SUMMER – 2022 EXAMINATION

Subject Name: Industrial Measurements **Model Answer :** **22420:IME**

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. N.	Sub Q. N.	Answer	Marking Scheme
1		**Attempt any FIVE of the following:**	**10 Marks**
1	a)	**State the need of transducer in Instrumentation System.** **Ans:** Instrumentation system basically consist of measurement and controlling of different physical variables such as temperature, pressure, flow, level, humidity, sound, pressure etc. Transducer is a device of instrumentation system which converts a physical energy into an electrical energy so that it measures the physical quantities and converts it in electrical quantities that can be measured and transmitted easily. **OR** The main function of a transducer is used to change the signal from mechanical to electrical. Transducer is important device of instrumentation system for detecting physical quantities such quantities as temperature, pressure, flow, level, humidity, sound, pressure, light etc. These physical quantities are transformed into electrical signal in modern instrumentation system.	2 Marks for correct answer
1	b)	**Define:-** **i)Atmospheric pressure** **ii) Gauge Pressure** **Ans:** **i) Atmospheric pressure**: It is measured interms of liquid column = 760 mm of Hg. (29.92 in Hg) **or** It is defined as the height of the barometric column at 0 ^{0}C at sea level. **ii) Gauge pressure** It is defined as the pressure difference between the point of measurement (actual pressure) and the ambient (atmospheric) pressure. Gauge Pressure =Absolute Pressure –Atmospheric Pressure	1 Mark for each bit = 2 Marks
1	c)	**List the types of electrical flow meter.** **Ans:** i) Turbine flowmeter ii) Electromagnetic flow meter iii) ultrasonic flowmeters iv) Hot wire anemometer v) Vortex flow meter	½ Mark for each of any four types

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1 d) **Define :-**
i) Laminar flow.
ii) Turbulent flow
Ans:

i) **Laminar flow**: flow occurs when the fluid flows in parallel layers, with no mixing between the layers. The flow is laminar when Reynolds number is less than 2000.

OR

The flow in which fluid flows smoothly such that fluid layers are parallel to each other

OR

No streamlines intersect each other; such type of flow is known as laminar flow.

OR

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

1 Mark

ii) **Turbulent flow**: flow occurs when the liquid is moving fast with mixing between layers.

OR

The speed of the fluid at a point is continuously undergoing changes in both magnitude and direction. The flow is turbulent when Reynolds number greater than 4000.

OR

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

1 Mark

1 e) **Write applications of level transducer (Any four).**
Ans:

i) To measure tank level.
ii) Tank level monitoring in chemical, water treatment.
iii) measure the level of the wet well to control the intake pumps
iv) measurement of liquid or solid material level of tanks used by dairies, chemical plants, mineral companies
v) Measurement of waste products in waste water treatment plants.
measurement of sand, crushed rock, and gravel level in gravel open-cast mines
vi) Measurement of level of water purification system

½ Mark for each of any four types = 2 Marks

1 f) **List units of temperature and conversion formula for them (Any two unit).**
Ans:

1. Degree Fahrenheit (°F)
2. Degree Celsius or centigrade (°C)
3. Kelvin (°K)
4. Degree Rankine (°R)
5. Degree Reaumur (°R')

½ Mark for each of any two units = 1 Mark

1	Fahrenheit to Celsius or centigrade	$^0C = \frac{5}{9}(^0F - 32)$
2	Celsius or centigrade to Fahrenheit	$^0F = \frac{9}{5}(^0C) + 32$
3	Fahrenheit to Rankine	$^0R = {}^0F + 459.7$

4	Celsius or centigrade to Kelvin	^{0} K = ^{0}C + 273.15
5	Kelvin to Celsius or centigrade	^{0}C= ^{0} K - 273.15
6	Kelvin to Rankine	^{0}R = 1.802 K
7	Rankine to Kelvin	^{0} K = 0.555 ^{0}R
8	Fahrenheit to Reaumur	^{0} R' = (^{0}F-32)/2.25
9	Kelvin to Fahrenheit	° F = 9/5 (K - 273) + 32
10	Fahrenheit to Kelvin	K = 5/9 (° F - 32) + 273

½ Mark for each of conversion formula of two units listed above = 1 Mark

1 g) **Name the metals used in J and K type thermocouple.**

Ans:

J type thermocouple: Iron, constantan
K type thermocouple: Chromel, Alumel

1 Mark each

2 Attempt any THREE of the following: 12 Marks

2 a)

State the working principle of potentiometer, describe the major difference in linear and angular potentiometer.

