electrical Transducers-

- Resistive
- Capacitive
- Inductive- LVDT, RVDT
- Piezoelectric

B. Attempt any Two: **8 marks**

a. With the help of neat sketch state working principle of Rota meter.

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

- When there is no flow through the Rota meter, the float rest at the bottom of metering tube.
- When fluid enters the tube, the float moves up and the flow area increases. The float moves up until the lifting force produce by flow and gravitational force acting on the float becomes equilibrium.
- Thus, the differential pressure and lifting force increase with rise in flow rate.
- A calibrated scale is printed on the tube. With the help of float position and calibrated scale, we can measure the flow rate.

b. Draw constructional diagram of LVDT. State it's working. What is residual voltage?

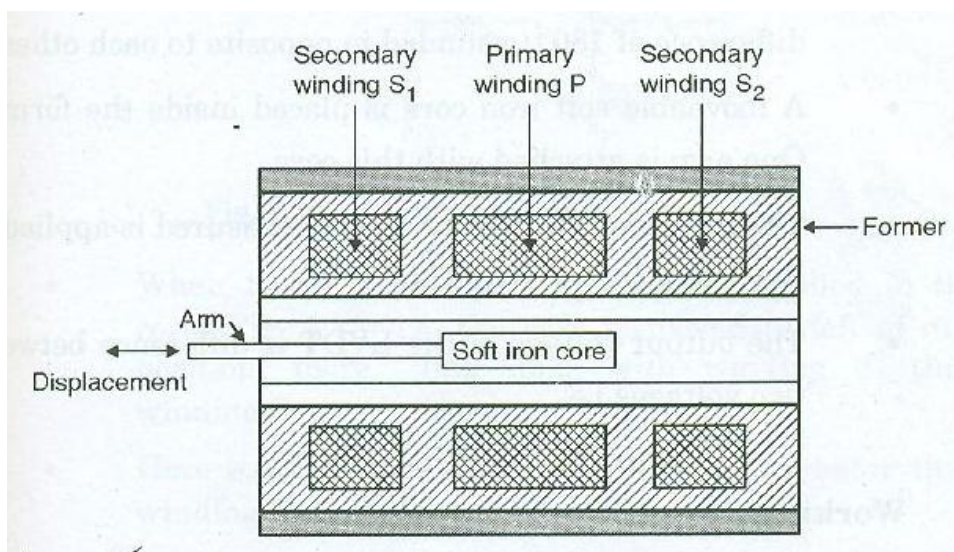Ans b. **Diagram: 2M; Working: 1M; Residual voltage: 1M**
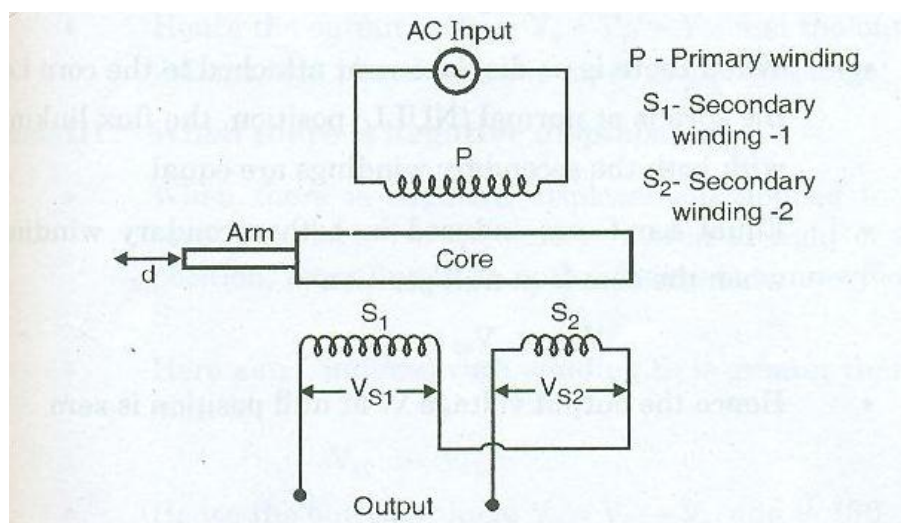

Fig: Cross section view of LVDT

Fig: Basic circuit diagram of LVDT.

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Working:

Case I: When there is no displacement.

- When there is no displacement attached to the core the core is at normal position, the flux linking with both the secondary winding are equal.
- Equal e.m.f. are induced in both secondary winding when the core is at null position:
  $V_{S1} = V_{S2}$
- Hence the output voltage V_o at null position is zero.

Case II: When there is positive displacement

- When there is positive displacement applied to the core i.e. the core is moved to left of null position, more flux links with winding S_1 than winding S_2
- Here e.m.f. induced with winding S_1 is greater than winding S_2 that is
  $V_{S1} > V_{S2}$
  Hence the output voltage $V_o = V_{S1} - V_{S2}$ and the output voltage is in phase with the input primary voltage.

Case III: When there is negative displacement

- When there is negative displacement applied to the core i.e. the core is moved to right of null position, more flux links with winding S_2 than winding S_1.
- Here e.m.f. induced with winding S_2 is greater than S_1 that is
- $V_{S2} > V_{S1}$
- Hence the output voltage $V_o = V_{S1} - V_{S2}$ and is 180^0 out of phase with the input primary voltage.

Residual Voltage

- Ideally the output voltage at null position should be zero but in actual practice small voltage drop occurs at zero displacement, it is called residual voltage.

c. State two advantages and two disadvantages of radiation type level measurement.

Ans c.

Advantages: 2M

- Quite suitable for large reservoirs of 30-40 m diameter
- Continuous measurement is possible.
- Non-contact device
- Measurement is independent on temperature, pressure, corrosion etc
- Rigid construction and withstand severe operating conditions.
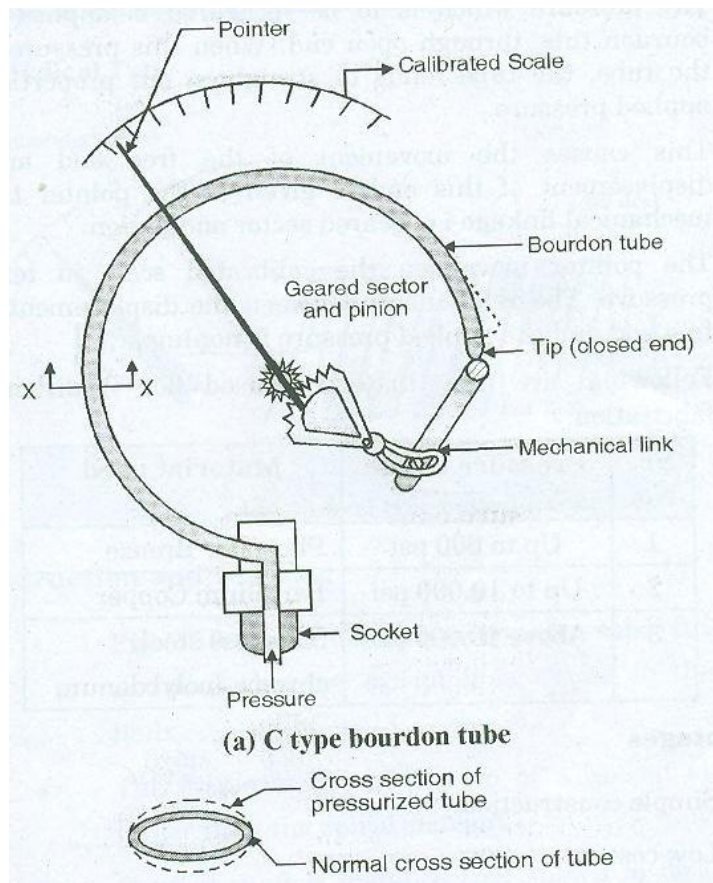
Disadvantages: 2M

