Subject Code: **12070**

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.

Q.1 Attempt any ten **(20 Marks)**

a. Define primary and secondary transducer and give one example of each (1 mark each)

Ans:

i) Primary Transducer: Primary transducer: The Mechanical device which converts physical quantity to be measured into a mechanical signal.

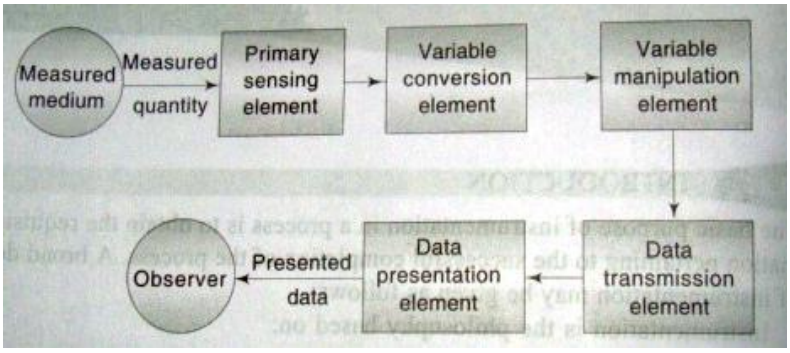
Ex: Bourdon tube **(any other correct example)**

ii) Secondary Transducer:: The Electrical device which converts this mechanical signal to the electrical signal.

Ex: LVDT **(any other correct example)**

b. Draw a Block diagram of Instrumentation System: (2 Marks)

Ans: Block diagram of Instrumentation System:



c. List the four different units of pressure. **(1/2 mark each)**

Ans: Units of pressure:

1) N/m2 2) Psi 3) Psia 4)Psig

[Note: examiner should also consider other units of pressure.]

d. List different type of orifice plate used in flow measurement. **(1/2 mark each)**

Ans: Different orifice plates used are

i) Concentric ii) Eccentric iii) Segmental iv) Quadrant edge

e. State two applications of electromagnetic flow meters. **(1 mark each)**

Ans: 1. It can handle slurries and greasy material.

2. It can be used as bidirectional flow meter

f. Define laminar flow and turbulent flow. **(1 mark each)**

Ans:

Laminar flow: - When all the molecules of flow are parallel to each other, it is called Laminar flow.

Turbulent flow: - When all the molecules of flow are scattered without fixed position it is called Turbulent flow.

g. State the working principle of head type flow meter **(2Marks)**

Ans**:** Working principle of head type flow meter:

A restriction or obstruction in a line of a flowing fluid introduced by head flow meters produces are differential pressure across the restriction element which is proportional to the flow rate. The flow rate is proportional to the square root of differential pressure.

OR

The flow rate is proportional to the square root of differential pressure can be given by the Bernoulli's theorem which states that in a flowing stream, the sum of pressure head, velocity head and elevation head at one point is equal to their sum at another point.

Examples of Head flow meter are orifice plate, venturi tube and pitot tube.

h. List the advantages of ultrasonic level measurement. (Any two 2 marks)

Ans: Advantages of ultrasonic level measurement:

i) It is used as non-contact method of level measurement.

ii) Can be used for aggressive liquid.

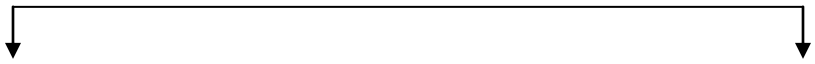
iii) Can be used for high temperature, dusty environment and uneven surface.

iv) Less maintenance.

v) They are mounted on top of tank.

i. Give the classification of level transducers. (2Marks)

Ans: Classification of level transducers:



Direct Method	**Indirect Method**
Hook type level indicators	**Hydrostatic pressure type**
Sight class	**Electrical method**
Float type	

j. Define (1 mark each)

i) Absolute Humidity

ii) Relative Humidity

Ans: (i) Absolute Humidity: water vapour present per unit volume is called as Absolute humidity.

Absolute Humidity= (mass of water vapour)/ (mass of dry air)

(ii) Relative Humidity: It is the ratio of actual water vapour pressure present to water vapour pressure required saturation at a given temperature. This is expressed in percentage.

Relative Humidity= (Actual water vapour pressure)/ (water vapour at saturation)

k. State the advantages and disadvantages of photoelectric tachometer. (1 mark each)

Ans: Advantages of photoelectric tachometer:

i) Non-contact type.

ii) Output is digital

Disadvantages of photoelectric tachometer:

i) Light source must be replaced from time to time.

ii)Pulse amplitude are constant.

l. Convert 200^0F (200 Fahrenheit) in Celsius, kelvin, Reaumur and Rankine scale (1/2 mark each)

Ans: Numerical: given 200 F

1. Celsius temperature scale: (˚C)

$$^{\circ}C = (5/9)^* (^{\circ}F - 32)$$

C=93.324

2. Kelvin temperature scale: (˚K)

$$^{\circ}K = ^{\circ}C + 273.15$$

K=366.474

3. Rankine temperature scale: (˚R)

Relation between ˚R & ˚F is given by,

$$^{\circ}R = ^{\circ}F + 459.69$$

Relation between ˚R & ˚K is given by,

$$^{\circ}R = (9/5)\,^{\circ}K$$

R=659.69

4. Reaumer

Réaumur	Re = (F - 32) / 2.25

Reaumer=74.66

m. List different types of pyrometers. **(1 mark each)**

Ans: Different types of pyrometers are:

i) Radiation pyrometer

ii) Optical pyrometer

n. What is Pt- 100 **(2Marks)**

Ans: Pt-100

A platinum resistance temperature detector (RTD) Pt100 is a device with a typical resistance of 100 Ω at 0°C (it is called **Pt100**). It changes resistance value as its temperature changes following a positive slope (resistance increases when temperature is increasing).

Q2. Attempt any four **(16 Marks)**

a. Describe the working of strip-chart type recorder with neat diagram.(Diagram 2 marks, explanation 2 marks)

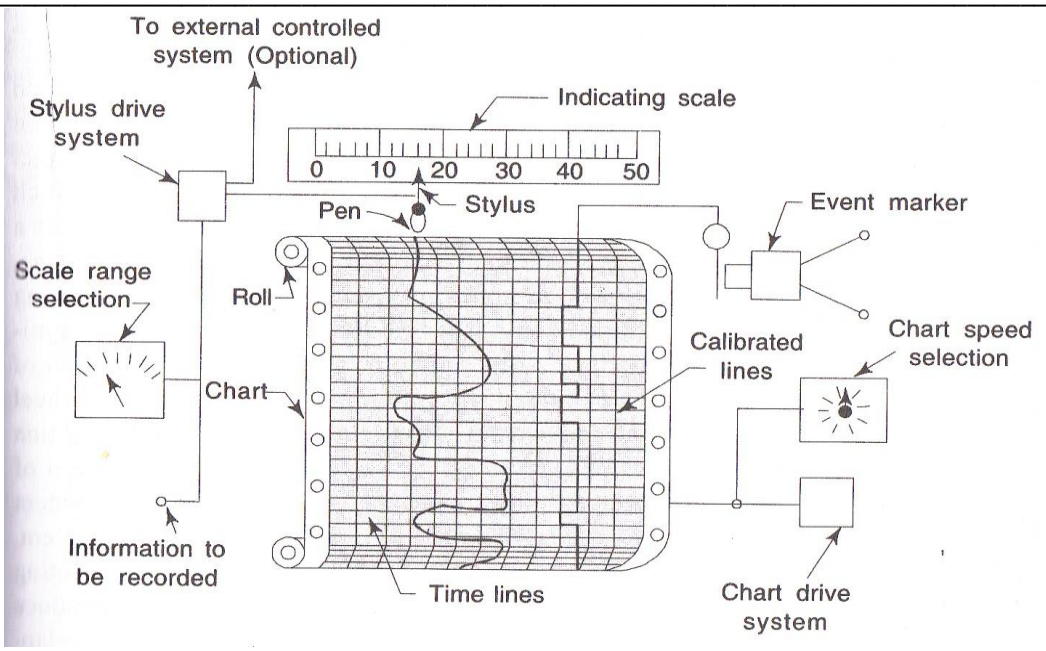
Ans: Strip Chart Recorder

It is a type of graphic recorder. They are used to record a function varying with respect to time.