Ans:

Working principle:

Potentiometer is resistive transducer. It is also called as POT or Voltage Divider.
It works on principle of change of resistance of the wire with its length

OR

A potentiometer basically works on the principle of varying the resistance of a fixed resistor by moving the sliding/rotary contact ie. the wiper. By displacing the position of the wiper, the length of the resistive constantan or manganin wire is change and change in the length of the wire is proportional to the change in the resistance in the circuit.

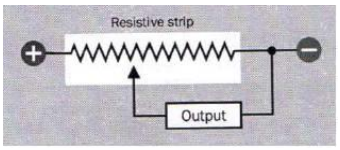
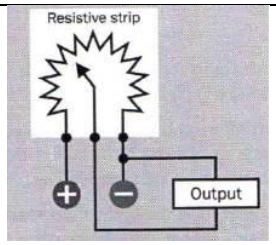
OR

Potentiometer is a passive component that works on moving the slider across the full length of the conductor. The input supply voltage is applied to the entire length of the resistor. The output voltage is measured as voltage drop between fixed and movable contact. The slider is adjusted manually over the resistive strip to change the resistance value from zero to a higher value. When the resistance changes, the current flowing through circuit changes. Hence according to Ohm's law, the resistive material also changes.

2 Marks for working Principle

Particulars	Linear Potentiometer	angular potentiometer
Principle	Potentiometer is a passive component that works on moving the slider across the full length of the conductor	A rotary potentiometer uses a rotational mechanism to alter the point of contact that exists between the circular resistor and the wiper terminal

1 Mark for each of any two differences = 2 Marks

Diagram		
Construction	Consist of strip of resistive polymer or insulator with coil of nichrome wire wrapped around it.	Arc-segment is present in rotary potentiometer and multi-turn rotary potentiometer.
Measurement	Linear position	Angular Position
Example	Examples are graphic equalizers and soundboards.	Rotary potentiometers work great with smaller electronic devices
Convert	Convert linear displacement into a voltage	Convert angular displacement into a voltage

2 b) **Write any two applications of capacitive and inductive transducer.**

Ans:

Application of Capacitive transducer:

- Capacitive Transducer is mostly used for the measurement of linear and angular displacement
- They are also used for the measurement of force and pressure.
- It can also be used to measure liquid level, volume, density etc.
- Humidity in gases is measured through the capacitive transducer
- Other typical applications are tolerance testing in mass production,
- Vibration measurement,
- Strain measurement
- Thickness measurement and thickness control of thin metal foils,
- Thickness measurement of plastic foils during production, beveling and bending of wafers in semiconductor production and many more

2 Marks for any two applications

Application of Inductive transducer:

- Used to measure the weight, force, and pressure
- Robotic cleaner
- Used for soil moisture testing
- Used in industries as well as servomechanisms like power turbines, hydraulics, automation, aircraft, and satellites etc.
- It is used in medical devices brain probing
- Dollar bill thickness in ATM Machine.

2 Marks for any two applications

2 c) **Describe the classification of pressure transducers.**

Ans:

Classification of Pressure measuring devices

1) Non elastic Pressure transducer/manometer
- U Tube manometer
- Well type manometer
- Inclined type manometer
- Barometer

1 Mark for each of 4 = 4 Marks

2) Elastic Pressure Transducer/Mechanical
- Bourdon tube
- Bellows
- Diaphragms
- Capsule

3) Electronics Pressure Transducer
- Inductive type :Bourdon tube with LVDT
- Diaphragms with Strain Gauge(Resistive)
- Capacitive Pressure Transducer
- Piezoelectric Pressure Transducer

4) Measurement of vacuum
- McLeod gauge
- thermal conductivity gauge
- pirani gauge
- thermocouple gauge.

2 d) **(i) Describe with neat diagram the measurement of pressure using Bourdon tube with LVDT.**

(ii) State the advantage of this system over Bourdon tube system.