- It is risky to use this method due to radiation effects.
- Adequate shielding is required to limit the radiation field intensity.

2. Attempt any FOUR: **16 marks**

a. State working principle of C type Bourden tube with neat diagram

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

(a) C type bourdon tube

- 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. Describe principle of operation of Doppler type ultrasonic flow meter with diagram.

Ans b. **Operation: 2M ; Diagram: 2M**
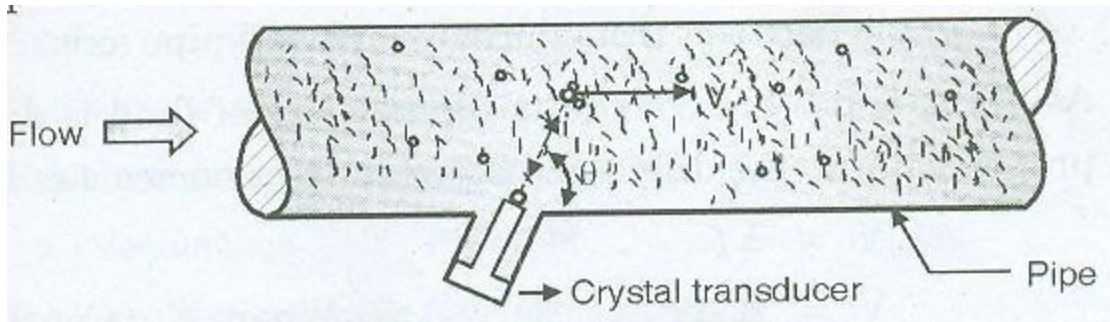
- One crystal transducer is mounted outside the pipe. This transducer emits an ultrasonic wave and the wave is projected at an angle through the pipe wall into the liquid.
- The transducer is basically piezoelectric crystal with a heavy backing to attenuate the unwanted rear movement.
- Some parts of 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.

c. Draw neat diagram of Gas filled thermometer. State its operating range and material used.

Ans c. **Diagram: 2M ; Operating range: 1M ; Material used: 1M**
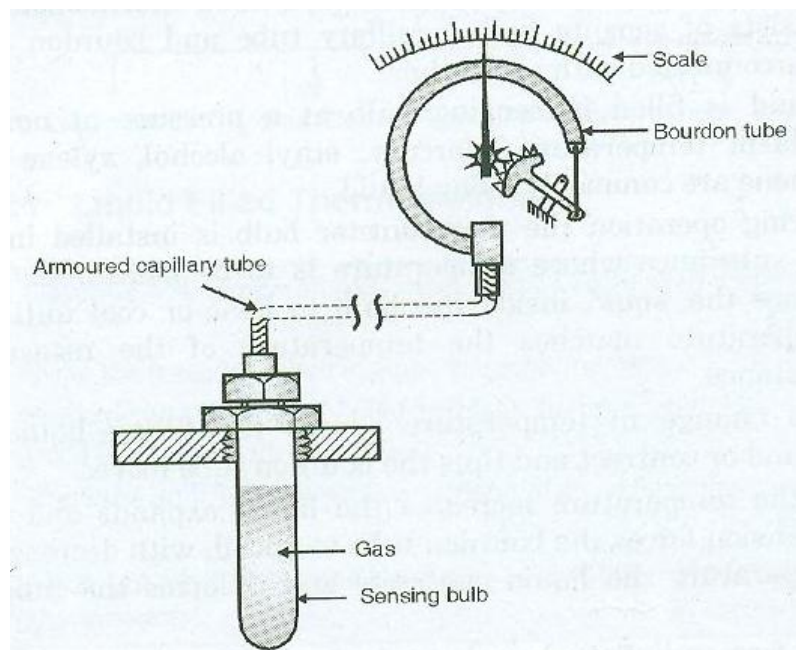
- Nitrogen gas is commonly used as it is inert, inexpensive and does not react with steel bulb material. Helium is also used for some conditions.
- Operating range: $-268^{o}C$ to $760^{o}C$

d. State need of level measurement. Also classify level measurement methods.

Ans d. **Need of level measurement: 2M; Classification: 2M**

- In almost all industries, vast quantities of liquids such as water, solvents, chemicals etc. are used in number of processes.
- Liquid level measurements are widely employed to monitor as well as measure quantitatively the liquid content in the tanks, containers, vessels, reservoirs or liquid columns.
- The liquid level affects both pressure and rate of flow in and out of the container and therefore its measurement/ control becomes important.
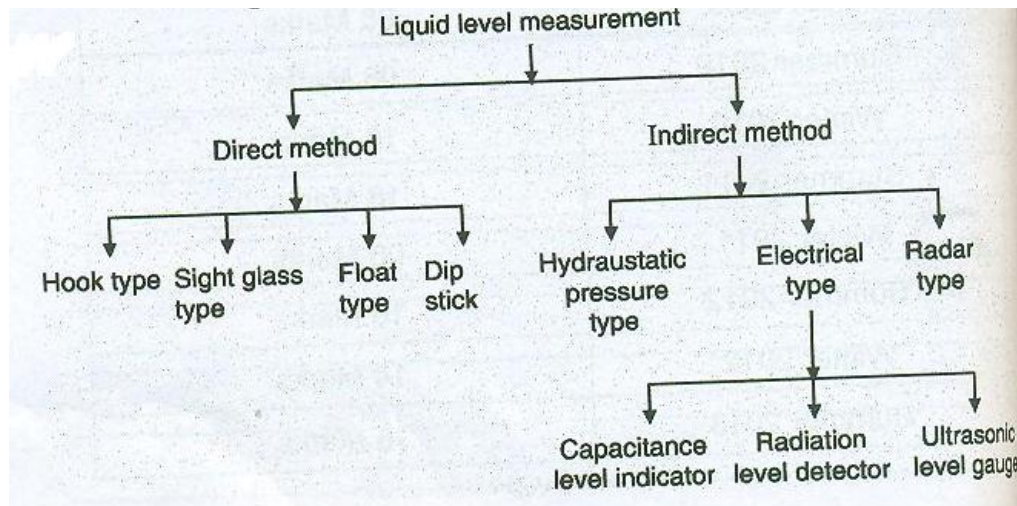
e. Define the terms:

    i. **Analog and Digital transducer**   **2M**

    ii.   **Primary and secondary transducer**   **2M**

Ans e.