Construction and working:

1. It consist of a long roll of graph paper known as chart, moving vertically and usually graduated in rectilinear coordinates.
2. The chart is usually driven by a synchronous motor equipped with a speed selector switch. To change the chart speed conveniently in fix increment.
3. A stylers is used for making marks on the moving chart which moves horizontally proportional to the quantity being recorded.
4. A range selector is used so that the input to the recorder drives system to the acceptable level.

Diagram:

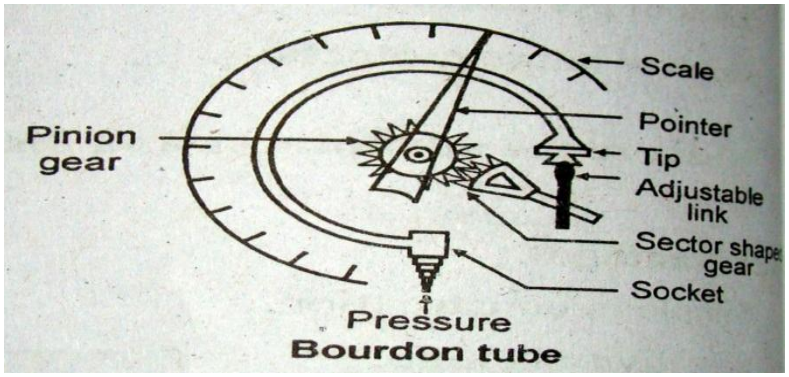


b. Draw the constructional details of 'C' type Bourdon tube and explain its working.

(Diagram 2 marks, explanation 2 marks)

Ans: Construction of C type bourdon tube Bourdon tube:

Pressure measurement displacement, primary transducer, pressure gauge



Construction and working:

- It consist of C type tube made up of phosphor bronze, steel and beryllium copper of non-circular cross section sealed at one end and attached by a light line work to the mechanism which operates the pointer
- Other end of the tube is fixed and soldered or wielded to a socket at the base through which pressure connection is made.

- As fluid under pressure enters the tube, it tries to change the section of the tube from owl to circular.
- The tip of the bourdon tube is connected to the pointer through the lever arrangement and the pointer is mounted on the spindle.
- As the section of tube changes there will be movement in lever, spindle and hence the pointer moves over the scale giving the pressure reading.

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

i) Working principle

ii) Constriction

iii) Maintenance cost

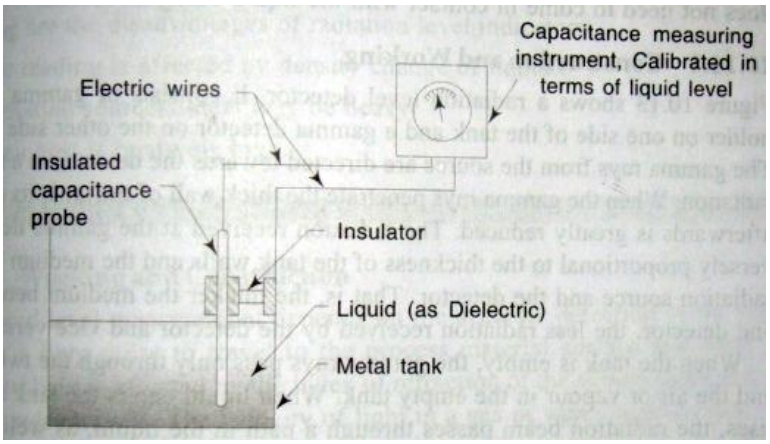
iv) Use

Ans: Compare verituri and orifice **(1 mark for each point)**

Sr. No.	**Verituri** Flow Meter	Orifice Plate Meter
Working principle	The restriction in the pipe of a flowing float introduced by Orifice plate or **verituri** tube, produces a differential pressure across a restriction element which is proportion to flow rate	The restriction in the pipe of a flowing float introduced by Orifice plate or **verituri** tube, produces a differential pressure across a restriction element which is proportion to flow rate
Construction	It consist of straight inlet section a converging conical inlet section, a cylindrical throat and the diverging recovery cone. They are made up of cast iron and steel	They are made up of stainless steel, nickel, monel, phosphor bronze. They are of concentric, eccentric, segmental and quadrant edge type
Maintenance cost	Expensive, carefully fabricated, purchase from proper manufacture	Cheap & easy to install. Homemade orifice plate possible
Use	Used for high flow rate. More accurate than Orifice Plate	Used with differential pressure devices. Can be used in wide range of pipe sizes

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

Ans: Capacitive level measurement (Diagram 2 marks, explanation 2 marks)



Capacitance level detector

The principle of operation of capacitance level indicator is based upon the familiar capacitance equation of parallel plate capacitor given by

$$C = K *(A/D)$$

Where,

C= capacitance, in farad

K= dielectric constant

A=area of plate, in meters square

D= distance between two plates, in meter.

Therefore, it is seen from the above equation that if A & D are constant, then the capacitance of a capacitor is directly proportional to the dielectric constant, and this principle utilized in the capacitance level indicator.

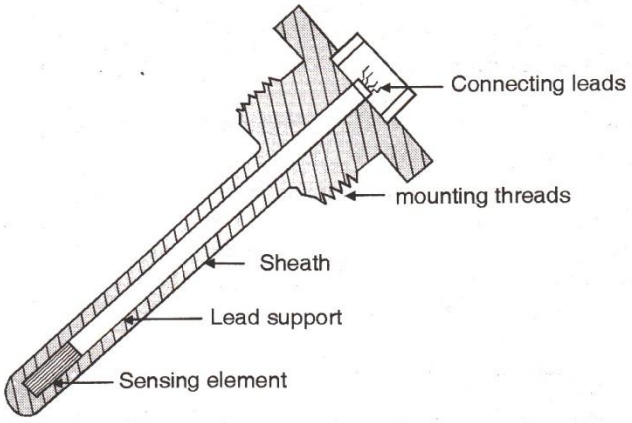
Construction & working:

Fig. shows a capacitance type liquid level indicator. It consist of an insulated capacitance probe (which is a metal electrode) firmly fixed near and parallel to the metal wall of the tank. If the liquid in the tank is non-inductive, the capacitance probe and the tank wall form the plates of a parallel plate capacitor and liquid in between them acts as the dielectric. If the liquid is conductive the capacitance probe and liquid form the plates of the capacitor and the insulation of the probe acts as the dielectric. A capacitance measuring device is connected with the probe and the tank wall, which is calibrated in terms of the level of the liquid in the tank.

When the level of liquid in the tank rises, the capacitance increases. When liquid level of the tank decreases, the capacitance also decreases. This increase and decrease in the capacitance is measured and is displayed on the indicator calibrated in terms of liquid level.

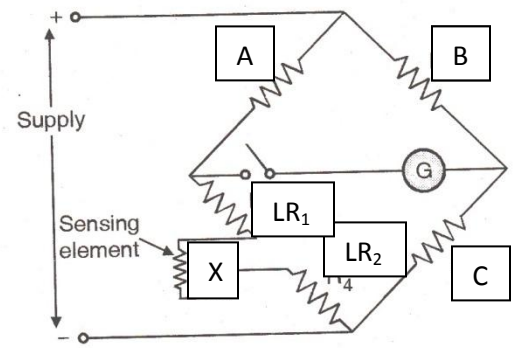
e. Give construction, working principle of RTD with a neat diagram. (Diagram 2 marks, explanation 2 marks)

Ans:



Construction:

1. It is made up of platinum, copper, tungsten or nickel wire in spring form
2. These wires are enclosed in a metal sheath
3. The wires are surrounded by porcelain insulator which prevents short circuit between wire and the metal sheath.
4. Two leads are attached to each side of platinum wire.
5. The lead of these instruments is placed in a media its temperature is to be measured.



Working principle of RTD

An RTD (resistance temperature detector) is a temperature sensor that operates on the measurement principle that a material's electrical resistance changes with temperature. The relationship between an RTD's resistance and the surrounding temperature is highly predictable, allowing for accurate and consistent temperature measurement.

Working of RTD

The change in resistance of RTD with change in temp can be measured by using wheat stone bridge. The RTD is fabricated in suitable form to insert in the medium whose temp is to be measured and is connected by leads to one and the arm & wheat stone bridge .The X is the sensing element [RTD] and LR1 & LR2 are the lead wire resistance through which they are connected to the bridge. A,B and C are resistance whose ohmic value is known.