Ans:

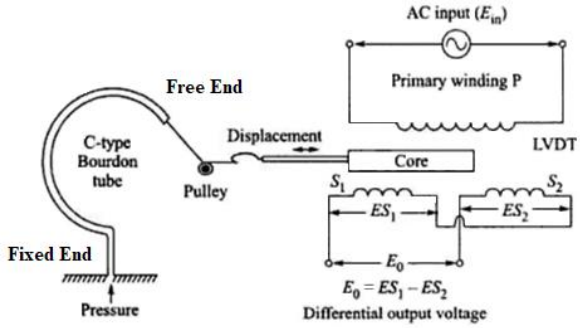
(i) Measurement of pressure using Bourdon tube with LVDT:

1 Mark for description

- The pressure measurement using bourdon tube and LVDT is shown in the figure.
- In this, the bourdon tube act as primary transducer and LVDT which follows the output of bourdon tube act as a secondary transducer.
- The bourdon tube senses the pressure and converts it into a displacement.
- The free end of bourdon tube shows this displacement.
- A cord is used to connect the free end of bourdon tube to the core of LVDT as shown in figure.
- When the free end shows the displacement, the core of LVDT also moves.
- This movement of core is proportional to the displacement of free end, which is proportional to the applied pressure.
- The LVDT gives analogues output which is a conversion of displacement into respective

e.m.f.

- This set up is used for measurement of pressure which is converted into electrical signal by LVDT.



1 Mark for diagram

Advantage of Bourdon tube with LVDT system over Bourdon tube system:

- An advantage of this set up is measurement of pressure which is converted into electrical signal by LVDT as secondary transducer. And In bourdon system pressure is converted into displacement not in electrical signal.
- Movement of LVDT core is proportional to applied pressure. The measurement of pressure is done by converting the applied pressure into a displacement by elastic pressure elements like bourdon tubes
- Bourdon tube system is elastic type system where Bourdon tube with LVDT is electrical type pressure measuring transducer
- It possesses high sensitivity
- Output of LVDT with Bourdon tube is linear
- Low Hysteresis
- Repeatability is good

½ mark for each of any four advantages = 2 Marks

3 Attempt any THREE of the following: 12 Marks

3 a) Classify the following transducer at least by two ways:

i) Strain gauge and

ii) Thermocouple

Ans:

i) Strain gauge: -

1. Unbounded strain gauges, and
2. Bonded strain gauges:- It divided as
   a) Wire Type strain gauge,
   b) Foil Type strain gauge,
   c) Semiconductor strain gauge.

1 Mark for each type = 2 Marks

ii) Thermocouple:-

a) Type E

b) Type J

1 Mark for each of any two types = 2 Marks

c) Type K
d) Type N
e) Type R
f) Type S
g) Type T

3 b) **Describe criteria for the selection at transducer for following applications.**
i) Weighting machine in grocery shop:-
ii) Water level controller for home:-

Ans:

i) Weighting machine in grocery shop:-
a. Type of transducer-Strain gauge/Load cell
b. Load cell accuracy
c. Environmental forces:- shock loading ,vibration,
d. Maximum load rating
e. Two point calibration and zeroing

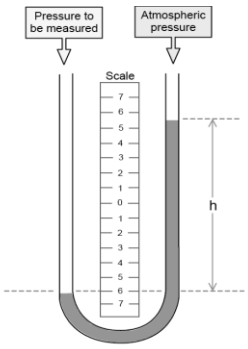
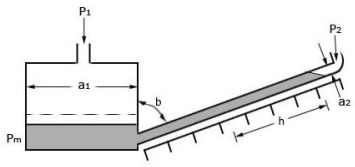
ii) Water level controller for home:-
a. Type of level transducer: - float type
b. Measuring range
c. Analog/ digital indication
d. Mounting method

(Any other relevant criteria can be considered)

2 Marks for each bit for at least two criteria = 4 Marks

3 c) **Differentiate between the u-tube manometer and inclined tube manometer.**

Ans:

Point of comparison	U-tube manometer	Inclined tube manometer
i) Construction	It consists of U-shape tube.	It has a well and column is mounted at an angle
ii) Accuracy	Less accurate than inclined tube	Better accuracy than U- tube
iii) No of Legs	Two legs are used	One leg is used
iv) Sensitivity	Less sensitive than inclined tube manometer	More sensitive than U-tube manometer
v) Diagram		

