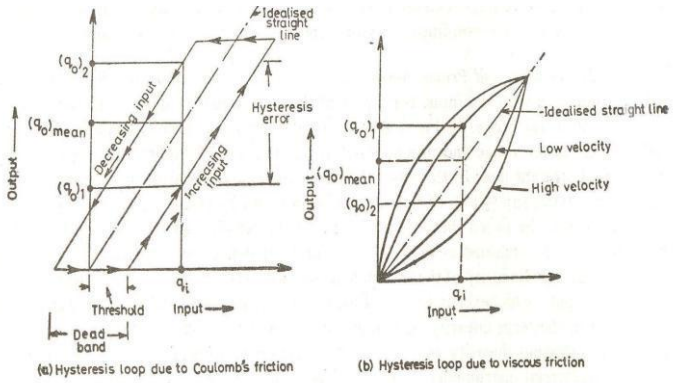
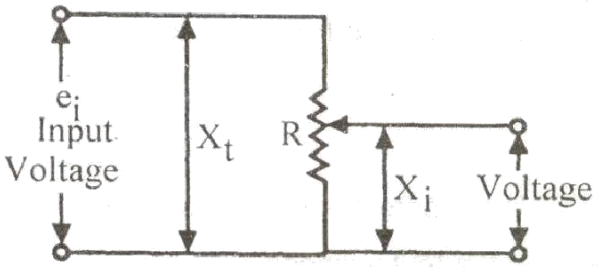
Important Instructions to examiners:

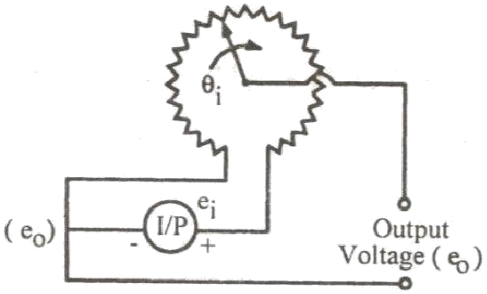
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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. No.	Sub Q. N.	Answer	Marking Scheme
1	a)	**Hysteresis** It is defined as the magnitude of error caused in the output for a given value of input, when this value is approached from opposite directions, i.e. from ascending order and then descending order. This is caused by backlash, elastic deformations, magnetic characteristics, but is mainly caused due to friction effects. Non coincidence of input output curve while loading and unloading is also called as hysteresis Hysteresis effects are best eliminated by taking the observations both for ascending and descending values of input and then taking the arithmetic mean. For example in fig (a) and (b), for the values of input q1, the output in ascending order is (q0)1 and in descending order (q0)2,  (a) Hysteresis loop due to Coulomb's friction (b) Hysteresis loop due to viscous friction Fig. 2.5 Typical output–input curves showing hysteresis effects Dead Zone	02M

It is defined as the largest change of the measurand to which the instrument does not respond. For example, in the output-input curve with hysteresis effect due to Coulomb's friction, the extent of the dead band is shown in fig. In such a cases, it is approximately twice the threshold value. 02M

b)Potentiometer is passive transducer since it requires external power source for its operation. Basically a resistance potentiometer consists of resistance element providing with a sliding contact. The sliding contact is known as wiper. The motion of the sliding contact may be translatory or rotational. Some have a combination of both motions with resistive element in the form of helix so called heliport. 02M





02M

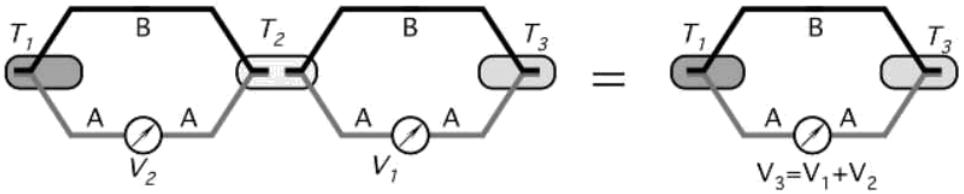
$$e_0 = \left(\frac{R_p \times \frac{X_i}{X_t}}{R_p} \times (e_i)\right)$$