At balance condition no current flows through galvanometer and hence it will show nil position balance condition of bridge is A/B=[(X+LR1+LR2)/C]

When X changes, the wheat stone gets unbalanced and galvanometer will show the deflection which is further calibrated to give temp reading.

f. Describe how humidity is measured by using humistor. (Diagram 2 marks, explanation 2 marks)

Ans: Humistor

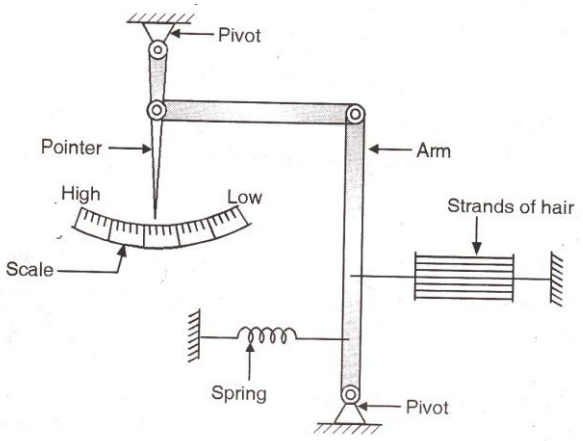


Fig. 6.3 : Hair hygrometer

Operation : -

Hair Hygrometer is a device used for humidity measurement. Materials such as human hair ,animal membrane ,wood and paper undergo changes in linear dimension when they absorb moisture from the atmosphere. Human hair become longer as the humidity if the surrounding increases and becomes short if air is dry.

This tendency of human hair is used in hair hygrometer.

Operation: It consists of strand of hair generally arranged parallel to each other and with sufficient space between them for giving free area to the air sample under test. This stand of hair is connected to the pointer or recording pen through' the mechanical linkage . The indicator scale is further calibrated to give direct indication of humidity.

Q3) Attempt any four of the following (16 Marks)

a) State the selection criteria for transducer.

Ans: The selection criteria based on Fundamental, environmental, Physical condition, compatibility with next stage **[each consist of 1 mark]**

Fundamental parameters: These include:

a) Type of measurand
b) Range of measurement.
c) Required precision, which includes:
   i) Allowable nonlinearity effects.
   ii) Allowable dead-zone effects
   iii) Frequency response
   iv) Resolution.

Environment: This includes consideration of:

a) Ambient temperature
b) Corrosive or non-corrosive atmosphere.
c) What shock and vibration to withstand

Physical conditions: These are:

a) Room or available space to mount the transducer
b) Whether the measurement is static or dynamic

c) How much energy can be extracted from measurand to do the measurement without much loading.

Compatibility with the next stage:

Normally, some standard signal conditioner and display devices are used with a transducer, unless they are custom-built to suit the requirements of the transducer. In the former case, the transducer should be so chosen as to meet the requirements of the next stage such as:

a) Impedance matching
b) Excitation voltage matching
c) Sensitivity tolerance matching

These criteria, of course are not exhaustive but they offer some guidance as regards selection of a transducer.

Transducers can be constructed from various materials and in many designs. But to gain acceptance in the field of instrumentation they must conform to the following six cardinal requirements:

1. Ruggedness to withstand overloads
2. Linearity
3. Repeatability
4. Stability and reliability
5. Good dynamic response
6. Convenient instrumentation.

b) Explain different pressure measure measurement using U-tube manometer.

(Diagram 2 marks, explanation 2 marks)

Ans:

Explanation:

The U-tube manometer is the basic and most widely used style of manometer. The Meriam U-tube manometer is a versatile, economical instrument for the measurement of pressures, vacuums or differential pressures. Pressure measurements are accomplished by balancing a vertical head of indicating fluid with the pressure to be measured. It consists of glass tube in U shape and filled with a liquid (water, mercury)

The scale is marked on it inches or cm .The fluid is inserted to tube until the level of fluid in both columns reaches to zero marking. When both column are open to the atmospheric pressure then level of fluid will remains at zero

When pressure line is connected to one arm of manometer then fluid in column will force to down and other column will rises up. By measuring the difference in height of fluid in two column, the pressure of inlet can be calculated.

The manometer principle is most easily demonstrated in the U-type manometer illustrated in Figure 1. Here, with both legs of the instrument open to atmosphere or subjected to the same pressure, gravity forces the surfaces of the liquid to be at exactly the same level or reference zero. Figure 2 shows the pressure is applied to one leg of manometer

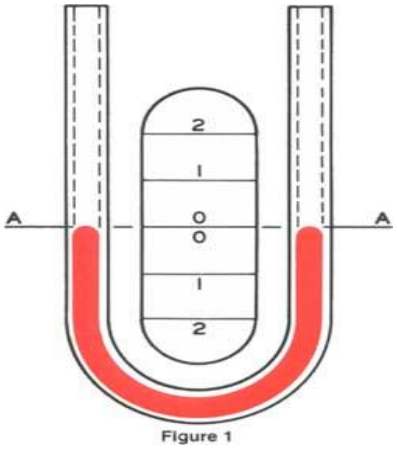


Figure 1

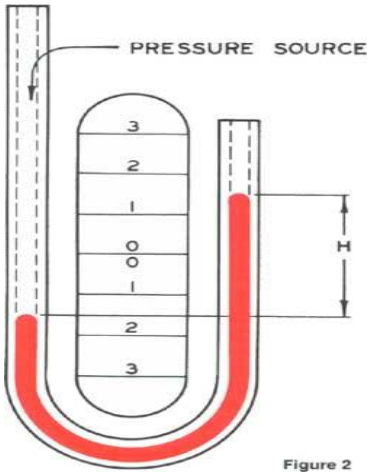


Figure 2

OR

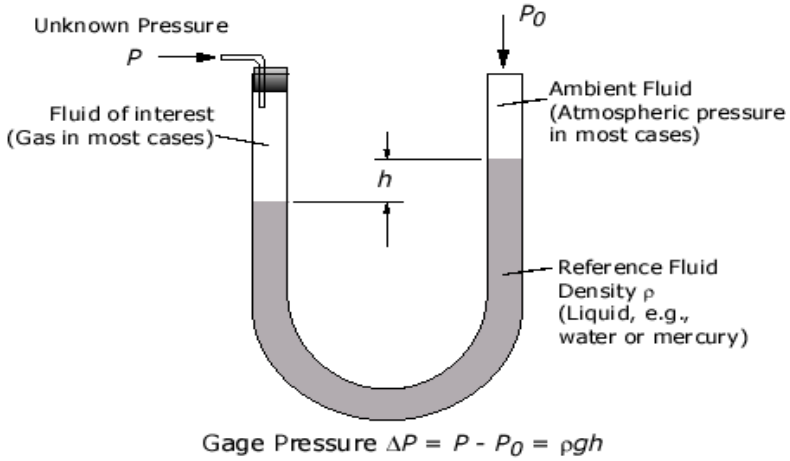


Figure 3. Measurement setup diagram

P1- p2 = (density of fluid in U tube - density of fluid whose pressure to be measured) g XH

Where H is difference in fluid level g is acceleration due to gravity

The pressure difference between the bottom and top of an incompressible fluid column is given by the incompressible fluid statics equation

$\Delta p = \rho g h$

Where g is the acceleration of gravity (9.81 m/s^2)

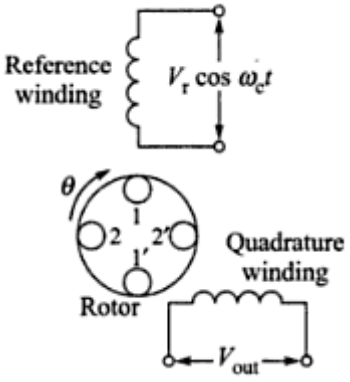
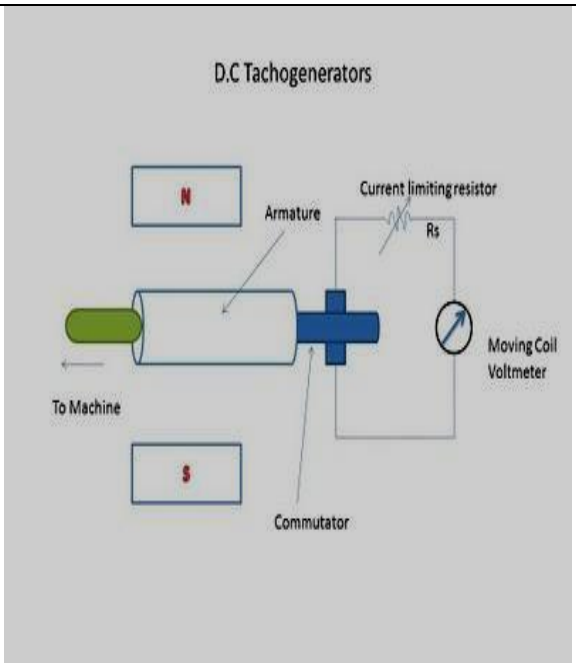
c) Write the application of following transducer: [1 mark for each application]