1 Mark for each of any four differences = 4 Marks

3 d) **Describe construction and working of orifice plate meter.**

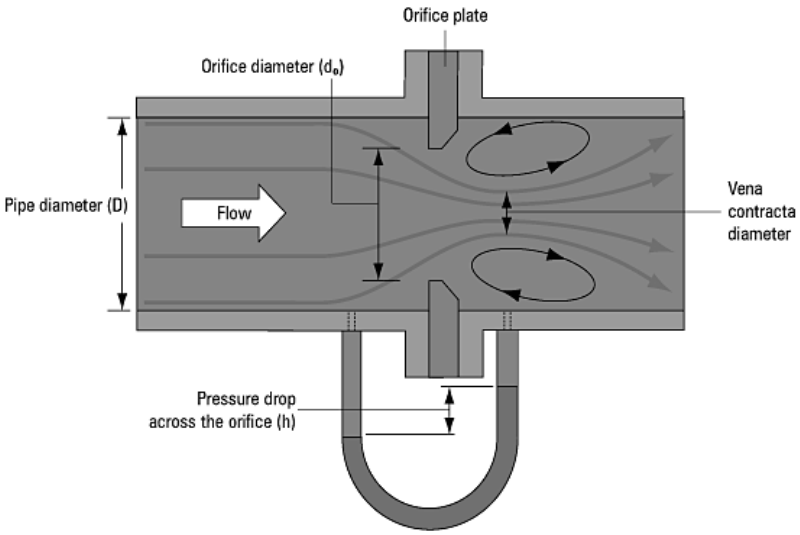
Ans:

Orifice Plate meter:

An Orifice Meter is basically a type of differential flow meter which is used to measure the rate of fluid flow (mainly Liquids or Gases), using the Differential Pressure Measurement principle.

Construction :-

1 Mark for diagram



1 Mark for construction

The orifice plate is being fixed at a section of the pipe, creates an obstruction to the flow by providing an opening in the form of an orifice to the flow passage.

Orifice meters are built in different forms depending upon the application-specific requirement, The shape, size, and location of holes on the Orifice Plate describe the Orifice Meter Specifications as per the following:

2 Marks for working

Concentric Orifice Plate

Eccentric Orifice Plate

Segment Orifice Plate

Quadrant Edge Orifice Plate

Working :-

The fluid flows inside the Inlet section of the Orifice meter having a pressure P1.

As the fluid proceeds further into the Converging section, its pressure reduces gradually and it finally reaches a value of P2 at the end of the Converging section and enters the cylindrical section.

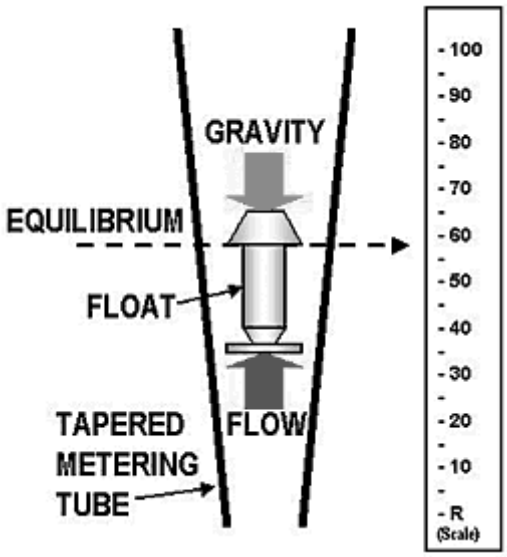
The differential pressure sensor connected between the Inlet and the the Cylindrical Throat section of the Orifice meter displays the difference in pressure (P1-P2). This differential pressure is measured using U tube manometer is in direct proportion to the flow rate of the liquid flowing through the Orifice meter.

4 Attempt any THREE of the following: **12 Marks**

4 a) **Draw neat sketch of Rota meter and explain the use of it for the flow measurement.**

Ans:

Rotameter:



2 Marks for Diagram

Fluid enters from the bottom of the tapered tube, then some of the fluid strikes directly into the float bottom and others pass aside the float. Now the float experience two forces in opposite direction, darg force upward and gravitational force downward.

Fluid flow moves the float upward against gravity. At some point, the flowing area reaches a point where the pressure-induced force on the floating body exactly matches the weight of the float. The float will find equilibrium when the area around float generates enough drag equal to weight - buoyancy.

As the float weight and gravity are constant, the distance float displaced upward is proportional to the flow velocity of the fluid passing through the tapered tube.