Analog Transducer: Analog transducers convert an input physical quantity or phenomenon into an analog output which is a continuous function of time. The output of these transducers is analog in nature.

Digital Transducer: Digital transducer converts an input physical quantity or phenomenon into discrete steps of electrical output, which is in the form of pulses. The output of these transducers is digital signals.

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Primary transducer: Primary transducers are detectors which sense a physical phenomenon. The transducer which directly comes in contact with measurand acts as a sensor to sense or detect the physical quantity is called primary transducers.

Secondary transducer: The displacement given by the Bourdon tube is now applied to the core of the LVDT to convert this displacement into proportional electrical quantity voltage. Thus there are two stages of transduction, first the pressure is converted into displacement by Bourdon tube then the displacement is converted into analogous voltage by LVDT.

Here the LVDT is called as secondary transducers.

f.   State two advantages and two disadvantages of photoelectric pick up speed measurement method.

Ans f. **(both any two points)**

Advantages: 2M

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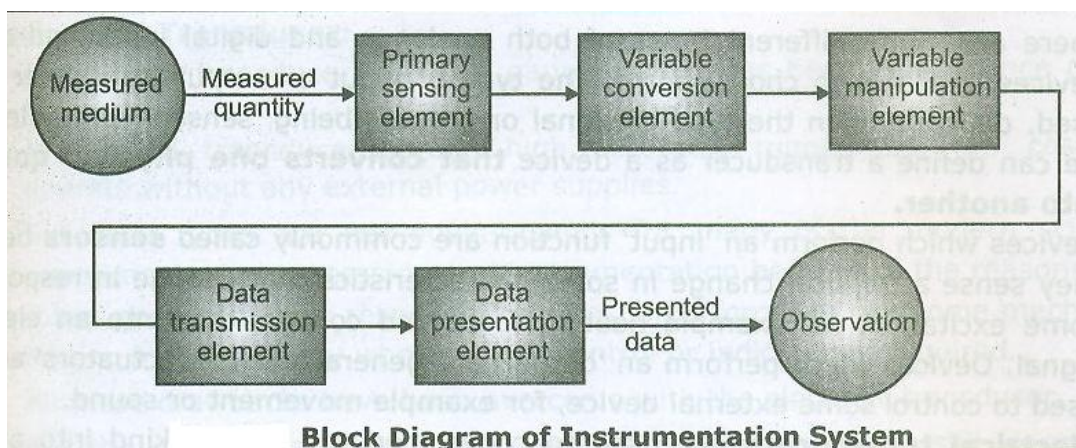- Continuous measurement is possible.

Disadvantages: 2M

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

3.   Attempt any FOUR: 16 marks

a.   Draw block diagram of instrumentation system. State function of each block.

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

Block Diagram of Instrumentation System

Functions of each block:

Primary sensing element:

This first receives energy from the measured medium and produces an output depending on measured quantity.

Variable conversion element:

Converts the output signal of the primary sensing element into a more suitable variable or condition useful to the function of the instrument.

Variable manipulation element:

Manipulates the signal represented by some physical variable, to perform the intended task of an instrument. In the manipulation process, the physical nature of the variable is preserved.

A data transmission unit:

Transmits the data from one element to the other.

A data presentation element:

Performs the translation function, such as the simple indication of a pointer moving a scale or the recording of a pen moving over chart.

b. Define:
     i. Absolute and Gauge pressure   2M
     ii. Atmospheric and vacuum pressure   2M

Ans b.

i. Absolute pressure: Absolute pressure is defined as actual total pressure including atmospheric pressure acting on a surface.

$$P_{Absolute} = P_{Atmospheric} + P_{Gauge}$$

Gauge pressure: Gauge pressure is defined as the difference between absolute pressure and atmospheric pressure.

$$Gauge\ pressure = P_{Absolute} - P_{Atmospheric}$$

ii. Atmospheric pressure: Atmospheric pressure is defined as the pressure exerted by the air surrounding to the earth. Unit of atmospheric pressure is pounds per square inch.

Vacuum pressure: Vacuum pressure is defined as the pressure below zero or negative pressure. It is also called as differential pressure.

P_{vacuum} = Pressure below zero or negative pressure

c. Draw capacitance level gauge diagram. State it's working.