Ans:

1. **Venturi tubs** are used in industrial and in scientific laboratories for measuring the flow of liquids. Venturi tube flow meters are frequently used in applications involving higher Turn Down Rates or lower pressure drops, particularly in areas where orifice plates fails to perform
2. **Orifice** plates are most commonly used for continuous measurement of fluid flow in pipes and used in refrigeration system, chemical, food, mills, mineral and paint industries
3. **An ultrasonic flow meter** measures the velocity of a liquid or gas (fluid) by using the principle of ultrasound.
4. **Positive displacement (PD) flow meters** measure the volumetric flow rate of a moving fluid or gas by dividing the media into fixed, metered volumes (finite increments or volumes of the fluid).

d) Compare A.C. and D.C. type tacho generator (Any four point) [1 mark for Each points]

Points	**AC tachometer**	**DC tachometer**
Outputs	**AC Tacho generators** give AC Voltage output proportional to speed of its mover	**DC Tachogenerators** give accurate DC Voltage output proportional to speed of its mover
Application	They are generally used in applications for indication and	They are widely used in applications for

	display purposes	feedback and display purposes.
Construction diagram		
Disadvantage	No problem of brush friction. So no maintenance problem	Brushes on small Tachometer Generators often produce Maintenance problems,
Current	Up to 50 mA	Up to 200 mA
speed	Up to 4000 rpm	Up to 10000 rpm
voltage	4V to 40 V / 1000 rpm	4V to 200 V / 1000 rpm

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

(Diagram 1 mark, explanation 3 marks)

Ans: Explanation:

- Many physical properties change with temperature, such as the volume of a liquid, the length of a metal rod, the electrical resistance of a wire, the pressure of a gas kept at constant volume, and the volume of a gas kept at constant pressure.
- Filled-system thermometers use the phenomenon of thermal expansion of matter to measure temperature change.

- The filled thermal device consists of a primary element that takes the form of a reservoir or bulb, a flexible capillary tube, and a hollow Bourdon tube that actuates a signal-transmitting device and/or a local indicating temperature dial. A typical filled-system thermometer is shown in Figure.
- In this system, the filling fluid, either liquid or gas, expands as temperature increases. This causes the Bourdon tube to uncoil and indicate the temperature on a calibrated dial.
- The filling or transmitting medium is a vapor, a gas, Liquid like, Mercury, ethyl, alcohol, tolune, xylene or another liquid. The liquid-filled system is the most common because it requires abulb with the smallest volume or permits a smaller instrument to be used.
- The gas-filled system uses the perfect gas law, which states the following for an ideal gas:

  T = kPV ----------1

  Where T =temperature, K= constant, P= pressure, V= volume

- If the volume of gas in the measuring instrument is kept constant, then the ratio of the gas pressure and temperature is constant, so that

  $$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$ ----------2

- The only restrictions on Equation 1, 2 are that the temperature must be expressed in degrees Kelvin and the pressure must be in absolute units.
- As the temperature changes ,volume of liquid changes by following equation

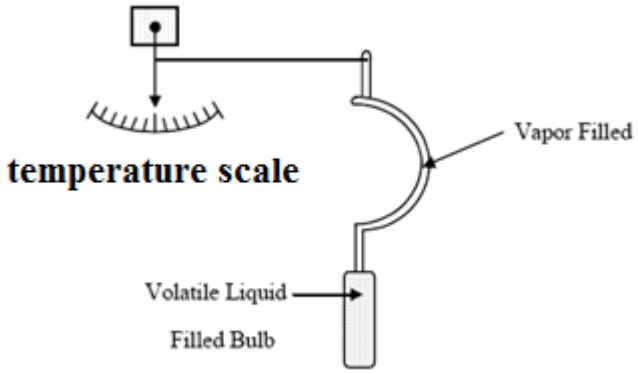
  V1=V0(1+BT)--------3

  Where V1 is original volume

  V0 is New volume

  B is coefficient of volumetric expansion

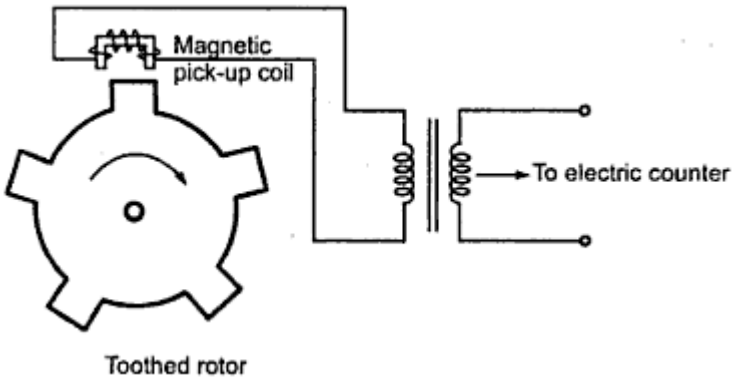
  T is rise in temperature



f) With the help of neat sketch explain working of magnetic pick-up type tachometer

(Diagram -2mark, explanation 2 mark)

Ans:



Working :

The Metallic toothed rotor is mounted on shaft and magnetic pick is placed near the rotor. The magnetic pick-up coil is nothing but a small permanent magnet with a coil wound on it. When the toothed rotor rotates, the reluctance of the air gap between pick-up and the toothed rotor varies.

This gives rise to included e.m.f. in the magnetic pick-up coil. The output is observed in the form of pulses.

The number of teeth of the rotor and its speed decides the frequency of pulses of induced e.m.f. so the frequency of pulses can be measured using electronic counter, while the number of teeth is known :; then the speed of rotation is given by,

$$\text{Speed (n) (in r.p.s.)} = \frac{\text{Pulses per second (P)}}{\text{Number of teeth (N)}} = \frac{P}{N} \text{ r.p.s.}$$

or $$n = \frac{P}{N} \times 60 \text{ r.p.m.}$$

Or Output frequency of the magnetic pickup is given as

$$f = \frac{\text{RPM X Number of gear teeth}}{60}$$

Q4) Attempt any four of the following **(16 Marks)**

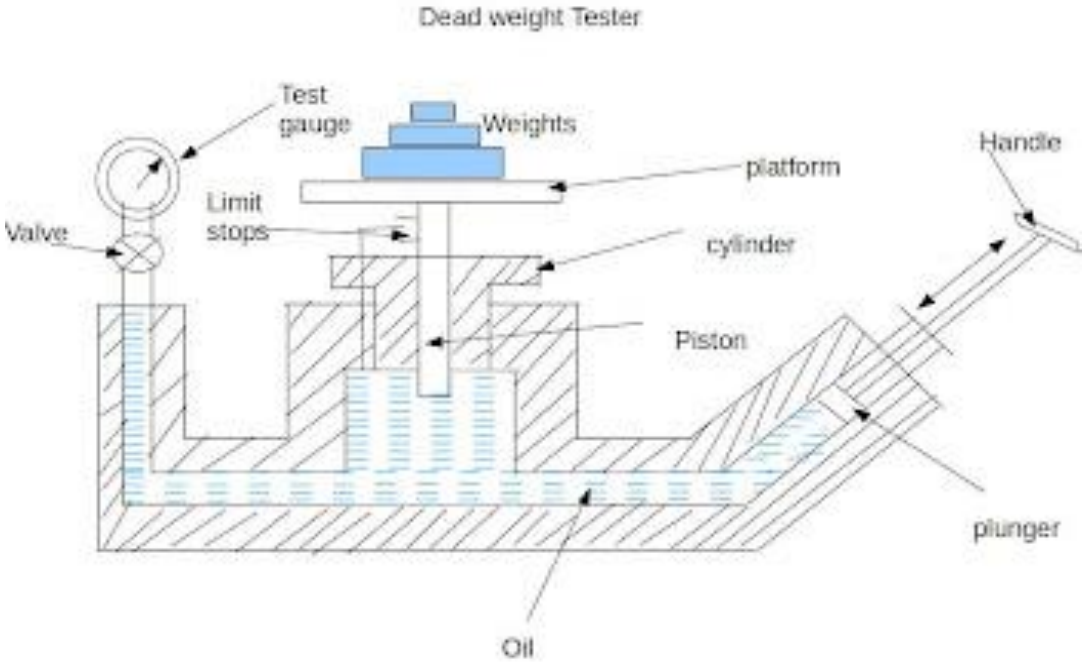
a) Classify each of the following transducers in two different categories.