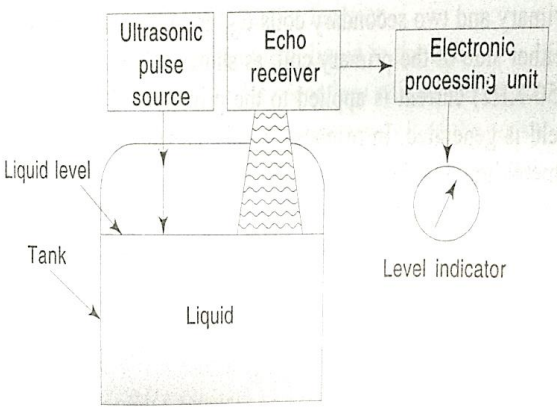
2 Marks for explanation of use

4 b) **i) State the working principle of ultrasonic type level measurement with help of neat sketch**

ii) State the frequency range of the same.

Ans:

i) Ultrasonic type level measurement:



2 Marks for diagram

It operates either by the absorption of acoustic energy as it travels from source to receiver or by attenuation (frequency change) of a vibrating diaphragm face, oscillating at 35 to 40 KHz.
It operates by generating ultrasonic pulse and measuring the time it takes for the echo to return. When an ultrasonic transmitter is mounted at top of the tank, the pulse travels in air at speed of 331 m/s at 0 ^{0}C.
The time of travel is an indication of depth of vapor space above the liquid in the tank. If ultrasonic transmitter is mounted on bottom of tank, time of travel reflects the depth of liquid in tank and speed of travel is function of what the liquid is. For water at 25 ^{0}C, an ultrasonic pulse travel at speed of 1496 m/s.

1 Mark for working principle

ii) 40 and 120 KHz

1 Mark for range

4 c) **Describe the salient features of the float type level measurement transducer.**
Ans:
Salient features of the float type level measurement transducer:

i) It is direct method of level measurement
ii) It is economical
iii) It has reliable design
iv) It operates over a large temperature range
v) It is possible to read the liquid level in tanks below ground level.
vi) The float is made of corrosion resisting material.
vii) Used when measurement is required for small changes in level.
viii) Liquid level from 1/2 feet to 60 feet can be easily measured.

½ Marks for each of any 8 features = 4 marks

(Any other relevant features can be considered)

4 d) **Compare ultrasonic type and radar type level measurement transducer**.
Ans: Comparison between ultrasonic type and radar type level measurement transducer:

Point of comparison	Ultrasonic type	Radar Type
i)Working principle	Generation of ultrasonic waves and measuring the time it takes for the echo to return.	The changes in the amplitude and/or phase of the reflected Signal is used to determine material present
ii)Construction	Consist of ultrasonic transducer which has a set of transmitter and receiver	Microwave signal is generated by the source which directing a constant frequency/amplitude modulated microwave Signal.
iii)Waves used	Ultrasonic waves	Microwave (electromagnetic)

1 Mark for each of any four points = 4 Marks

iv) Receiver End	At receiver, photodiode or phototransistor is used	At receiver, parabolic antenna is used
v)Transmitter End	Transmitter uses piezoelectric material as like quartz	Transmitter is oscillator that generates microwaves of linear sweep and fixed bandwidth.
vi) Uses	For hazardous liquids and solids	For continuous level measurement.

4 e) **Write the advantages and limitations of optical pyrometer.**

Ans:

Advantages of optical pyrometer:

1. The optical pyrometer is useful for high temperatures.
2. It is useful for monitoring the temperature of moving object and distant objects
3. It has good accuracy.
4. No need for contact with target of measurement.
5. It is light in weight.

1 Mark for each of any two advantages = 2 Marks

Limitation of optical pyrometer:

1. The accuracy may be affected by dust, smoke and thermal background radiation.
2. The optical pyrometer is not useful for measuring the temperature of clean burning gases that do not radiate visible energy.
3. It is more expensive.
4. It causes human error.

1 Mark for each of any two limitations = 2 Marks

5 Attempt any TWO of the following: 12 Marks

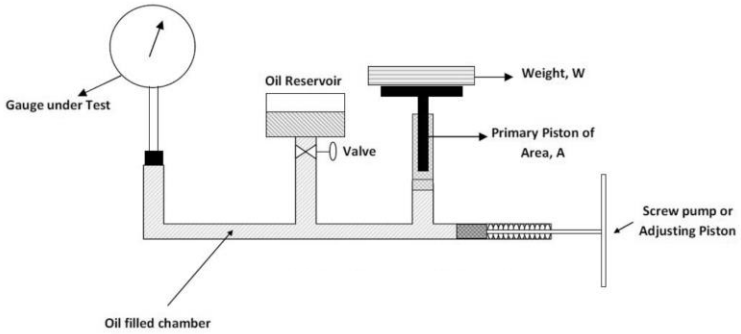
5 a) **i) Describe the calibration procedure with help of sketch for capsule and diaphragm type transducer.**

ii) State the range of pressure measured by diaphragm type transducer.

