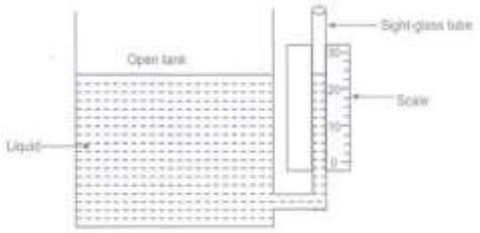
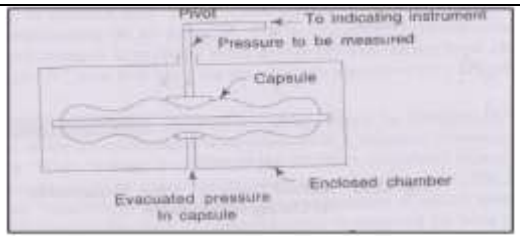
WINTER – 19EXAMINATIONS

Subject Name: Industrial measurements **Model Answer** Subject Code: 22335

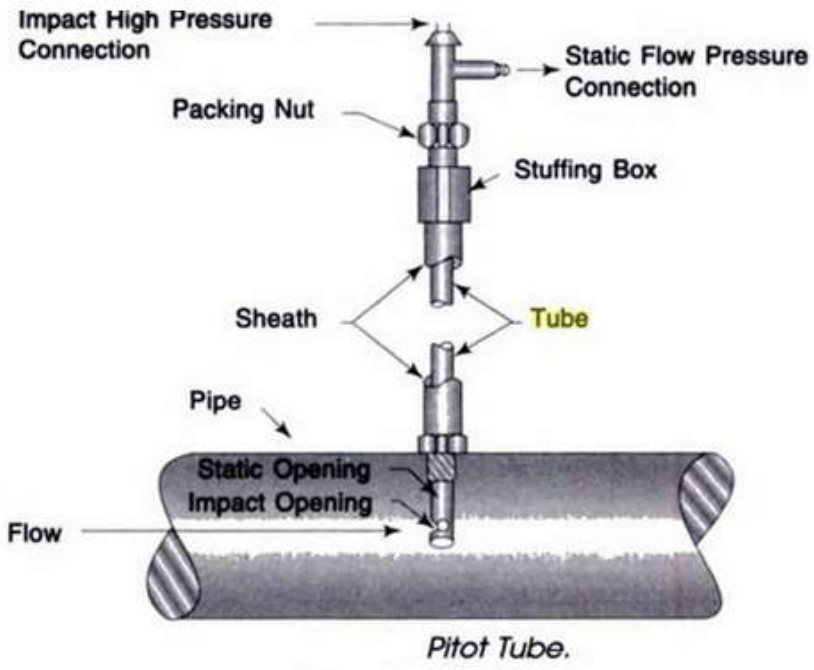
Important Instructions to examiners:

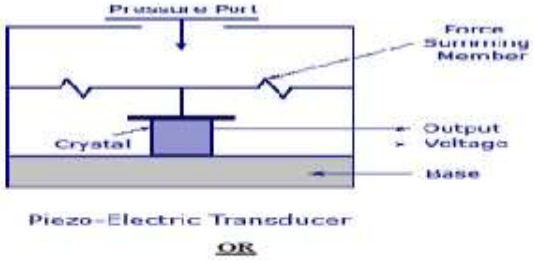
1) The answers should be examined by key words and not as word-to-word as given in themodel answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given moreImportance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constantvalues 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.