1. **Thermocouple**
2. **LVDT**
3. **Bourdon tube**
4. **Strain gauge**

Ans: Any two classification for each transducer type **[1/2 mark each]**

	Classification1	**Classificaton2**	**Classification 3**
Transducer	**Based on active or passive**	**based on primary and secondary**	**Based on principle or output**
Thermocouple	Active	Primary	Thermoelectric type
LVDT	Passive	Secondary	Inductive type
Bourdon tube	passive	Primary	Mechanical type
Strain gauge	Active / passive	secondary	Electro mechanical

b) Explain the working of dead weight tester with neat diagram. (Diagram 2 marks, working 2 Marks)



Working:

The dead weight tester is basically a pressure producing and pressure measuring device. It is used to calibrate pressure gauges. The following procedure is adopted for calibrating pressure gauges. Calibration of pressure gauge means introducing an accurately known sample of pressure to the gauge under test and then observing the response of the gauge. In order to create this accurately known pressure, the following steps are followed.

1. The valve of the apparatus is closed.

2. A known weight is placed on the platform.

3. Now by operating the plunger, fluid pressure is applied to the other side of the piston until enough force is developed to lift the piston-weight combination. When this happens, the piston weight combination floats freely within the cylinder between limit stops.

4. In this condition of equilibrium, the pressure force of fluid is balanced against the gravitational

force of the weights puls the friction drag.

Therefore, PA = Mg + F

Hence : P = Mg + F / A

where, P = pressure

M = Mass; Kg

g = Acceleration due to gravity ; m/s^2

F = Friction drag; N

A = Equivalent area of piston – cylinder combination; m^2

Thus the pressure P which is caused due to the weights placed on the platform is calculated.

5. After calculating P , the plunger is released.

6. Now the pressure gauge to be calibrated is fitted at an appropriate place on the dead weight tester.

7. The same known weight which was used to calculated P is placed on the platform. Due to the weight, the piston moves downwards and exerts a pressure P on the fluid.

8. Now the valve in the apparatus is opened so that the fluid pressure P is transmitted to the gauge, which makes the gauge indicate a pressure value.

9. This pressure value shown by the gauge should be equal to the known input pressure P. If the gauge indicates some other value other than p the gauge is adjusted so that it reads a value equal to p. Thus the gauge is calibrated.

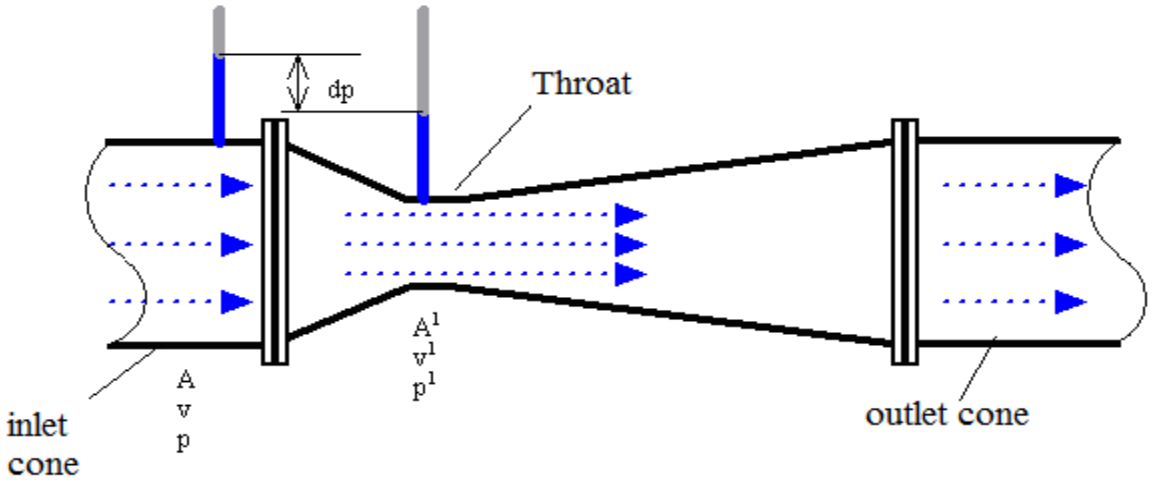
c) Describe working venturi meter with a neat sketch. (Diagram 2 marks , working 2 marks)

Ans: Working:

- Due to simplicity and dependability, the Venturi tube flowmeter is often used in applications where it's necessary with higher Turn Down Rates, or lower pressure drops, than the orifice plate can provide The venturi tube consist of three sections inlet cone, throat and outlet cone .
- The inlet cone (converging cone) is that through which flow is inserted Typically angle of inlet varies from 19^0 to 23^0.

- The second part is throat which is straight in nature and small in diameter, mistily throat is made by bronze so it can be easily replaced and venturi tube is made by cast iron .The outlet cone(diverging cone) has increased diameter the angle of outlet varies from 5^0 to 15^0 .
- The venturi tubes are available with two different sizes

  1. Short recovery cone type- suitable for short obstructed line and having larger pressure loss
  2. Long recovery cone type-which has less pressure loss
- In the Venturi Tube the fluid flow rate is measured by reducing the cross sectional flow area in the flow path, generating a pressure difference. After the constricted area, the fluid is passes through a pressure recovery exit section, where up to 80% of the differential pressure generated at the constricted area, is recovered.



Fluid passing through smoothly varying constrictions experience changes in velocity and pressure. These changes can be used to measure the flowrate of the fluid.

$$Q = v_1 A_1 = v_2 A_2$$
$$p_1 - p_2 = \tfrac{\rho}{2}(v_2^2 - v_1^2),$$

Where ρ is the density of the fluid,

Q is flow rate

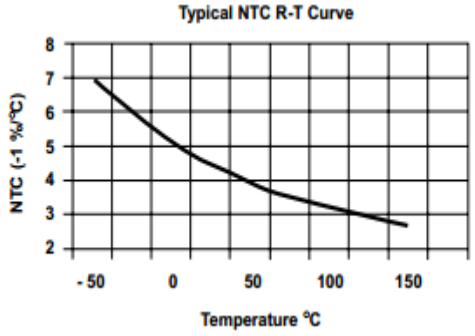
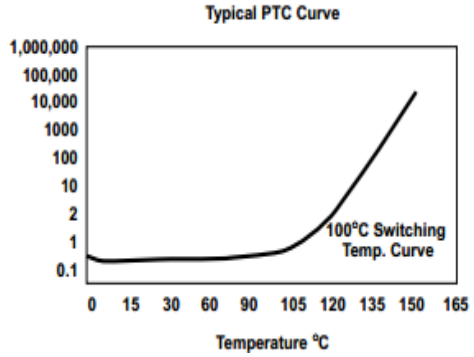
A1 and A2 are area

v_1 is the (slower) fluid velocity where the pipe is wider,

v_2 is the (faster) fluid velocity where the pipe is narrower (as seen in the figure)

d) Compare NTC and PTC w.r.t. thermistor (any four points) (1 Mark for each point)

Ans:

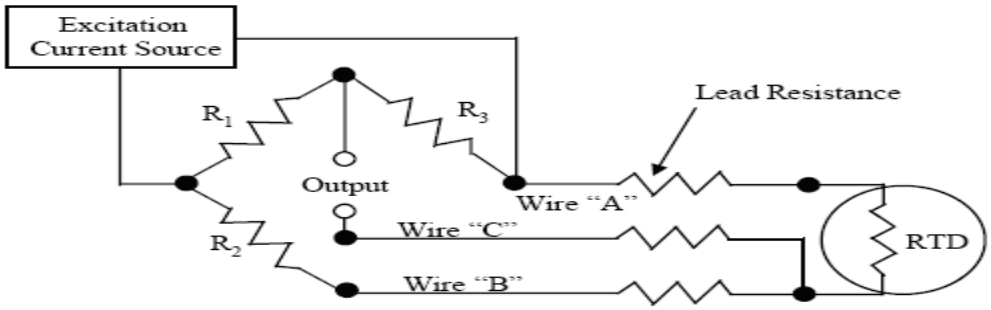
Factor	**NTC thermistor**	**PTC thermistor**
Application	Negative Temperature Coefficient Thermistors, used mostly in temperature sensing	Positive Temperature Coefficient Thermistors, used mostly in electric current control.
Characteristics		
Material	NTC thermistors are composed of sintered metal oxides such as manganese, nickel, cobalt, iron, copper and aluminum.	The PTC thermistor is generally a polycrystalline ceramic material composed of oxyalate or carbonate with added dopant materials.
Definition	An NTC thermistor is one whose zero-power resistance decreases with an increase in temperature.	A PTC thermistor is one in which the zero-power resistance increases with an increase in temperature

e) Explain three wire lead compensation in RTD. (Diagram 2 marks, Explanation 2 marks)

Ans: Explanation:

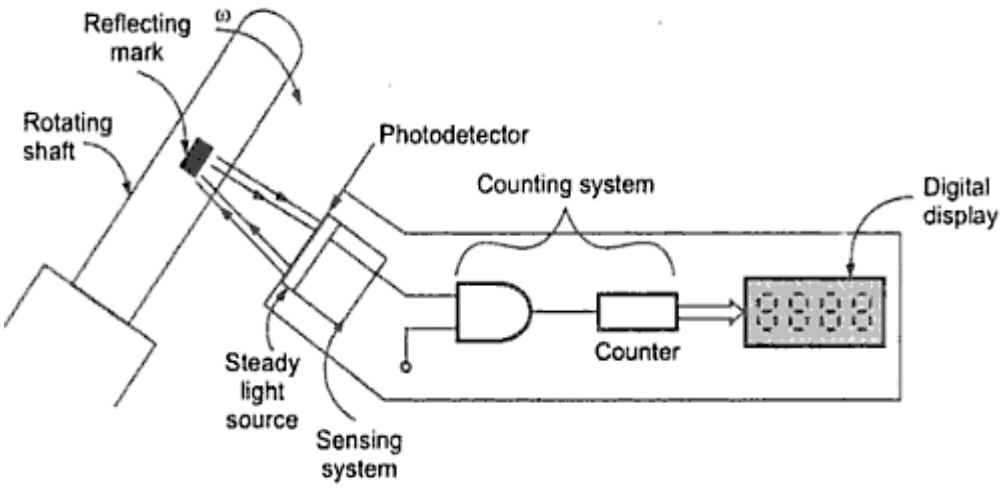
- **Resistance thermometers**, also called **resistance temperature detectors** (**RTD**s), are sensors used to measure temperature by correlating the resistance of the RTD element with temperature (RTD) Temperature detector consisting of a fine coil of conducting wire (such as platinum) that will produce a relatively linear increase in resistance as temperature increases.
- The three wire connection to the Wheatstone bridge measurement circuit, as shown in Figure.

- If wires A and B are perfectly matched in length, their impedance effects will cancel because each is in an opposite leg of the bridge.
- The third wire, C, acts as a sense lead and carries a very small current (in the microampere range).



Three wire RTD Bridge circuit

f) Describe how speed is measured by photo- electric method with neat diagram. [Diagram 2 marks, Explanation 2 marks]



Photoelectric tachometer

- The photoelectric tachometer is a type of non-contact type tachometer which is also called a digital tachometer. It uses a principle of retroreflective scanning. In this, scanning, the light source and photosenser are placed in a common housing. Light source sends a light toward the retroreflective target from which it gets reflected. This reflected light is sensed by a photosensor. The photosensor produces output proportional to the reflected light with which measurement can be done.
- The photoelectric tachometer pick-up consists of a steady light. The light has very low output power or beam strength as the device is battery operated. It also consists of a photodetector or a photocell. The photosensor uses the photovoltaic effect.
- These devices accept the light energy and convert it to an electrical energy. In photoelectric tachometer, the photodetector senses the reflected light and produces an electrical pulse.
- This arrangement is called sensing system of tachometer.
- A piece of reflective tape or reflecting mark in the form of chalk mark is affixed at a point on the shaft of the rotating object. The steady light is focused on the reflecting mark from the tachometer the light gets reflected from the mark, which is sensed by a photodetector. It produces electrical signal min the form of pulse.
- The reflected light produces one pulse per revolution. The electronic counting system consists of a gate and counter. The gate has length control as one input and a pulse from photodetector as the other input. The gate remains open for the time decided by gate length control. The counter counts the number of pulses available in the gate period. As pulse and revolution relation is known, the counter converts the information into a speed. This angular speed value is then given to the digital readout where it is displayed on a digital display. This display gives value of angular speed directly in r.p.m.

- These tachometers are divided into two categories, namely those using visible light and those operating in the infrared region. But their operating principle is the same. For photoelectronic tachometer, the speed in r.p.s. is given by,

$$\text{Speed}(n)\ (\text{in r.p.s.}) = \frac{\text{Pulses per second}}{\text{Number of slots}}$$

Q5. Attempt any two of the following. (16 Marks)

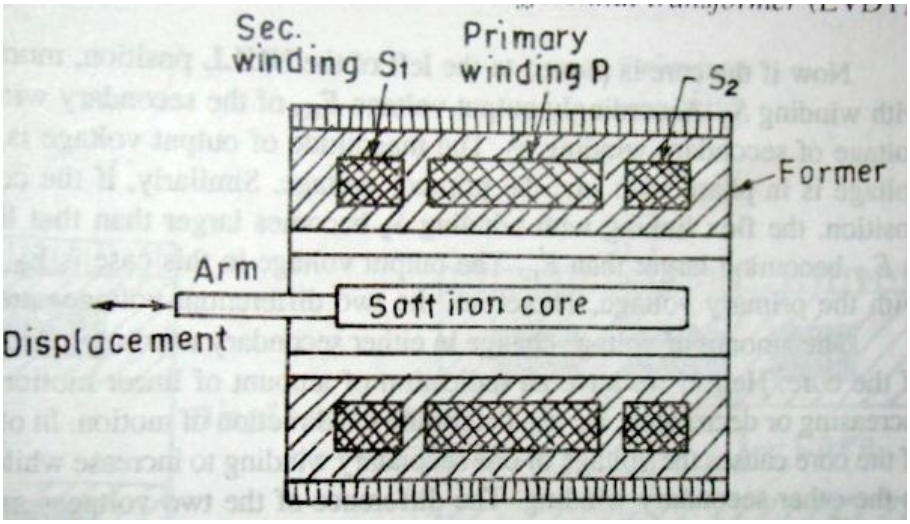
a) Explain construction and working of LVDT with circuit diagram. Also state the application of LVDT. (Construction and Working 6 marks, application 2 marks)

Ans: **Linear Variable Differential Transducer**

The LVDT is the most widely used inductive transducer to translate linear motion into electrical signal.

Construction:

A differential transformer consists of a primary winding and two secondary windings. The windings are arranged concentrically and next to each other. They are wound over a hollow bobbin which is usually of a non-magnetic and insulating material as shown in figure.



A ferromagnetic core (armature) in the shape of a rod or cylinder is attached to the transducer sensing shaft. The core slider freely within the hollow portion of the bobbin. An ac excitation is applied across the primary winding and the movable core varies the coupling between it and the two secondary windings. When the core is in centre position, the coupling to the secondary coils is equal. As the core moves away from the centre position the coupling to one secondary becomes more and hence its output voltage increases, while the coupling and output voltage of the secondary decreases in the complex winding configuration, the two secondary windings are connected in series opposition.

Working:

Any physical displacement of the core causes the voltage of the one secondary winding to decrease while simultaneously, reducing the voltage in the secondary winding. The difference of the two voltages appears across the output terminals of the transducer and give a measure of the physical position of the core and hence the displacement.

When the core is in neutral or zero position, voltages induced in the secondary windings are equal and opposite and the net output is negligible. As the core is moved in one direction from the null position the differential voltage i.e. the difference in the secondary voltages, will increase while maintaining and in phase relationship in the voltage from the input source. In the other direction from the null position, the differential voltage will again increases but will be 180˚out of phase with the voltage from the input source. By comparing the magnitude and phase of the output (differential) voltage with the input source, the amount and direction of the core and hence of displacement may be determine. Variation of output voltage with the core position is shown in figure.