Ans:

i) Calibration procedure for capsule and diaphragm type transducer:

Deadweight Testers (DWT) are the primary standard for pressure measurement. A dead weight tester is an instrument that calibrates pressure by determining the weight of force divided by the area the force is applied.



2 Marks for diagram

Typically a dead weight tester consists of a base, screw press/regulator, piston/cylinder

assembly, A fluid (oil) that transmits the pressure and a mass set of weights.
PRESSURE = FORCE / AREA = W/A
As the area of a piston of DWT is accurately Known so that it is constant
Therefore, PRESSURE(P) ∝ FORCE (Weight)

3 Marks for Calibration steps description

CALIBRATION STEPS :-
Connect the pressure gauge to the test port on the dead weight tester as shown in the diagram above.
Ensure that the test gauge is reading zero, if not correct the zero error and ensure that the gauge is reading zero before proceeding with the calibration exercise.
Select a weight and place it on the vertical piston
Turn the handle of the adjusting piston or screw pump to ensure that the weight and piston are supported freely by oil.
Spin the vertical piston and ensure that it is floating freely
At steady state condition record the gauge reading and weight
Increasing weights until the full range or maximum pressure is applied to the gauge and then decreasing weights until the gauge reads zero pressure.
Calculate the error at each gauge reading and ensure that it is within the acceptable accuracy limits.

ii) The common range for pressure measurement varies between 50 Pa to 0.1 MPa. (Any other example can also be considered)

1 Mark for Range

5 b) **Describe the problems occurs in working of ultrasonic flowmeter and write the procedure to troubleshoot these problems.**

Ans:

Problems occurs in working of ultrasonic flowmeter:

Problem 1: For Doppler ultrasonic flow measurement it is considered that the calibration of the flowmeter varies with the speed of sound through the fluid (c). As c increases, Δf must proportionately decrease for any fixed volumetric flow rate Q. Since the flowmeter is designed to directly interpret flow rate in terms of Δf, an increase in c causing a decrease in Δf will thus register as a decrease in Q.
Remedy 1: The speed of sound for a fluid must be precisely known in order for a Doppler ultrasonic flowmeter to accurately measure flow.

2 Marks for each of three problems and respective remedy = 6 Marks

Problem 2: Temperature affects liquid density, and chemical composition which affects bulk modulus and hence the speed of sound in liquid. Thus, temperature and composition both are influencing factors for Doppler ultrasonic flowmeter calibration.
Problem 3: The Doppler effect applies only to flowmeter applications where bubbles or particles of sufficient size exist in the fluid to reflect sound waves, it is only the speed of sound through liquids (and not gases). We simply cannot measure gas flows using the Doppler technique, and so factors uniquely affecting gas density (e.g. pressure) are irrelevant to Doppler flowmeter calibration. Another limitation of Doppler ultrasonic flowmeters is their inability to measure flow rates of liquids that are too clean and too homogeneous. In flow

measurement applications where we cannot obtain strong sound-wave reflections, Doppler-type ultrasonic flowmeters are useless.

Remedy 2 & 3: A requirement for reliable operation of a transit-time ultrasonic flowmeter is that the process fluid be free from gas bubbles or solid particles which might scatter or obstruct the sound waves. Hence applicable for gas flow streams as well as on liquid flow streams.
Problem 4: A potential problem with the transit-time flowmeter is being able to measure the true average fluid velocity when the flow profile changes with Reynolds number

Remedy 4: popular way to mitigate this problem is to use multiple sensor pairs, sending acoustic signals along multiple paths through the fluid (i.e. a multipath ultrasonic flowmeter), and to average the resulting velocity measurements.
Problem 5: Ultrasonic flowmeters are adversely affected by swirl and other large-scale fluid disturbances,

Remedy 5: Substantial lengths of straight pipe upstream and downstream of the measurement flow tube should be maintained to stabilize the flow profile.