c) Law of Intermediate Temperature

02M

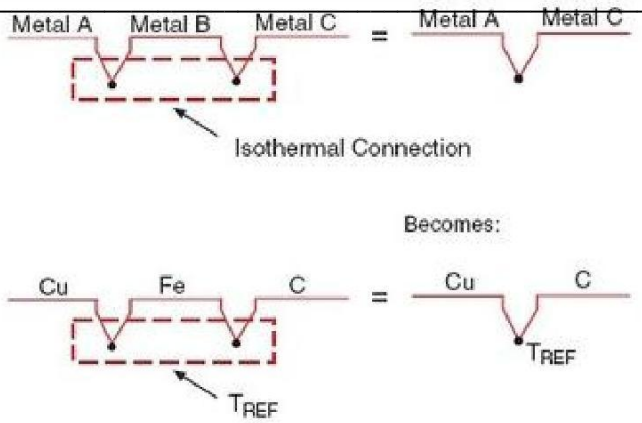
Consider thermocouple in which their junctions are at temperature T1 and T3 which produces the emf V3 . If other two thermocouples junctions are at temperature T1 and T2 producing emf V1, other at T2 and T3 producing emf V2 where T1<T2<T3 then V3 is algebraic sum of two emf V1 and V2

V3 = V1 + V2



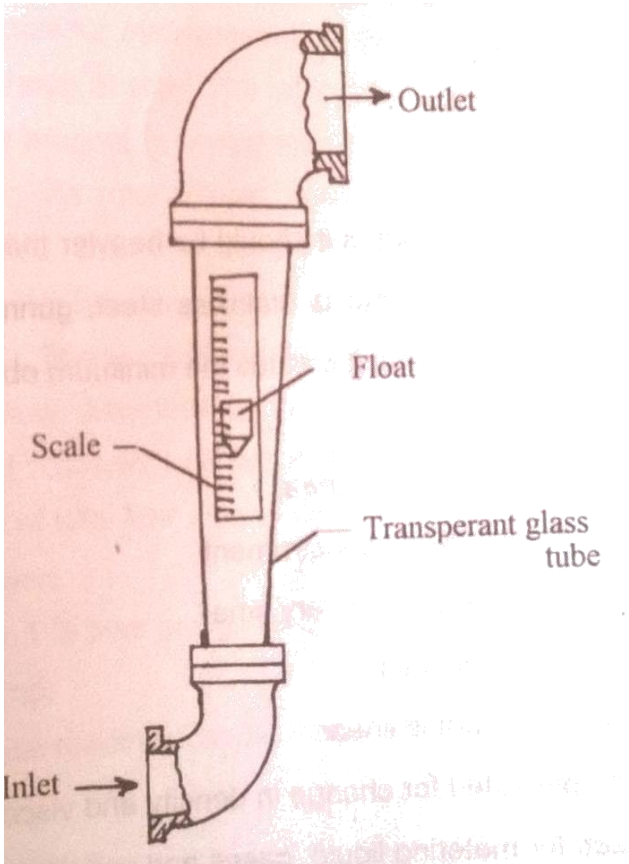
02M

Law of Intermediate Metals
This law states that third metal inserted between two dissimilar metals of a thermocouple junction will have no effect on the output voltage as long as two junction formed by additional material are at same temperature.



LAW OF INTERMEDIATE METALS

d)



02M

Rotameter is a variable area meter in which area is varied by a float in a tapered tube. In variable area meter, the size of area is adjusted by the amount necessary when flow changes. The float of the rotameter adjusts the size of area by using and falling in the tapered tube. Depending on the rate of flow, the float takes a position in the tube that increases or decreases the size of the area and thus keeps the differential pressure constant.

02

The rotameter consists of a transparent glass tube placed vertically such that the larger end is at top. This assembly is enclosed in a safety transparent shield for protection. Flow inlet is

provided at bottom of glass tube while flow outlet is at the top. The glass tube is graduated with a linear scale. When there is no flow, the float rests at the bottom of the glass as maximum diameter of float is less than the minimum bore of glass tube.

e) Gauge Factor is define as the unit change in resistance per unit change in length of strain gauge wire .

Mathematically Gauge factor is

= (**R/R)/ (L/L)**

Axial strain = L/L

Lateral Strain = d/d

02M

Strain Gauge materials

Advance : It is 55 % copper, 45 % nickel having gauge factor 2. It is most commonly used as it has reasonable gauge factor. It can be easily worked and soldered.

Isoelastic: It is 36 % nickel, 8 % copper, 4 % Mn, Si and molybdenum and rest of iron, It has gauge factor 3.5. It has high gauge factor. It useful in dynamic measurement.

Nichrome: It is nickel, chromium alloy having gauge factor 2.