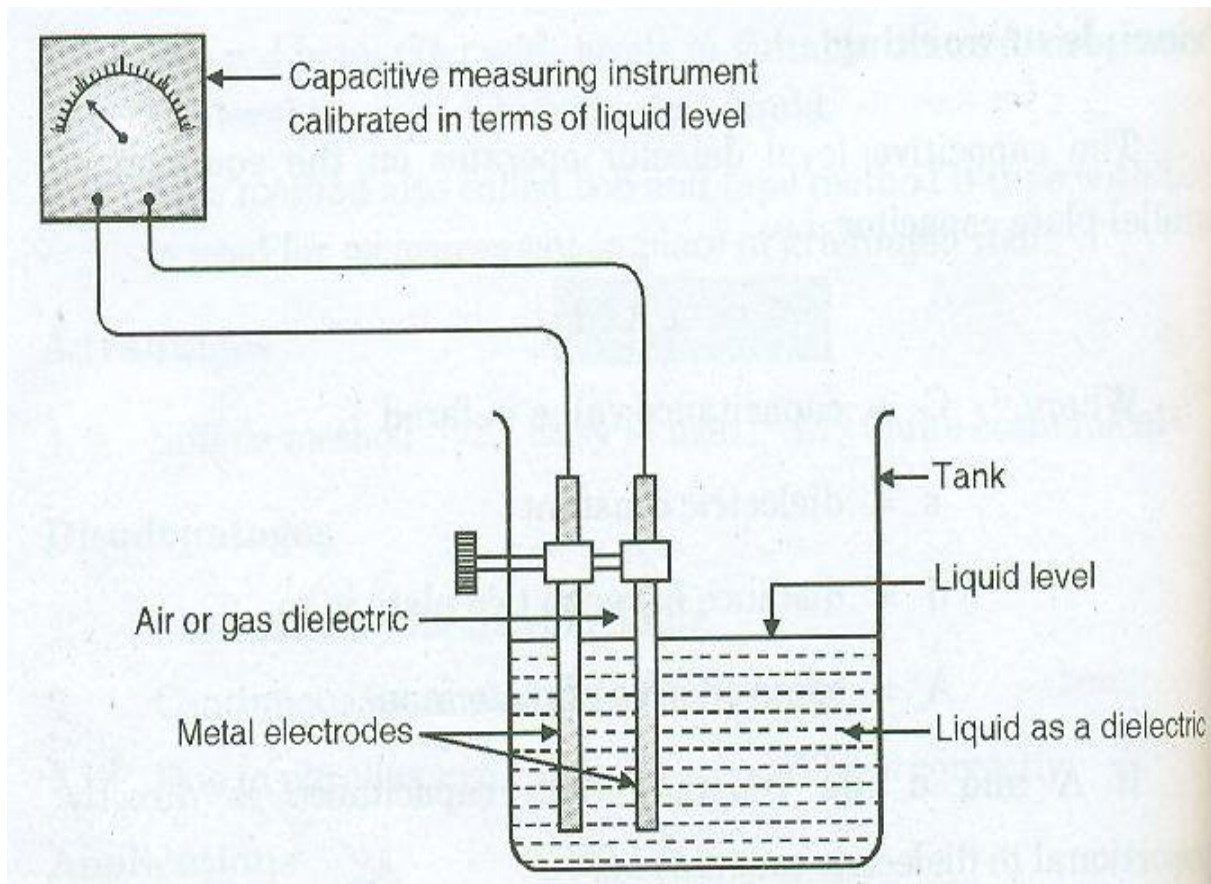Ans c. **Diagram: 2M ; Working: 2M**

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.

d. Compare RTD and thermistor with reference to material used, cost, operating range and application.

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

Sr.No	Parameters	RTD	Thermistors
1	Material	Material used in the RTD are platinum, copper, nickel, tungsten	Material used in thermistor are magnies, copper, cobalt, iron oxides etc.
2	Cost	High cost	Low cost
3	Applications	It is used for measurement of radiant energy in the industry	It is used to measure flow, pressure of liquid, level etc
4	Operating range	-270^oC to 2800^oC	-150^oC to 300^oC

e. What is Psychrometer? Draw neat diagram of sling type hygrometer.

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

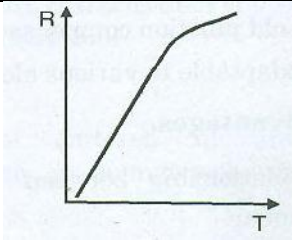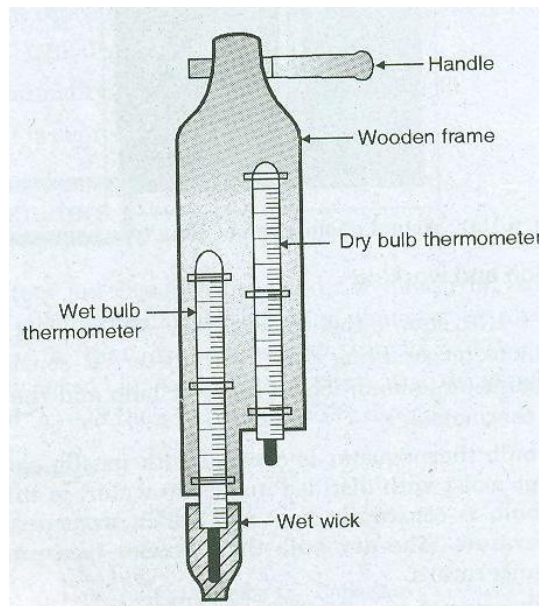Psychrometers are instruments used for measuring relative humidity.
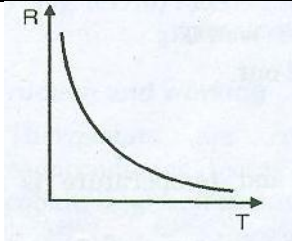

Fig: Sling type hygrometer

f.   State comparison between PTC and NTC

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

Sr.No	PTC	NTC
1	It is positive temperature coefficient	It is negative temperature coefficient
2	As temperature increases resistance also increases $R\alpha\ T$	As temperature increases resistance also decreases $R\alpha\ 1/T$
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		

4. Attempt any FOUR :   **16 marks**

a.   Describe working principle of ultrasonic level detector with diagram.

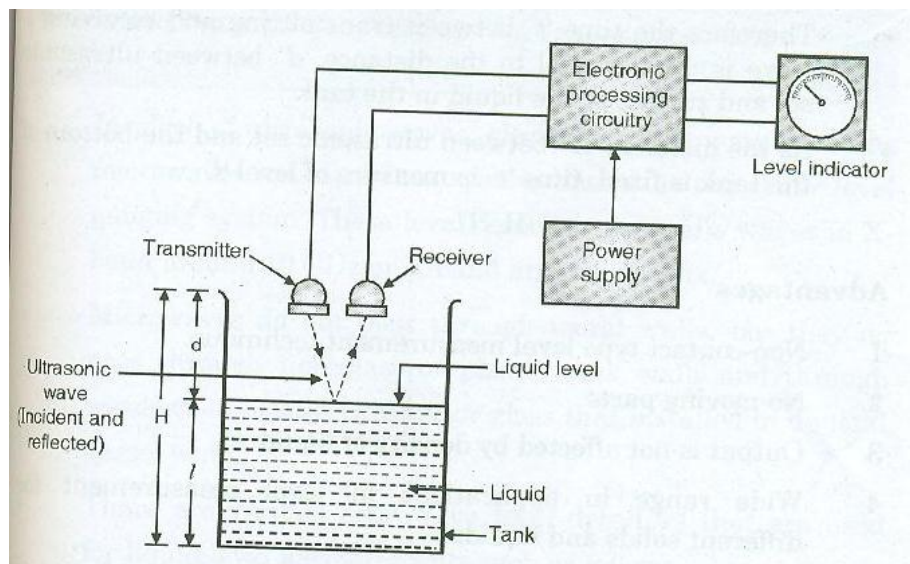Ans a. **Working principle : 2M ; Diagram: 2M**

Fig: Ultrasonic liquid level gauge

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

There are two way of measurement of liquid level:

   1. Doppler Type   2. Time difference type

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The ultrasonic waves generated by transmitter and directed towards the liquid surface in the tank which is to be measure.

These waves get reflected from the surface of the liquid and are received by the receiver. The time take by the wave is a measure of the distance travelled by the wave.

Therefore the time 't' between transmitting and receiving a wave is proportional to the distance 'd' between ultrasonic set and surface of the liquid in the tank.

As the distance 'H' between ultrasonic set and the bottom of the tank is fixed time 't' is measure of level 'l'

$$t \, \alpha \, d \, \alpha \, (H-1)$$

b. State selection criteria of transducer (8 points)

Ans b. 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

c. Convert 200^oF (Fahrenheit) into Celsius, Kelvin, Reaumur. Rankine scale

Ans c. **Each conversion: 1M**

Relation between different temperature scales are

$^oC = 5/9 \, (^oF - 32\,^oF)$

$^oK = \,^oC + 273.15$

$^oR = \,^oF + 459.69$

Given temperature is in ^oF (Fahrenhiet) $= 200\,^oF$

temperature in $^oC = 5/9 \, (200-32) = 840/9$

Temperature= 93.33 °C

Temperature in °K= °C+273.15

$\qquad$ = 93.33+ 273.15

Temperature= 366.48 °K

Temperature in °R= °F +459.69

$\qquad$ = 200+459.69

Temperature= 659.69 °R

d. State humidity measured Hair Hygrometer with neat diagram.