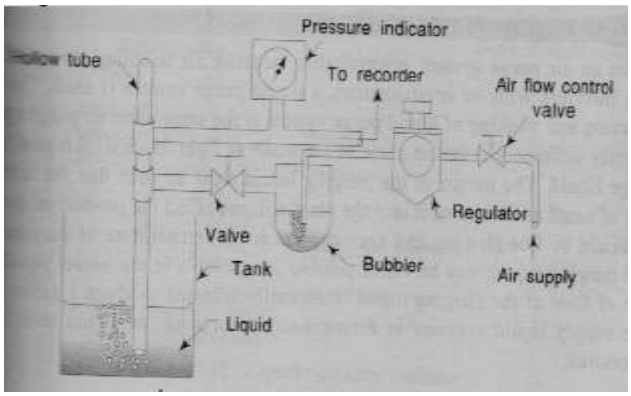
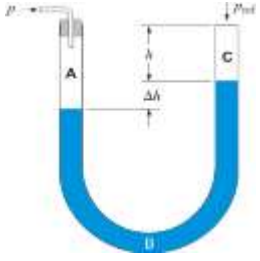
Q. No.	Sub Q. N.	Answer	Marking Scheme
Q.1		**Attempt any <u>five</u>of the following:**	**10-Total Marks**
	a)	**Define active and passive transducer. (1 mark each)**	**2M**
	Ans:	**Active Transducers:** .The active transducer does not use any external power source for producing the output. Example Solar Cell, Tachogenerator, Thermocouple, Photovoltaic cell, piezoelectric **Passive Transducers:** The passive transducer requires the additional energy source for working. Example LVDT, Thermistor, RTD, Strain gauge, potentiometer, capacitive transducer	**1M** **1M**
	b)	**Give classification of pressure measuring devices.**	**2M**
	Ans:	**Classification of pressure measuring devices.** 1 .Non elastic Pressure transducer/manometer i) U tube ii) Well type manometer iii)Inclined Type manometer 2. Elastic Pressure Transducer/Mechanical i) Bourdon tube ii) Bellows iii) Diaphragms 3.Electronics Pressure Transducer	**2M**

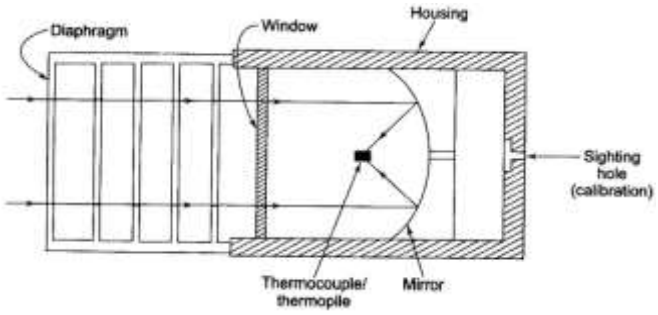
		i)Bourdon Tube with LVDT ii)Diaphragms with Strain Gauge(Resistive) iii)Capacitive, Piezoelectric	
	c)	**Sketch the neat diagram of sight glass measurement.**	**2M**
	Ans:		**2 M**
	d)	**Draw the neat digram of capsule.**	**2M**
	Ans:		**2 M**
	e)	**State working principle of RTD.**	**2M**
	Ans:	The resistance of RTD increases with increase in the temperature. The relation between the resistance element and temperature is as given below: $Rt=R0(1+\alpha t)$ α - temperature coefficient of the material R0- temperature at t0	**2M**
	f)	**Classify the following transducer on the basis of active and passive.** **(i) RTD:** **(ii) Piezoelectric:**	**2M**
	Ans:	**i. RTD: Passive device** **ii. Piezoelectric: Active device**	**1M each**
	g)	**List the materials for RTD and Thermocouple.**	**2M**
	Ans:	<table><tr><td></td><td>**Material**</td></tr><tr><td>**RTD**</td><td>Material used in the RTD are platinum, copper, nickel, tungsten</td></tr></table>	**1M**

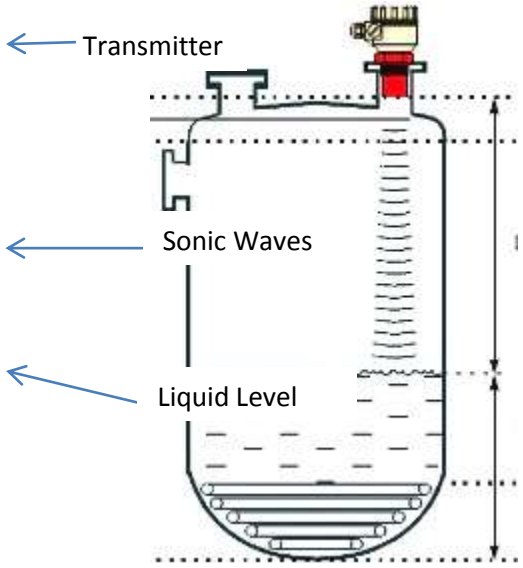
		Thermocouple	**TYPE Material** T Copper/constantan E Chromel/ constantan J iron/ constantan K Chromel/alumel R Platinum/platinum/13%Rhodium S Platinum/platinum/10%Rhodium B Platinum6%/platinum/30%Rhodium G Tungsten/Tungesten/Rhodium26% C Tungsten 5%Rhodium/Tungesten/Rhodium25%	