Maganin : Manganin is a trademarked name for an alloy of typically 86% copper, 12% manganese, and 2% nickel. It has 0.47 gauge factor and low temperature coefficient.

Any four---2M

Monel : It has high temperature coefficient and gauge factor as 1.9.

This is alloy of Ni (67 %) and Cu (32 %) with small amount of iron and Mn

6Nickel : It has negative gauge factor (-12). It exhibits reduced resistance though length

increases and diameter decreases.

Generally thin strong paper is used for supporting or backing.

Usually, **Duco cement** is used as binding material.

f)

Hydraulic controllers	**Electronic control system**	
Uses oil as a working media	Electricity is operating medium	
Speed of response is slow	Extremely high speed of response	
More space is required	Less space is required	
Fairly good accuracy	Very high accuracy	
Unaffected by electrical noise	Susceptible to noise pick-ups	Any four
Are complicated and difficult to maintain	Are simple and easily maintained	---4M

g) A transducer senses the desired input in one physical form and converts it to an output in another physical form. Example: The input variable to the transducer could be a pressure, acceleration. Temperature and the output of transducer may be displacement, voltage or resistance change depending on type of transducer element — 02M

Classification of transducer — 02M

Active Transducer: These transducers does not require external source of power to produce their output.

Passive Transducer: These transducer derive the power required for generating output from an external source of power.

Resistive Transducer: This type of transducer converts the input into change in resistance.

Inductive Transducer: These type of transducers convert the input into change in inductance.

Capacitive Transducer: These type of transducers convert the input into change in capacitance.

2 a) — Any four----4M

Accuracy	Precision
It is the closeness with which an instrument reading approaches to the true value of the quantity being measured.	It is the degree of reproducibility among several independent reading of the same true value under specified condition.
It is expressed as the limit of error of a measuring g device	It is the degree of reproducibility among several independent reading of the same true value under specified condition.
Accuracy of measurement means conformity of the truth.	Precision refers to degree of agreement within group of measurement.
Expressed on the basis of % actual scale or full scale reading. Accuracy necessarily is with precision.	Precision in measurement does not guaranties accuracy.
Measurements are dependent on the systematic errors	Measurements are dependent on the random errors
Determined by proper calibration	Determined by statistical analysis

b)

Observational Errors

There are many sources of observation errors. As an example, the pointer of a voltmeter rests slightly above the surface of the scale. Thus an error on account of parallax will be occurred unless the line of the observer is exactly above the pointer. To minimize parallax error, highly accurate meters are provided with mirrored scale. 02M

When the pointers image appeared hidden by the pointer, observer's eye is directly in line with the pointer. Although a mirrored scale minimizes parallax error. An error is necessarily present though it may be very small.

Since, the parallax errors arise on account of pointer and the scale not being in the same plane, we can eliminate this error by having the pointer and the scale in the same plane.

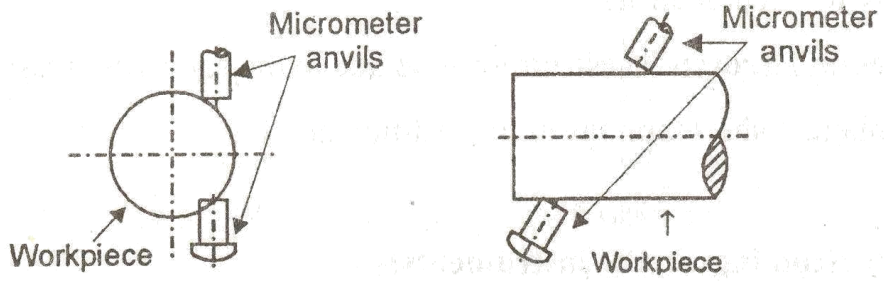
Wrong Reading Taken, Tendency to Read High or to Read Low , Lack of Experience, Parallax Errors are the observational errors