Diagram

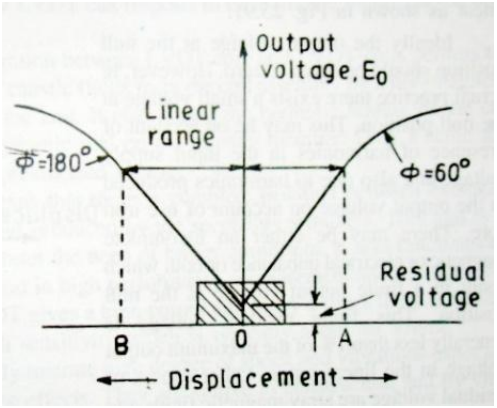


Fig. Variation output voltage with linear displacement of an LVDT

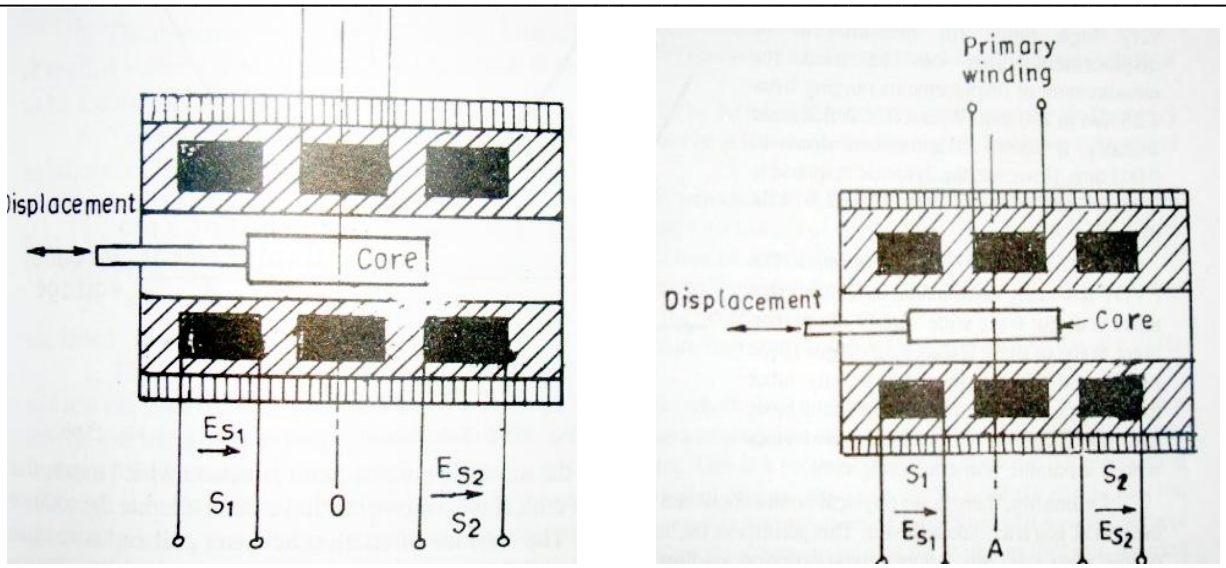


Fig LVDT at different positions

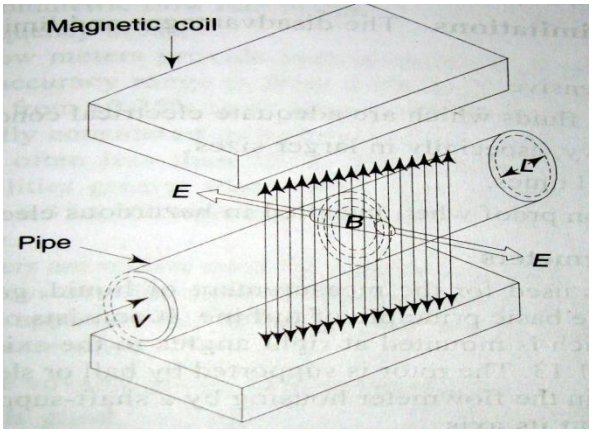
Application: (Any two points)

1. LVDT is used to measure 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.

Useful for measurement weight or pressure exerted by liquid in the tank

b) Explain electromagnetic flow meter with neat diagram and state advantages and disadvantages. (Diagram 2 marks, working 2 marks, Advantages 2 marks, disadvantages 2 marks)

Ans: Diagram: -



Principle of working (Basically on Faraday's Law of electromagnet) :-

- It consists of non-ferromagnetic measuring tube with electrically insulated inner surface & magnetic coil & electrode.
- The field coil through which current flow generate magnetic field with perpendicular to axis of tube.
- Magnetic field penetrate the measuring tube & process liquid flowing through it liquid must be electrically constant voltage

  V=KBDV Vα B DV

  K = constant

  B= induction

  D = Diameter tube

  V = flow velocity

  Flow = G1 HD/ 4KB

Simple: - A magnetic field applied to the metering tube which results in potential difference proportional to flow velocity perpendicular to flux line. It requires conducting fluid.

Advantages: – **(Any two points)**

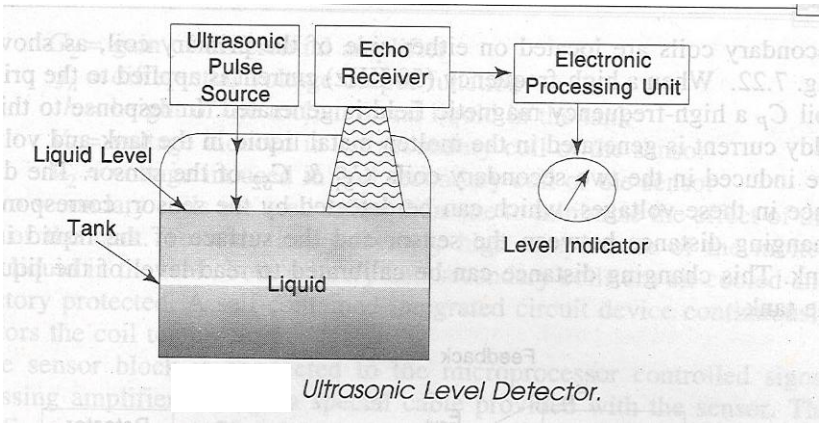
1. It can handle slurries and greasy materials.
2. It has very low pressure drop.
3. It is totally obstruction less.
4. It is available in several construction materials.

Disadvantages: - (Any two points)

1. It is relatively expensive.
2. It works only with fluids which are adequate electrical conductors.
3. It is relatively heavy, especially in larger size

c) Describe working principle of level measurement by ultrasonic level detector. State any two advantages and disadvantages. (Diagram 2 marks, working 2 marks, Advantages 2 marks, disadvantages 2 marks)

Ans: Diagram: -



Ultrasonic Level Detector.

Working and Construction

- Ultrasonic level detectors operate either by the absorption of acoustic energy as it travels from source to receiver. It operates by generating an ultrasonic pulse and measuring the time it takes for the eco to return. Figure illustrates the working of an ultrasonic level detector.

  - Ultrasonic level detectors consist of a set of transmitter and receiver.
  - It is connected to electronic processing unit which calculates the time taken by ultrasonic wave to travel from Transmitter to receive.
  - Level Indicator is used to display liquid level.
  - The ultrasonic wave generated by transmitter is directed towards the liquid surface.
  - These waves get reflected by liquid surface and received by the receiver.
  - The time taken by the wave is a measure of the distance travelled by the wave.

Advantages: - (Any two points)

Following are the advantages of ultrasonic level detectors:

(i) Ultrasonic level detectors are non-contact type measurement techniques. They have the ability to measure level without making physical contact with the process material,

(ii) They have no moving parts.

(iii) The reliability of the reading is unaffected by changes in the composition, density, moisture content, electrical conductivity, or dielectric constant of the process fluid.

Disadvantages: - (Any two points)

Following are the disadvantages of ultrasonic level detector:

(i) An ultrasonic transmitter is subject to much interference, which affects the strength of the echo it receives.