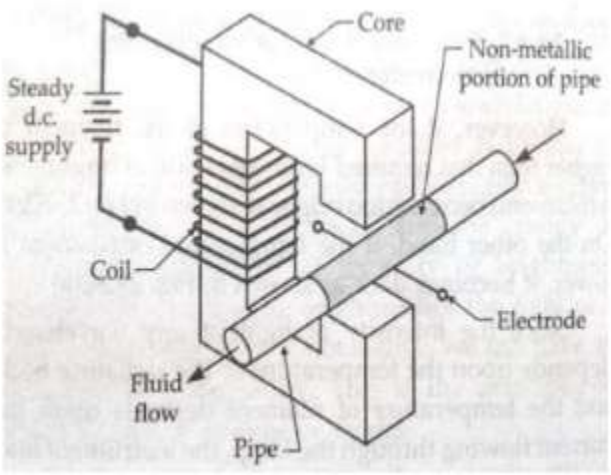
Q.2		**Attempt any THREE of the following:**	**12-Total Marks**
	a)	**Describe with neat sketch working of pitot tube.**	**4M**
	Ans:	**Diagram**  *Pitot Tube.*	**2M**

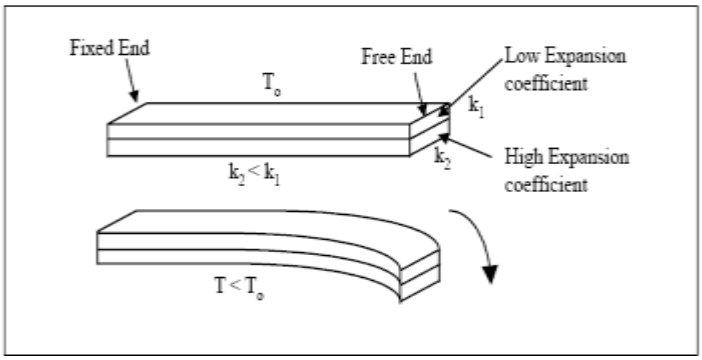
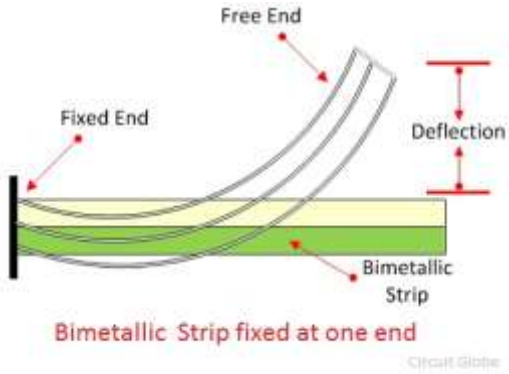
		Pitot Tubes Pitot tubes are used mainly for the measurement of fluid velocity. The operating principle of a pitot tube is based on the fact that when a solid body is kept centrally and stationary in a pipe line with a fluid streaming down, the velocity of the fluid starts diminishing due to the presence of the body till it is reduced to zero directly in front of the body. This point is known as the stagnation point. As the kinetic head (pressure) is lost by the liquid, it gains a static head. Thus, by measuring the difference between pressure at normal flow line and that at stagnation point, the fluid velocity is determined. A pitot tube consists of a tube with an impact opening of 3.125 to 6.35 mm which is placed directly in the line of flow, and a static opening at 90° from the impact opening, as shown in Fig. 11.6. The differential pressure across these taps is proportional to the velocity of the fluid. The measurement of quantity rate is calculated from the ratio of average velocity to the velocity at the point of measurement. For an accurate measurement, the pitot tube is moved across the entire diameter of the pipe to measure the velocity at several points and then the true average velocity is calculated. The accuracy of a pitot tube may range from ±1/2 to ±5%. Pitot tubes are rarely used in process streams but are used occasionally in utility streams where high accuracy is not necessary.	**2M**
b)	**Explain with neat labelled sketch the working of piezoelectric transducer.**		**4M**
Ans:	**Principle of operation**: When a pressure or force or vibration applied to the crystalline material like quartz crystal or crystalline substances then an e.m.f. is generated across the material or vice versa. **Diagram:**  Piezo-Electric Transducer OR 	**2M** **2M**
c)	**State the following for diaphragm and bourdon tube.** **(i) Material of construction** **(ii) Range of Pressure.**		**4M**
Ans:	**Diaphragms** are flexible circular discs, either flat or corrugated made up of materials such as brass, bronze		**2M**