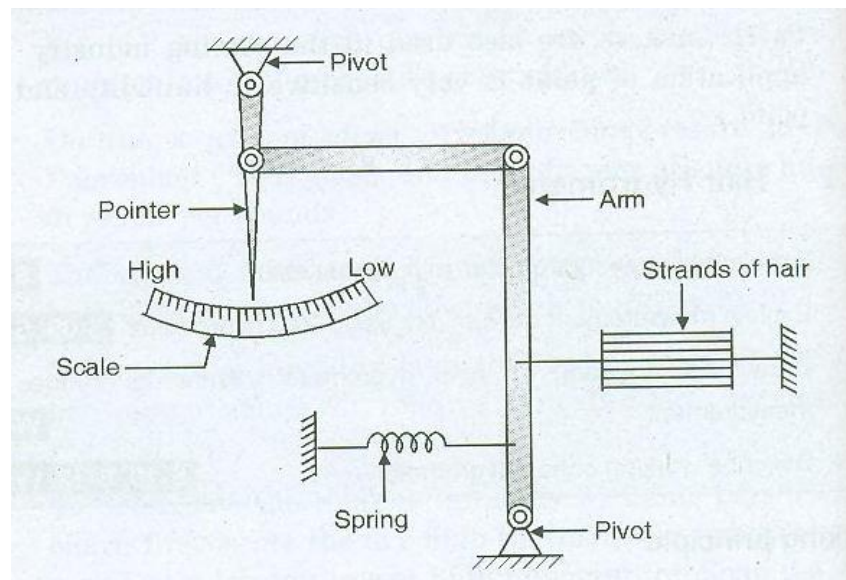Ans d. **Diagram: 2M; state humidity measured: 2M**

Fig: Hair Hygrometer

- 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.

e.   State See back effect and Peltier effect. Write material used in different thermocouples.

Ans e. **See back effect: 1M; Peltier effect: 1M**

See back effect state 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 state that for two dissimilar metals closed loop, if current forced to flow through the closed loop then one junction will be heated and other will become cool.

Material Used: (any four – 2 marks)

J type: Iron / Constantan
K type: Chromel / Alumel
R type: Platinum
S type: Platinum
T type: Copepr / Constantan

f.   Name different non- elastic pressure transducers. Draw neat sketches of any two of them.

Ans f. **Two diagram: 1 Mark each**

Different non- elastic pressure transducers are   2 Marks

* U- Tube manometer
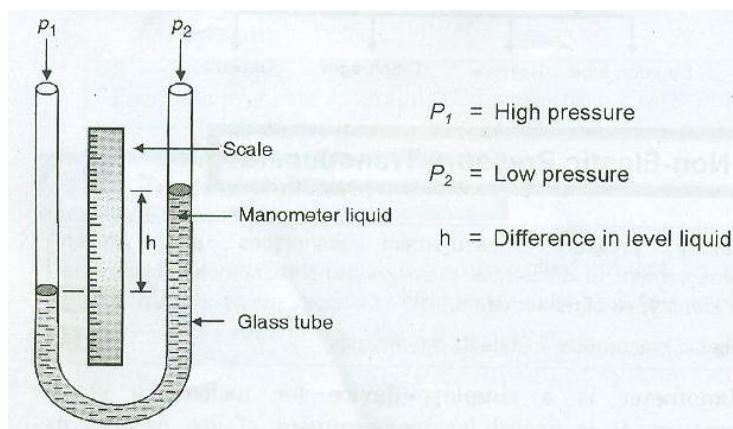* Inclined tube manometer
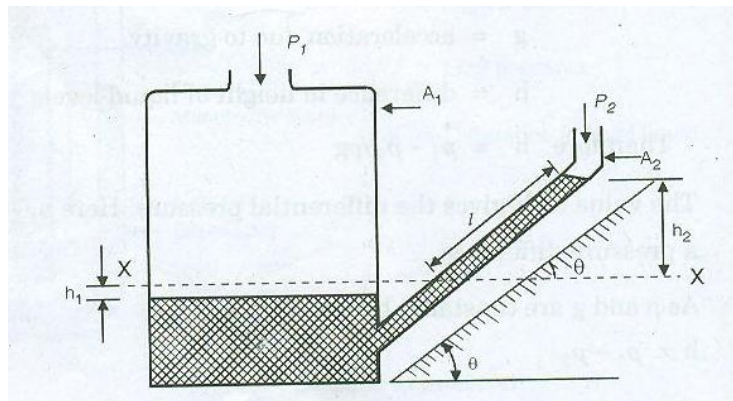* Well type manometer
* Micro- manometer

Fig: U- Tube manometer

(OR)

Fig: Inclined tube manometer
(OR)

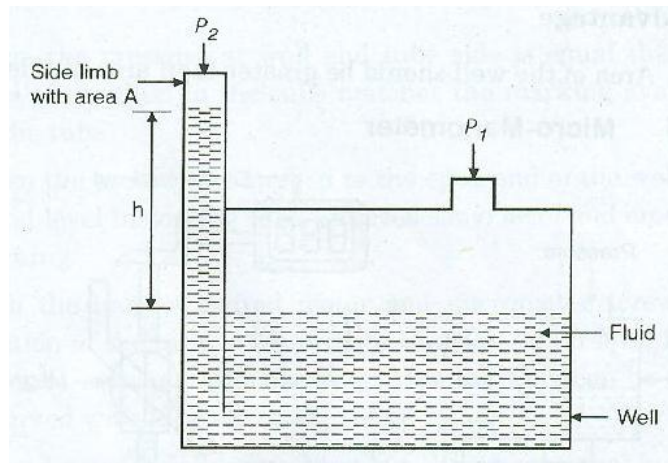**Fig: Well type manometer**
(OR)