(Any relevant problem with troubleshooting steps to be considered)

5 c) **Draw labelled diagram of electromagnetic flow meter and write the output equation of it and basic condition for working of this flow meter.**

Ans:

Electromagnetic flow meter:

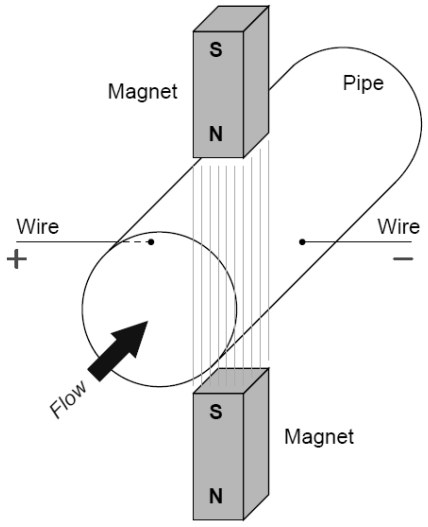
It works on the principle of electromagnetic induction. When any conductor moves in magnetic field, an emf is induced in it. The emf is given by,

2 Marks for equation

$$E = Blv$$

Where,
E = Motional EMF (volts)
B = Magnetic flux density (tesla)
l = Length of conductor passing through the magnetic field (meters)
v = Velocity of conductor (meters per second)

2 Marks for diagram



Conditions:

1 Mark for

1. The liquid must be a reasonably good conductor of electricity
2. Both electrodes must contact the liquid
3. The pipe must be completely filled with liquid
4. The flow tube must be properly grounded to avoid errors caused by stray electric currents in the liquid.

each of any two conditions = 2 Marks

6 Attempt any TWO of the following: 12 Marks

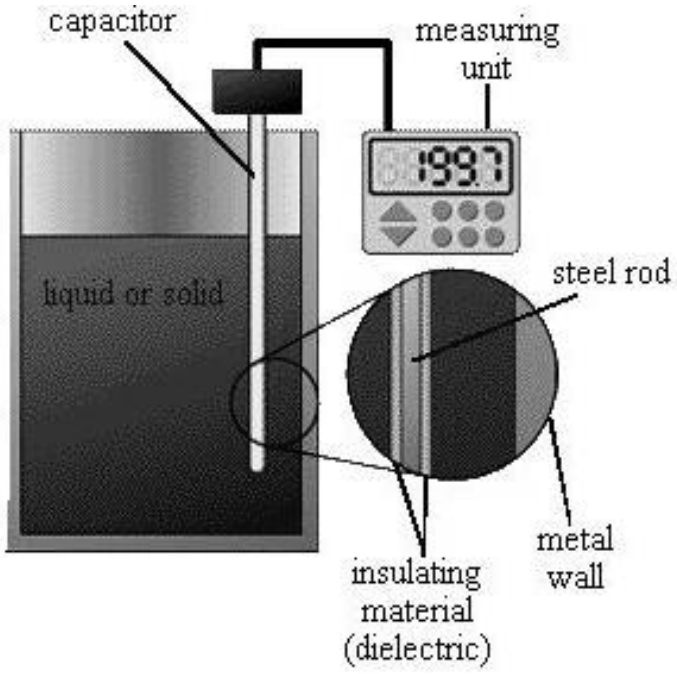
6 a) Explain the calibration procedure for capacitance type level transducer.

Ans:

Calibration procedure for capacitance type level transducer:

Calibration procedure for capacitance type level transducer:

In calibration of capacitive level sensor, first measuring the change in capacitance with respect to tank's level shift with the help of sensor's probe. Then, the capacitance change is converted into a linear, accurate 4-20mA signal using a level transmitter.



2 Marks for setup

1. Remove the level transmitter from the system tank.
2. Check whether transmitter shows zero reading by connecting with multimeter otherwise release the pressure.
3. Connect the capacitive sensor probe to the pre-calibrated level transmitter.
4. Set multimeter to milliamps knob.
5. Fill the corresponding liquid in correct density and note down the readings. Fill liquid in steps of 5% or 10% in both ascending and descending orders and note down the readings.
6. Check for errors if there is zero and span adjust should be done.
7. For zero calibration: Connect a multimeter and rotate the zero pot and stop when multimeter shows 4ma.

4 Marks for

8. For span calibration: Fill the chamber to maximum liquid level and rotate the span screw to 20ma. **calibration procedure**
9. After doing zero and span trimming again check the reading at in steps of 5% or 10% from 0% to 100%.
10. Repeat the procedure twice or thrice.