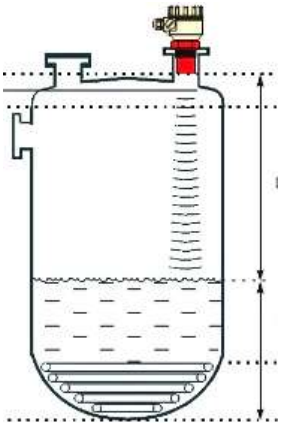
		Pressure ranges of diaphragm gauges fall between 10 mbar (0,145 psi) and 40 bar (580,15 psi). **Bourdon tubes** are made from materials such as phosphor bronze, alloy steel, stainless steel, monel metal, and beryllium copper. Pressure range of bourdon tube is almost 100,000 psi (700 MPa).	**2M**
	d)	**Describe with neat diagram air- purge method of level measurement.**	**4M**
	Ans:	**Diagram:**  **Working:** When there is no liquid in the tank or the liquid level in the tank is below the bottom end of the bubble tube, the air flows out of the bottom of the bubble tube and the pressure gauge indicates zero. In other words, there is no back pressure because the air escapes to the atmosphere. As the liquid level in the tank increases, the air flow is restricted by the depth of liquid and the air pressure acting against liquid head appears as back pressure to the pressure gauge. This back pressure causes the pointer to move on a scale, calibrated in terms of liquid level. The full range of head pressure can be registered as level by keeping the air pressure fed to the tube, slightly above the maximum head pressure in the tank. The range of the device is determined by the length of the tube. Because air is continuously bubbling from the bottom of the tube, the tank liquid does not enter the bubbler tube and hence, the tube is said to be purged. The common purging fluids are air, but, if air reacts with the tank fluid or is absorbed, different gases (like carbon or nitrogen) are chosen depending on liquid properties.	**2M** **2M**
Q.3		**Attempt any FHREE of the following:**	**12-Total Marks**
	a)	**Explain with labeled sketch the working of "U tube manometer'.**	**4M**
	Ans:	**Diagram:**  	**2M**

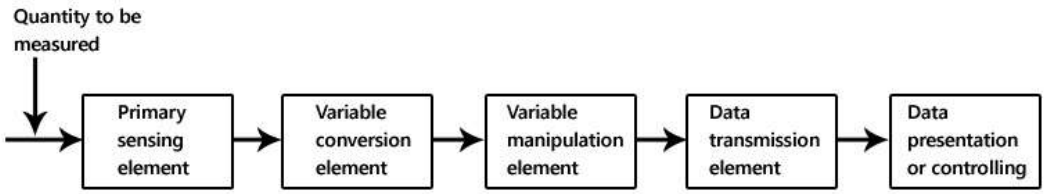
		Explanation: • The U-shaped tube filled with liquid measures the differential pressure, i.e., the difference in levels 'h' between the two limbs gives the pressure difference (P1 - P2) between them. • When pressure is applied at limb 1, the fluid recedes in limb 1, and its level rises in limb 2. This rise continues till a balance is struck between the unit weight of fluid and the pressure applied. • If the pressure applied at one opening; say limb 1 of the U-tube, is atmospheric pressure, the difference gives the gauge pressure at limb 2.Knowing the length of the column of the liquid, H, and density of the filling liquid, we can calculate the value of the applied pressure. • The applied Pressure = $\rho \times g \times h$ • $(P1-P2)= \rho \times g \times (h1-h2)$	**2M**
	b)	**Explain with neat sketch the working of radiation pyrometer temperature measuring device.**	**4M**
	Ans:	**Diagram:**  **Explanation:** A radiation pyrometer is a non-contact temperature sensor that infers the temperature of an object by detecting its thermal radiation emitted naturally. Working principle • An optical mirror collects the visible and infrared energy of an object and focuses it on a detector, as shown in the Figure. • The detector converts the collected energy into an electrical signal to control a temperature display or a control unit. • The detector receives the photon energy of the optical system and converts it into an electrical signal. • Two types of detectors are used: thermal (thermopile) and photon (photomultiplier tubes). • Photon detectors are much faster than the thermopile type. • This allows you to use the type of photon to measure the temperature of small objects	**2M** **2M**