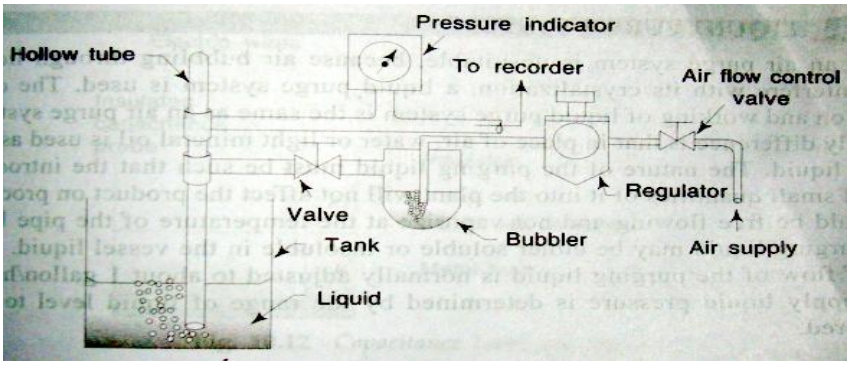
(ii) Temperature compensation is essential in ultrasonic level measurement,

(iii) The dirt, irregular and slope surfaces affect the accuracy of the measurement.

Q6. Attempt any two of the following. (16 Marks)

a) Describe working of level measurement by air purge system with neat diagram. Also state its advantages. (Construction and working 6 marks, advantages 2 marks)

Ans: Construction and Diagram :-



1) It consist of a hollow tube inserted in the liquid tank. There are Two connections one is for regulated air supply and other is for pressure gauge which is callibrated in terms of liquide lavel. A bubbler is connected to check the flow of air supply. A level recorder is used for continues recording of liquid level.

2) Air purge popularly known as bubbler tube which is mostly used for hydrostatic level measurement for any liquid.
3) As shown in diagram when no liquid, pressure gauge indicate zero.
4) As liquid level increases which act on pressure gauge, pointer moves according to pointer Level is calibrated.
5) The level range is depending on length of tube.

Advantages:

1) In this system the pressure gauge can be placed above or below the tank level as well as can Keep 500 feet away
2) It is useful for corrosive or abrasive liquids

b) What is piezoelectric effect? Name two piezoelectric materials. Explain construction and working of piezoelectric type transducer with neat sketch.

(Construction and working 4 marks, principle and material used 2 marks each)

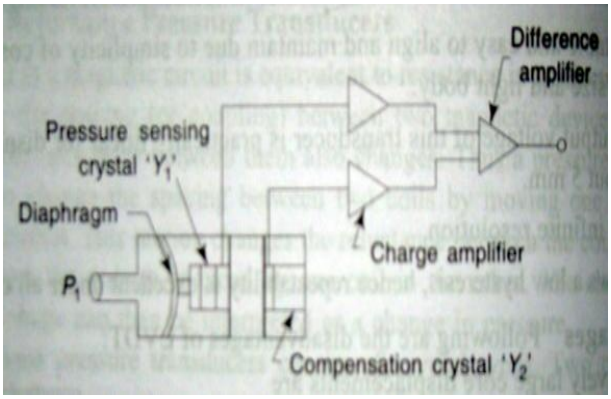
Ans: Piezoelectric Effect: -

When pressure or force is applied on piezoelectric crystals such as quartz crystal then an electric charge is generated across that crystal.

Piezoelectric Materials: - (Any two)

1) Barium Titanate.
2) Rochelle salts.
3) Quartz crystal.

Diagram :-



These device utilize the piezoelectric characteristics of certain crystalline and ceramic materials (such as quartz) to generate an electric signal.

Principle:

Such transducers depend upon the principle that "when pressure is applied on piezoelectric crystals (such as quartz),an electrical charge is generated". There are about 40 crystal line materials that, when subject to a "squeeze", generate electric charge. Some of the piezoelectric materials are barium titanate sintered powder, crystal of quartz, tourmaline, and Rochelle salts. Figure shows a piezoelectric pressure transducer.

It consists of a diaphragm by which pressure is transmitted to the piezoelectric crystal Y1. This crystal generates an electric signal which is amplified by a charge amplifier. A second piezoelectric crystal Y2 is included to compensate for any acceleration of the device during use. This compensation is needed because rapid acceleration of the transducer creates additional pressure on the piezoelectric crystal. Vibration is a major source of high, rapidly changing acceleration.

Piezoelectric pressure transducers may be used to measure pressures over ranges upto 0 to 50000 psi. However, piezoelectric transducers cannot measure steady pressures. They respond only to changing pressure.

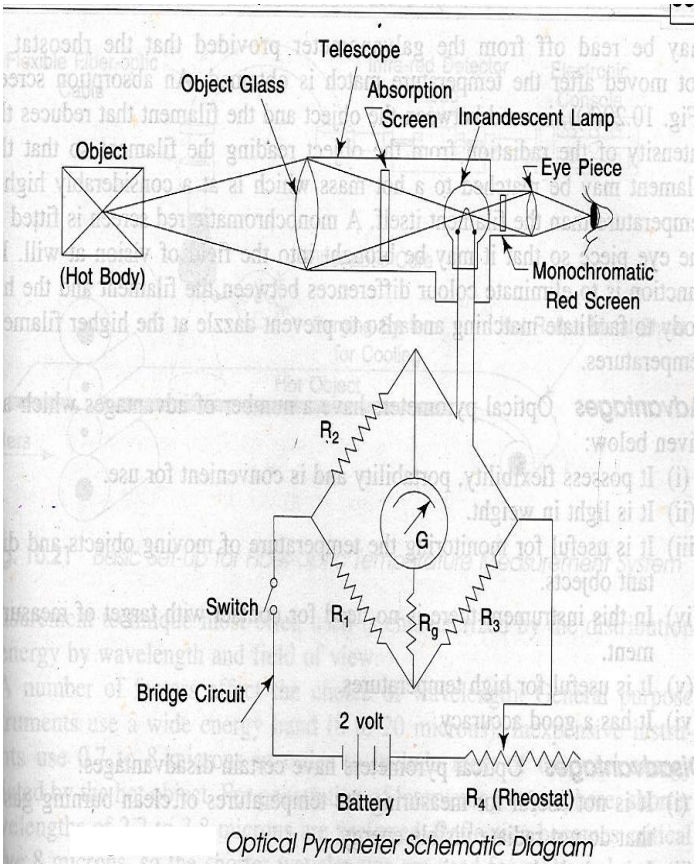
c) What is pyrometry? Describe working optical pyrometer with neat diagram. State its applications. (definition 1 mark, diagram 3 marks, working 2 marks, applications 2 marks)

Ans: Pyrometry:-

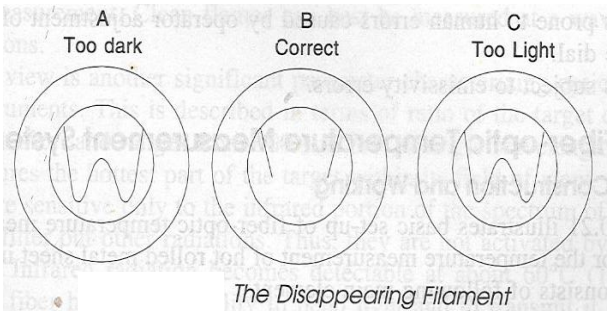
When physical contact with the medium to be measured is not possible due to very high temperature, Pyrometers are used. Operation of pyrometer is based on thermal radiation. Radiation pyrometry measures the radiant heat emitted by hot body.

Optical Pyrometers

Diagram:- -



Optical Pyrometer Schematic Diagram



The Disappearing Filament

Construction and Working. -

Operation of optical pyrometers is based on the comparison of the intensity (brightness) of the visual radiation emitted by the hot body with the radiation emitted by the source of known intensity.

The brightness (or intensity) of radiation emitted by the hot body whose temperature is to be measured, is matched with the brightness of a calibrated reference (lamp) whose temperature is known. Figure shows the schematic arrangement of an optical pyrometer.

An optical pyrometer consists of an incandescent lamp filament used as the reference source of radiation. This is arranged in the field of vision of a telescope through which both it (the filament) and the hot body, are viewed simultaneously.

The filament is heated by a 2 volt battery in series with a rheostat by which the temperature of the

filament is adjusted.

This filament is connected in one arm of a wheat-stone bridge circuit across which is connected a moving coil galvanometer.

The electrical resistance of lamp filament varies in accordance with its temperature, while the resistance in other arms of the bridge are of a material, the ohmic value of which not alter with change of temperature.

As the temperature of the filament is increased the bridge is progressively thrown out of balance.

The degree of unbalance is shown by the magnitude of the galvanometer deflection which is calibrated in terms of temperature.

Application:

1. It is widely used for accurate temperature measurement of furnace.
2. Temperature measurement of molten metals.