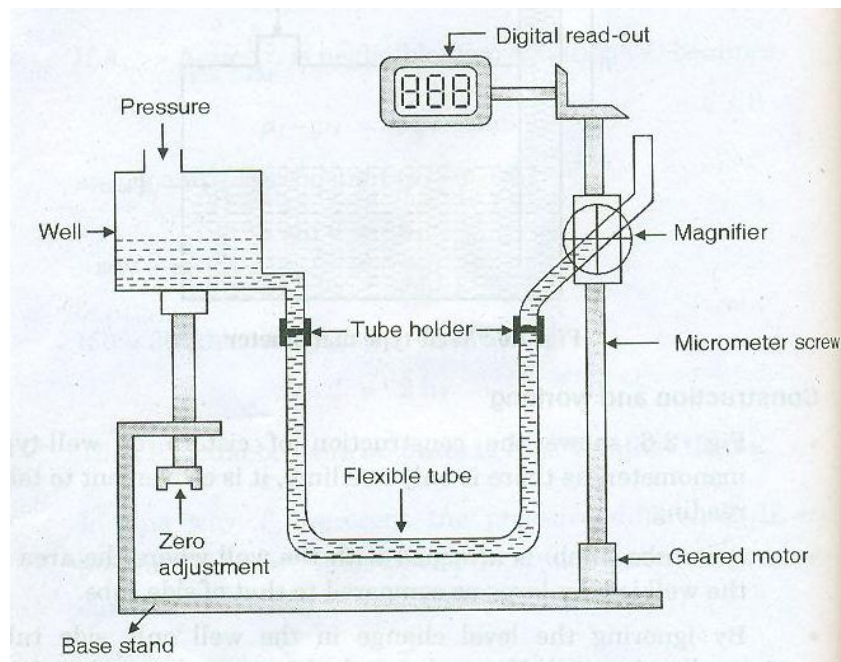**Fig: Micro- manometer**

5. Attempt any FOUR: **16 marks**

a. State two advantages and two disadvantages of Electromagnetic flow meter.

Ans a.

Advantages of Electromagnetic flow meter (any two)   2M

1. As there is no obstacle in the path of fluid, no pressure loss.
2. Linear relationship between input flow rate and output voltage.
3. Output is independent of viscosity, pressure and temperature.
4. Good transient response.
5. It can handle slurries and greasy materials.
6. It is available in large pipe size.
7. It can be used as bidirectional flow meter.

**Disadvantages of Electromagnetic flow meter are (any two)   2M**

1. Cost is high

2. Useful for only fluids possesses conductivity, hence limited use.
3. It must be explosion proof when installed in hazardous electrical area.

b. State working principle of bimetallic thermometer with neat diagram.

Ans b. **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.

(a) Before heating   (b) After heating
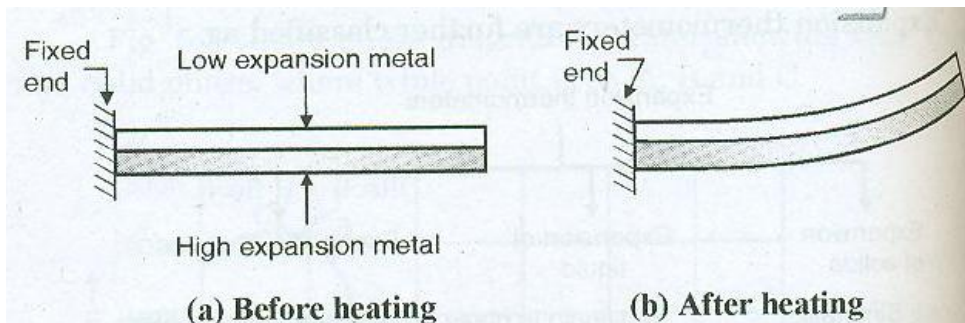
c. State principle of operation of Piezo- electric transducer. State its application.

Ans c. **Operation: 2M; Application: 2M**

- The piezoelectric element used for converting mechanical movement into electric signals.
- The mechanical deformation generates charges and this charge appears as a voltage across the electrodes.

The voltage is given by

$V = Q/C$
where, V = e.m.f. across electrode
Q = charges
C = capacitance
Operating principle
When force or pressure is applied to the piezoelectric material like quartz crystal or barium titanate, then an emf is generated across the material or vice versa.

Applications (any two)

1. Piezoelectric transducers are used in high frequency accelerometer.
2. Piezoelectric materials are used in industrial cleansing apparatus.
3. It is used in under water detection system i.e. SONAR.
4. These are used in measurement of surface roughness in accelerometers and vibration picks ups.
5. It is used in ultrasonic flow meters, non-destructive test (NDT) equipments
6. Piezoelectric materials are used in ultrasonic transducers.
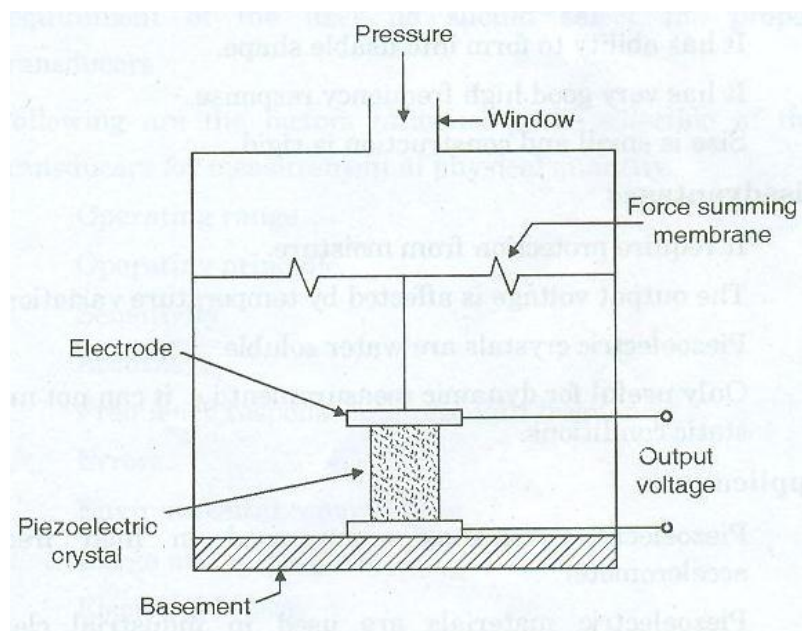
Pressure measurement using piezoelectric transducer

d. Compare ultrasonic and radar level measurement on basis of construction, waves used, application and cost

Ans d. Each point: 1M

| Sr.No.	Parameter	Ultrasonic level measurement	Radar level measurement
1	Construction	This gauge 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.
2	Waves used	Ultrasonic waves	Electromagnetic i.e. microwave
3	Application	It is used for hazardous liquids and solids	It is used for continuous level measurement
4	Cost	Expensive	Fairly expensive

e. Compare contact type and non-contact type speed measurement methods.

Ans e. Each point: 1M

Sr. No	Contact type speed measurement	Non-contact type speed measurement
1	Physical contact is present between meter and shift	No physical contact between meter and rotating shaft.
2	As output is electrical signal to indicate reading	As the output are digital pulses, no need of A/D converter.
3	Due to contact with rotating parts maintenance is high	As there is no contact structure is maintenance free.
4	e.g. A.C> Tachometer, D.C. Tachometer	e.g. Magnetic pick up meter photoelectric tachometer etc.

f. State how pressure measurement can be done using Dead weight Tester.