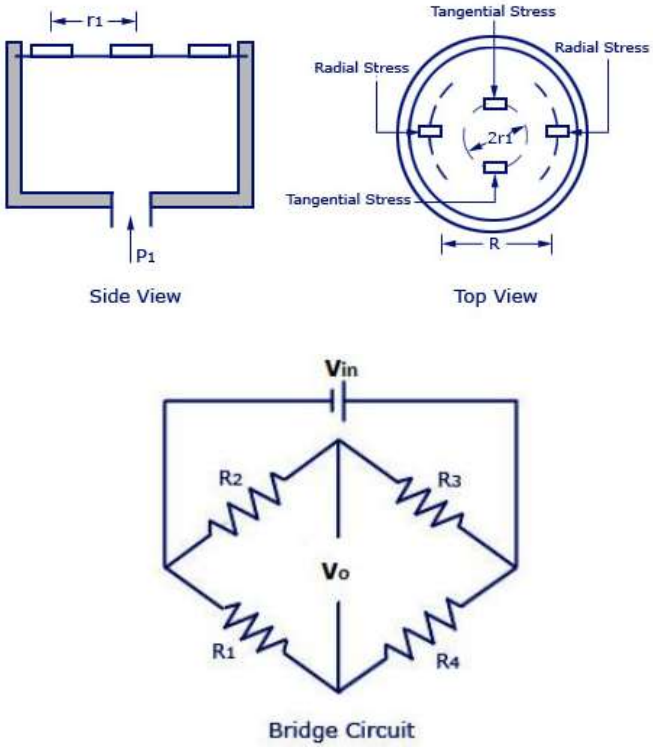
		that move at high speed	
	c)	**Explain with neat sketch the working of ultrasonic level measurement.**	**4M**
	Ans:	**Diagram:**  	**2M**
		Explanation: • An ultrasonic level transmitter is mounted on the top of the tank and transmits an ultrasonic pulse down into the tank. • This pulse, travelling at the speed of sound, is reflected back to the transmitter from the liquid surface. • The transmitter measures the time delay between the transmitted and received echo signal and the on-board processor calculates the distance to the liquid surface using the formula. • **Distance = (Speed of sound in air x time delay) / 2** • The time period between transmission and reception of the sound pulses is directly proportional to the distance between the transducer and surface.	**2M**
	d)	**Calculate o/p resistance of RTD PT100 at temp 60^0C and 110^0C temperature.**	**4M**
	Ans:	**AnsGiven : R_0= 100Ω at 0^0C, α=0.000389, Find out resistance at 60^0C and 110^0C** **Resistance at 60^0C** **R_T= R_0 (1+α (T_1-T_0)** **= 100(1+ 0.00389(60-0)** **= 123.34 Ω** **Resistance at 110^0C** **R_T= R_0 (1+α (T_1-T_0)** **= 100(1+ 0.00389(110-0)** **= 142.79Ω**	**2M Each**

Q.4	(A)	**Attempt any TWO of the following :**	**12-Total Marks**
	a)	**Explain with neat labelled sketch the working of electromagnetic flow meter.**	**4M**
	Ans:	**Diagram:**  **Fig: Electromagnetic Flow meter**	**2M**
		Explanation: Electromagnetic Flow Meters are based on FARADAY'S LAW INDUCTION. These meters are also called as Magflow or Electromagnetic Flow Meters. A magnetic field is applied to the metering tube, which results in a potential difference proportional to the flow velocity perpendicular to the flux lines. The physical principle at work is electromagnetic induction and mathematically defined as E=k*B*D*V. where, E=Induced Voltage (Linear with velocity), k=Proportionality Constant, B=Magnetic Field Strength (Coil Inductance), D=Distance between electrodes, V=Velocity of process fluid, the induced voltage (E) is directly proportional to the velocity (V) of the fluid moving through the magnetic field (B).	**2M**