6 b) **i) Describe the working of RTD with help of sketch.**
ii) Write its two applications and material used in it.
Ans:

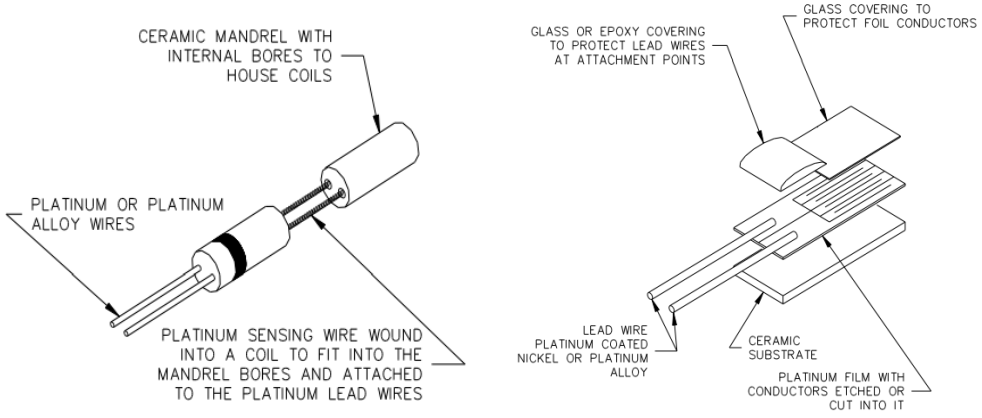
i) Resistance Temperature Detector (RTD):

An RTD **(**Resistance Temperature Detector) also known as a Resistance Thermometer is a device which contains an electrical resistance source which changes resistance value depending on it's temperature. This change of resistance with temperature can be measured and used to determine the temperature of a process or of a material. The variation of resistance of the metal with the variation of the temperature is given as,

$$R_t = R_0[1 + (t - t_0) + \beta(t - t_0)^2 + \cdots\cdots]$$

Wire wound elements contain a length of very small diameter wire (typically .0005 to .0015 inch diameter) which is either wound into a coil and packaged inside a ceramic mandrel, or wound around the outside of a ceramic housing and coated with an insulating material. Larger lead wires (typically .008 to .015 inch diameter) are provided which allow the larger extension wires to be connected to the very small element wire. 2 Marks for Principle

Film type sensing elements are made from a metal coated substrate which has a resistance pattern cut into it. This pattern acts as a long, flat, skinny conductor, which provides the electrical resistance. Lead wires are bonded to the metal coated substrate and are held in place using a bead of epoxy or glass.



2 Marks for sketch

ii) Two applications of RTD and material used in it

RTD is used in power electronics, computer, consumer electronics, food handling and processing, industrial electronics, medical electronics, military, and aerospace.
RTD's are typically ordered as 100 Ohm Platinum sensors, other resistance's (200 Ohm, 500 Ohm, 1000 Ohm, etc.) and materials (Nickel, Copper, Nickel Iron) can be specified. **1 Mark for 2 applications and 1 Mark for two materials**

6 c) **Suggest the temperature transducer with reason for the following applications.**

i) Temperature of the winding of electrical machines.

ii) Temperature of refrigerator and air conditioner.

iii) Temperature of furnace and oven.

Ans:

i) Temperature of the winding of electrical machines.

To read the temperature in the electric motor windings, need a wired temperature sensor protected by heat shrink tubing. These measuring devices are distinguished by their high electrical resistance. The electrical machine like generators, motors, transformers may have different KW/ KVA capacities. Higher the capacity more is the current hence the temperature. According to the temperature range different measuring elements are preferred.

Measuring element: Bimetallic strip, Pt 100, Pt 1000, Ni 1000, NTC, PTC, K type thermocouple.

Operating temperature range: temperature class -20°C to 180°C

In domestic motors bimetallic strip is preferred for temperature measurement and control.

ii) Temperature of refrigerator and air conditioner:

Refrigerator or air conditioners are the cooling devices hence the temperature generally maintained below room temperature. The freezer part of refrigerator, temperature is maintained between 40º F (4ºC) to 0º F (-18ºC). Here the **thermistor** / **thermostat** as a temperature sensor is best suitable.

iii) Temperature of furnace and oven:

In the furnaces or oven the temperature is high above 100ºC and may have upper limit greater than 1200ºC. Hence for the temperature upto 550ºC PT-100, PT-1000 sensors are preferred and for higher temperatures J, K,S,T, R type Thermocouple sensors are preferred.

1 Mark for correct suggestion and 1 mark for reason = 2 Marks (for each bit)

Total 6 Marks