Ans f. Diagram – 2 marks, Explanation: 4M
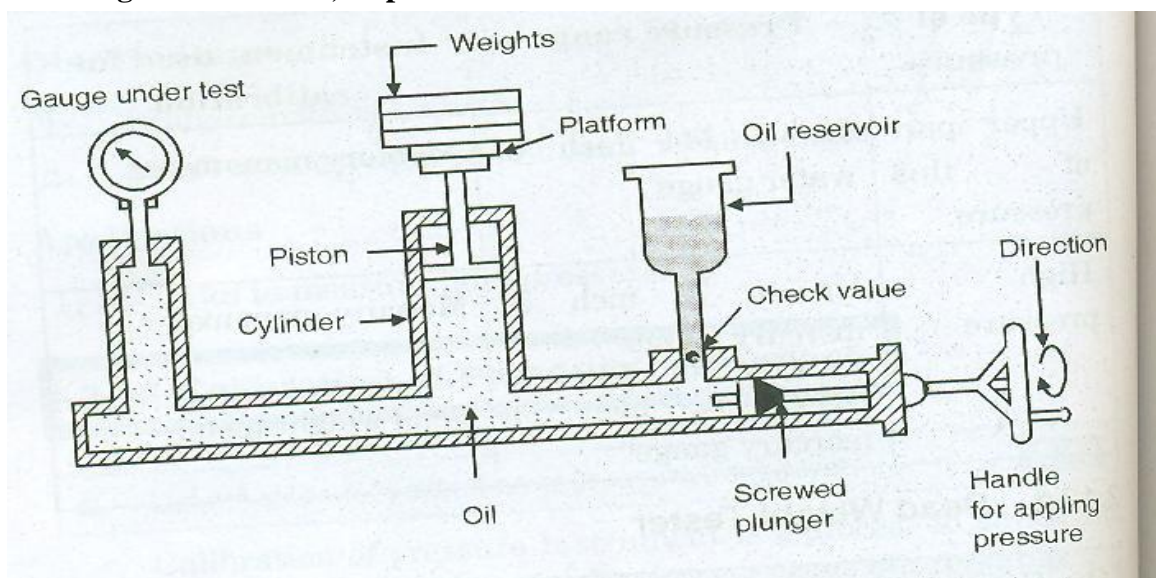
- The handle is fully drawn out and the oil is allowed to enter in the cylinder (i.e. gauge and piston)
- A known accurate weight is placed on the platform. The area of the piston is also known; hence we can calculate the pressure.
- Now the handle is turn to pressure in clockwise direction so that the 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.

6. Attempt any FOUR   **16 marks**

a. Compare Active and passive transducer(4 points)

Ans a. **4 points: 4M**

Sr. No	Active Transducers	Passive transducers
1	Do not require external power supply for its operation	Require external power supply for its operation
2	It is also called as self-generating transducer	It is also called as Externally powered transducers
3	Operate under energy conversion principle	Operate under energy controlling principle
4	e.g. Thermocouple, Piezoelectric transducer etc	Thermistors, Strain gauges etc
5	Signal conversion is easy	Signal conversion is complicated.

b. Compare Capsule and bellows with help of material used, construction, range of measurement, working principle.

Ans b. **4 points: 4M**

Sr. No	Parameters	Capsule	Bellows
1	Material used	Beryllium copper or stainless steel or nickel alloy	Brass, Bronze, steel & monel, beryllium copper, alloy of nickel & copper
2	Range of measurement	1000m bar to 0.5 m bar	Range below 155.1 Hg (3 psi) upto 40 mHg for large size bellows

| 3	Construction		
4	Working principle	Change in pressure causes change in dimension of capsule, which is transmitted to the rotary pointer through mechanical linkage. The pointer gives the reading proportional to applied pressure	When there is no pressure applied to the bellows there is no any movement of the wall elements, as soon as pressure is applied inside the bellows there is an expansion on the wall of bellows.

c. Compare orifice plate and ventury tube with reference to working principle, construction, maintenance and cost.

Ans c. **4 points: 4M**

Sr.No	Parameter	Orifice plate	Ventury tube
1	Working principle	It is variable area flow meter in which the differential pressure is developed by using orifice plate by inserting it in the path of the fluid flow.	Ventury tube operates on the principle that when restriction is placed in the path of flow, it produces differential pressure across the restriction which is proportional to the flow rate.
2	Construction		
3	Maintenance	High	Less
4	Cost	Low	High

d. Draw neat sketches of linear and rotary potentiometer liquid level gauges.

Ans d. **Each diagram: 2M**
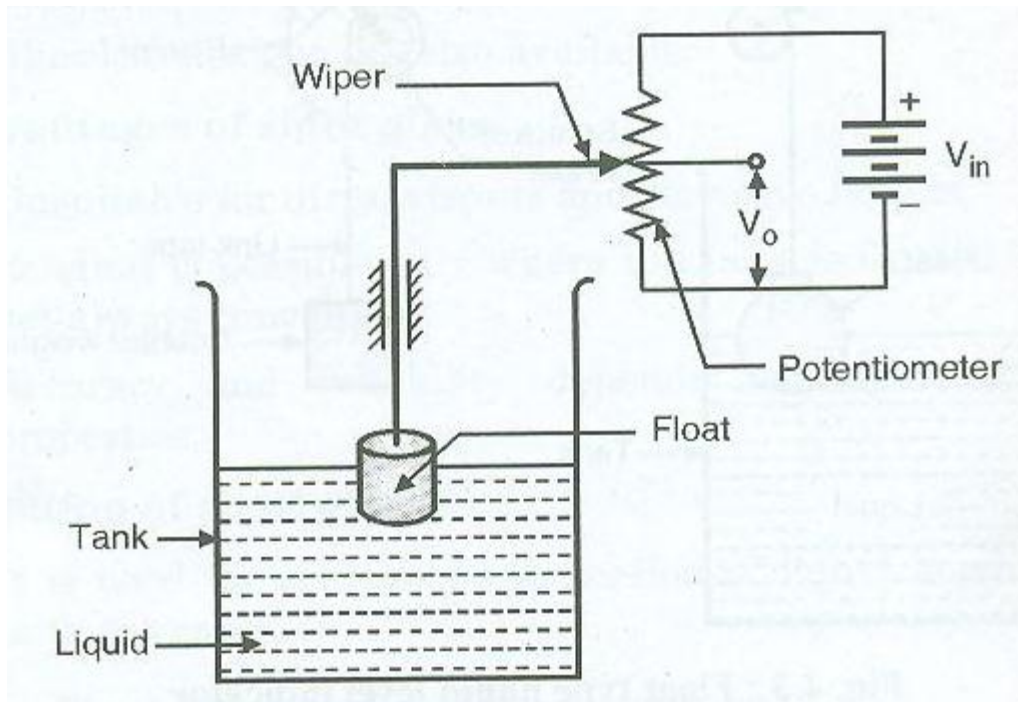
Linear potentiometer liquid level gauges
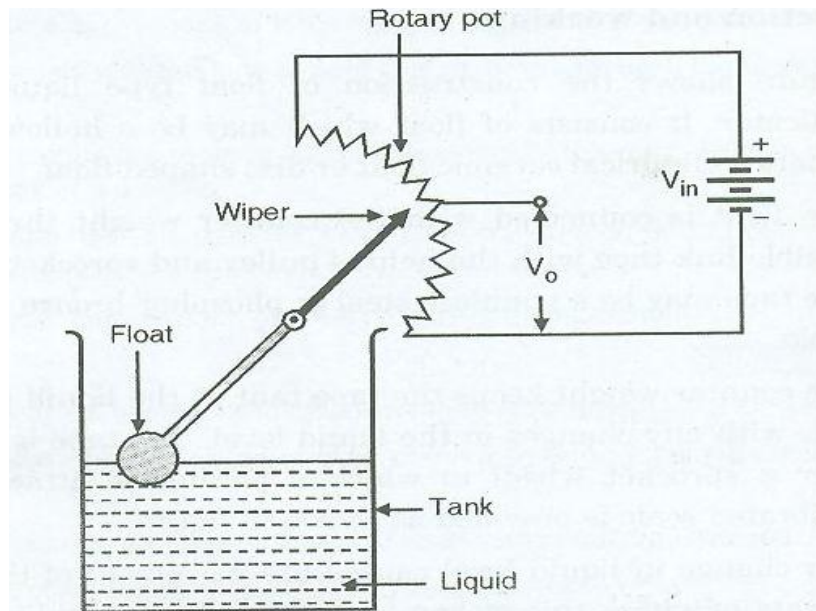
Rotary potentiometer liquid level gauges