	b)	**Explain with neat labelled sketch working of Bimetallic thermometer.**	**4M**
	Ans:	**Diagram:**   Bimetallic Strip fixed at one end	**2M**
		Explanation: • The bimetallic strip is constructed by bonding together the two thin strips of different metals. • The metals are joined together at one end with the help of the welding. • The bonding is kept in such a way that there is no relative motion between the two metals. The physical dimension of the metals varies with the variation in temperature. • Since the bimetallic strip of the thermometer is constructed with different metals. Thereby, the length of metals changes at different rates. • When the temperature increases, the strip bends towards the metal which has a low-temperature coefficient. And when the temperature decreases, the strip bends towards the metal which has a high-temperature coefficient. • The figure above shows the bimetallic strip in the form of the straight cantilever beam. The strip fixed at one end and deflects at the other end. • The range of deflection of bimetallic strip depends on the type of metals used for construction. The deflection of the metal is directly proportional to the length of the strip and the variation of temperature and is inversely proportional to the thickness of the strips	**2M**

	c)	**Convert the value of 500mm of Hg into bar and psi units.**	**4M**
	Ans:	**i) 1mm of Hg= 0.0193368 psi** **500mm of Hg= 500*0.019338=9.669psi** **ii) 1mm of Hg= 0.666612 bar** **500mm of Hg= 500*0.666612= 333.306 bar**	**2M Each**
	d)	**In a process industry, suggest a suitable level measuring technique for viscous liquid in a tank.**	**4M**
	Ans:	**Ultrasonic Level Meter is, suggest a suitable level measuring technique for viscous liquid in a tank, in a process industry.** **Diagram:**  **Working Principle:** • An ultrasonic level transmitter is mounted on the top of the tank and transmits an ultrasonic pulse down into the tank. • This pulse, travelling at the speed of sound, is reflected back to the transmitter from the liquid surface. • The transmitter measures the time delay between the transmitted and received echo signal and the on-board processor calculates the distance to the liquid surface using the formula. • **Distance = (Speed of sound in air x time delay) / 2** The time period between transmission and reception of the sound pulses is directly proportional to the distance between the transducer and surface.	**1M** **2M** **1M**

	e)	**Describe with neat sketch function of each block of instrumentation system.**	**4M**
	Ans:	**Diagram:**  **Explanation:** 1.**Primary sensing element** The primary sensing element is also known as sensor. Basically transducers are used as a primary sensing element. Here, the physical quantity (such as temperature, pressure etc.) are sensed and then converted into analogues signal. **2.Variable conversion element** It converts the output of primary sensing element into suitable form without changing information. Basically these are secondary transducers. **3.Variable manipulation element** The output of transducer may be electrical signal i.e. voltage, current or other electrical parameter. Here, manipulation means change in numerical value of signal. This element is used to convert the signal into suitable range. **4.Data transmission element** Sometimes it is not possible to give direct read out of the quality at a particular place (Example – Measurement of temperature in the furnace). In such a case, the data should transfer from one place to another place through channel which is known as data transmission element. Typically transmission path are pneumatic pipe, electrical cable and radio links. When radio link is used, the electronic instrumentation system is called as telemetry system. **5.Data presentation or controlling element** Finally the output is recorded or given to the controller to perform action. It performs different functions like indicating, recording or controlling.	**2M** **2M**
Q.5		**Attempt any <u>TWO</u> of the following:**	**12Total Marks**
	a)	**Explain with neat labelled sketch the electrical pressure transducer diaphragm strain gauge with reference to** **(i) Working** **(ii) merits**	**6M**

	Ans:	**Diagram (with strain gauges on diaphragm):**  	**2M**
		Working: This method uses the principle of converting pressure into a displacement by elastic elements which act as primary transducers. The displacement created is converted into an electrical parameter by secondary transducers. The figure above shows an arrangement of pressure measurement using four strain gauges mounted on a flat diaphragm. The gauges are electrically connected in a bridge circuit as shown in the figure. The diaphragm act as primary transducer and bonded strain gauges as secondary transducers. As pressure is applied, the diaphragm deflects causing radial and tangential stresses on the strain gauges. The stress cause strain on the gauges, changing the resistance of strain gauges. The change in resistances produces unbalance in the bridge circuit, producing an output voltage proportional to the applied pressure.	**2M**
		Merits: 1) Strain gauges are small and easy to install. 2) Good accuracy and stability. 3) Good resolution and easy to maintain 4) Contain no moving parts. 5) Readily adaptable to electronic systems (through wheatstone bridge circuit) and has fast speed of response.	**2M**
	b)	**Describe calibration procedure of RTD pt 100 with neat sketch and reading in the**	**6M**

		range of 0 to 500^{0}C.	
	Ans:	**Calibration setup:**	**2M**

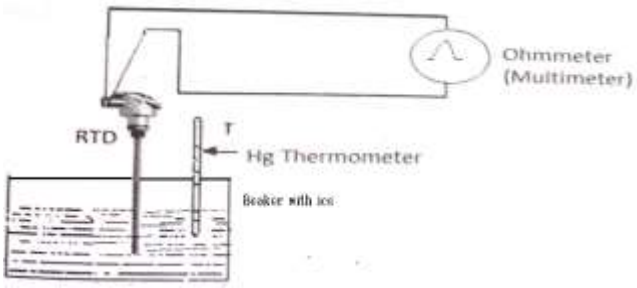


Fig.1 Ice-bath

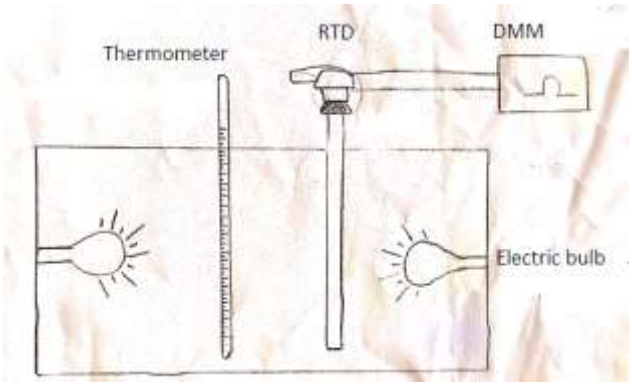


Fig.2 Temperature-well

2M

Procedure:

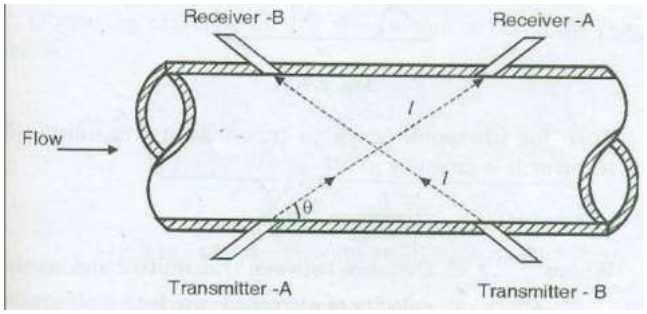
1) Immerse the RTD into ice-bath and note down the resistance and temperature (as shown in fig.1).
2) Immerse the RTD into a temperature-well capable of covering the required temperature range (as shown in fig.2).
3) Connect the RTD to a multi meter (set as Ohmmeter).
4) Switch on the temperature-well (lamps).
5) Record the readings of temperature and resistance at regular intervals up to the maximum range.
6) Calculate the error, ie, the difference in theoretical and practical values.
7) Plot the calibration graph, temperature Vs. resistance.

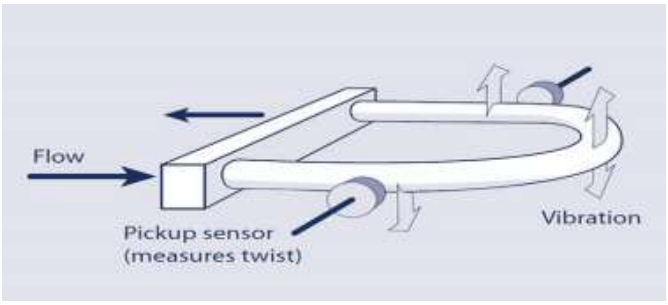
2M

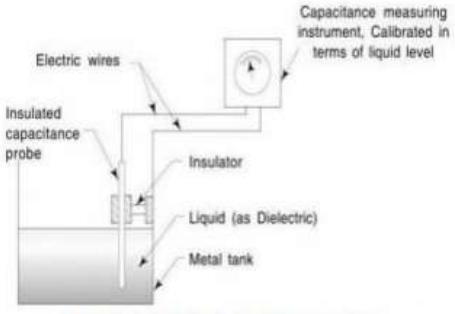
Calibration Table (readings provided is according to 5 point calibration)
Span is 500^{0}C

Sr No.	Temperature in ^{0}C	Resistance in Ohms(theoretical value – from the RTD chart)	Resistance in Ohms(measured value)	Error
1	0	100		