e. Describe working of optical pyrometer with neat diagram. Also write its operating range.

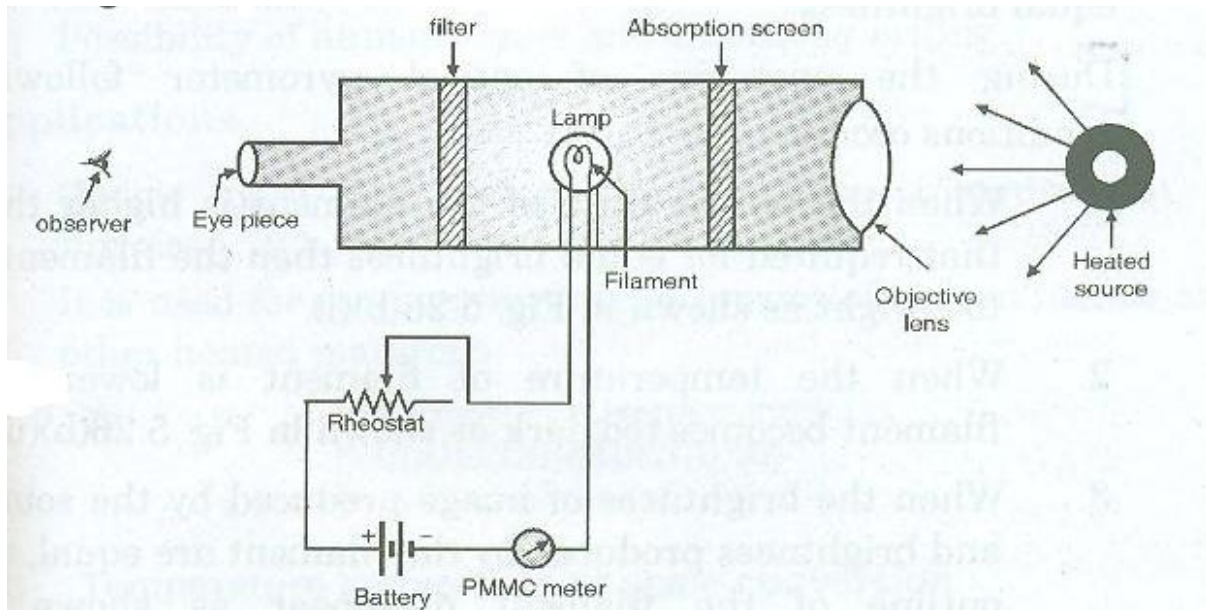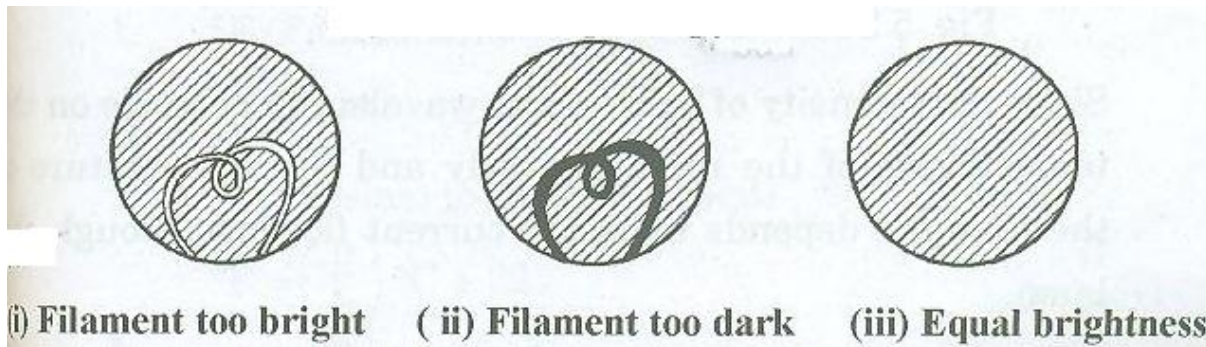**Ans e. Diagram – 2 marks, working: 1M; Operating range: 1M**

Fig: Optical pyrometer

(i) **Filament too bright**   (ii) **Filament too dark**   (iii) **Equal brightness**

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.

During the operation of optical pyrometer following conditions occurs.

1. 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.
2. When the temperature of filament is lower, the filament becomes too dark as shown in fig.
3. When the brightness of image produced by the source and brightness produced by the filament are equal, the outline of the filament disappears as shown in fig.

Operating Range: 1400^0C to 3000^0C

f. What is strain gauge? Compare bonded and Un- bounded strain gauge.

Ans f. **Strain gauge: 2M; Compare (any two): 2M**

- Strain gauge is a passive transducer which uses the variation in resistance in conducting wire to sense the strain produced by the pressure or force on the wire.
- It is nothing but the metal conductor. If a metal conductor stretched or compressed, its resistance changes as length and diameter of conductor change.

Sr.No	Bonded Type	Unbounded Type
1	The strain gauge wire is bonded with base material	These are simple wires connected between two points
2	Dynamic frequency range is greater than unbounded type.	Dynamic frequency range is less
3	Used in biomedical, structural, mechanical and industrial field	Applications is in transducers
4	Simple in use	Construction is complicated.