		2	125	147.94		
		3	250	194.07		
		4	375	238.39		
		5	500	280.9		

	(c)	**Describe ultrasonic flow meter with reference to** **(i) Construction** **(ii) Working** **(iii)Merits**	**6M**
	Ans:	**Diagram of time difference type ultrasonic transmitter:**  **Construction:** Time difference type ultrasonic flow meter consists of two transmitters and two receivers inserted into the pipeline, separated by a distance 'l' as shown in fig. **Working**: The operating principle of ultrasonic flow meter is based on the apparent change in the velocity of propagation of ultrasonic wave pulses in a fluid with a change in velocity of fluid flow. Ultrasonic waves are transmitted by Transmitter A in the direction of flow which is received by receiver A. Transmitter B transmits the wave in the opposite direction of flow and is received by receiver B. the difference in time taken by the waves from upstream to downstream is measured using a detector, which is a measure of the actual flow through the pipe. **Merits:** 1) It doesn't impose additional resistance to the flow 2) Its velocity/ output relationship is linear 3) It has no moving parts 4) High repeatability	**2M** **2M** **2M**
Q.6		**Attempt any TWO of the following:**	**12Total Marks**
	(a)	**Describe coriolis mass flow measuring device with reference to** **(i) Construction** **(ii) Working** **(iii)Merits**	**6M**

	Ans:	**Construction ('U' shaped tube flow meter):**  Coriolis meters are available in various designs, fig. shows a 'U' shaped tube flow meter. It consists of a 'U' shaped tube enclosed in sensor housing connected to an electronic unit. The tube is vibrated at its natural frequency by magnetic devices located at the end of the tube. **Working:** Coriolis flow meters works on the principle of 'Coriolis' effect. In a basic Coriolis meter, the fluid passes through one or more slightly bent tubes that are stimulated to oscillate in opposition to one another (or to a reference frame, for a single tube meter) to create an environment for the Coriolis Effect to occur. As the fluid flows through the tubes, the Coriolis Effect causes the downstream side of the oscillating tubes to slightly lead the upstream side, creating a small twist in the tubes. The rate at which the tube twists differs based on how fast or slow the fluid is flowing through the tubes. The twisting is directly proportional to mass flow rate. The twisting tube motion is measured by sensors located on the tubes. The signals from these sensors are processed to quantify the amount of twisting (in units of time) by comparing the time difference between the motions of the tubes detected at the inlet and outlet of the tubes. **Merits:** 1) Output doesn't depend on the temperature and pressure conditions. 2) Useful for adhesive fluids. **3)** Can be used for liquid nitrogen.	**2M** **2M** **2M**
	(b)	**Describe with neat labeled sketch the capacitance type level measurement with reference to** **(i) Calibration procedure** **(ii) Merits**	**6M**
	Ans:	**Diagram:**	**2M**



Calibration procedure: **2M**

1. Remove the sensor from the system (tank).
2. Check whether it shows zero reading otherwise, set to zero using 'zero adjustment pot'.
3. Fill liquid to 100% level
4. Check whether it shows maximum reading otherwise, set it to maximum using 'span adjustment pot'.
5. Now, fill the corresponding liquid in correct density and note down the readings .ie,fill liquid at 25%, 50%, 75% and 100% in both ascending and descending orders and note down the readings.
6. Check for errors,if present repeat the zero and span adjustments.

2M

Merits:

1) High sensitivity
2) Continuous measurement and control is possible
3) There are no moving parts
4) Suitable for slurry applications

	c)	**Explain any eight points selection criteria of transducer used for suitable application.**	**6M**
	Ans.	1. Operating range: Should have good resolution over the entire Range specified by the manufacturer. 2. Operating principle: As per the requirement, user should select transducer based on appropriate operating principle. 3. Sensitivity: it must be sensitive to small variation in input. 4. Accuracy: should have high degree of accuracy. 5. Frequency response and resonant frequency: It should have flat frequency response curve. 6. Errors : Minimum 7. Environmental compatibility: It should be compatible to the working environment. 8. Usage and ruggedness: Mechanical and electrical intensities of transducer verses its size and weight must be considered. 9. Electrical aspect: should consider Power rating, operating voltage and length and	**1M each**

		type of cable used. 10. Stability and Reliability: To handle and operate effectively, it should have high degree of stability and reliability. 11. Loading effect: Input impedance should be high and output impedance should be low to handle loading problems. 12. Static characteristics: should have high resolution, high degree of repeatability and low hysteresis. 13. General selection criteria: factors like Cost, compatibility, availability and technical assistance.	