Operational Errors

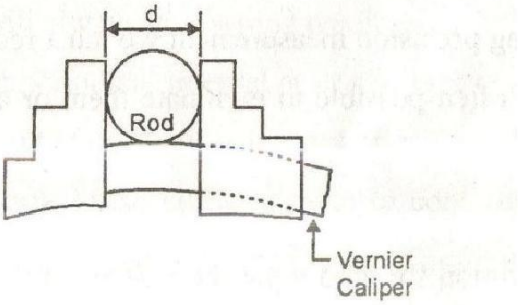
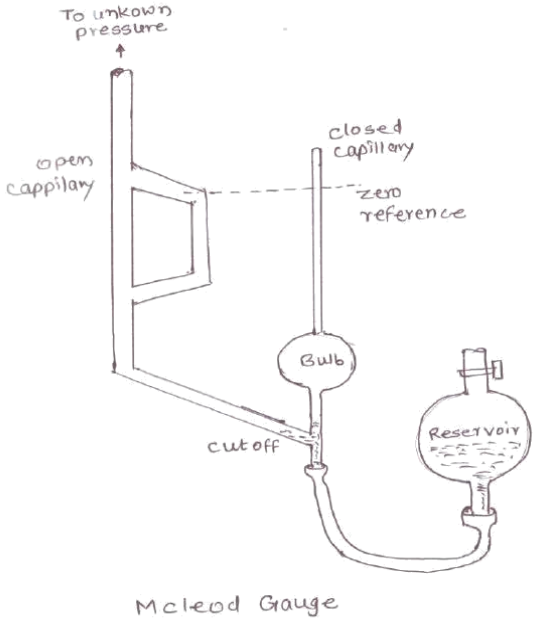
02M

Quite often errors are caused by poor operational techniques. There is an old saying that instruments are better than the people who use them. Too often the errors caused in measurements are due to the fault of the operator than that of the instrument. A good instrument used in a unintelligent way gives erroneous results.

Misalignment error



Excessive Pressure

	c)		02M
		 Mcleod Gauge **Mcleod Gauge** The gas enters the gauge through the open capillary tube and fills the tubes down to the level of mercury in the reservoir. The pressure is equal through the tubes and the bulb. Mercury is pumped up from the reservoir. As the mercury raises the cut-off, it traps the gas inside the bulb. The mercury is then pumped higher in the open end capillary tube until all the gas in the bulb is compressed into the bulb. Operator allows the mercury to rise until it reaches zero reference line on the closed capillary tube. The mercury rises faster in the open capillary tube. The compression of gas in closed capillary tube makes the pressure of trapped gas higher than the measured pressure. This pressure difference causes difference in the mercury level in the two tubes. Mathematically pressure is calculated as $P = KHHo(1 - KH)$	02M
	d)	LVDT is a displacement measuring device. It is the device which converts the linear	1M

displacement in voltage produced and then the voltmeter is calibrated in terms of displacement.

A movable soft iron core is placed inside the former.

The displacement to be measured is applied to an arm attached to the soft iron core. In practice, the core is made of Ni-Fe alloy which is slotted longitudinally to reduce eddy current losses.

02M

When the core is in its normal (null) position, equal voltages are induced in the two secondary windings.

Accordingly, output voltage E_{S1} of the secondary winding S_1 is more than E_{S2}, the output voltage of secondary winding S_2.

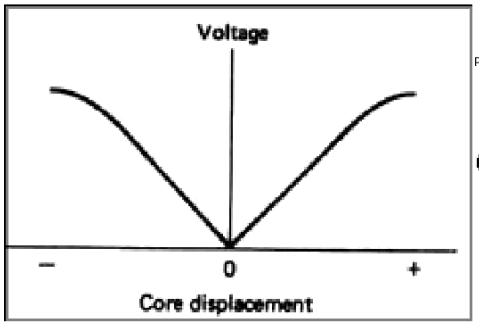
The magnitude of voltage is thus E_{S1}- E_{S2} and the output voltage is in phase with E_{S1}, the output voltage of secondary winding S_1.

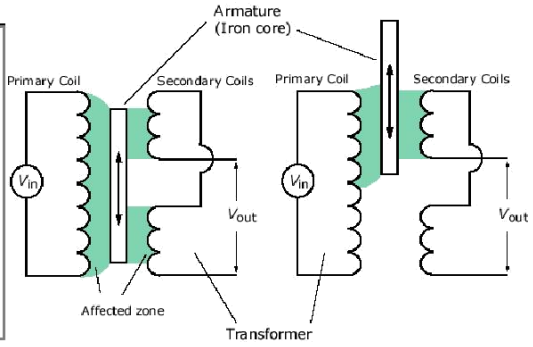
Similarly, if a core is moved to the of null position, then the flux linking with winding S_2 becomes larger than that with winding S_1. This results in E_{S2} becoming larger than Es_1. The output voltage in this case is $E_0 = E_{S2}$- E_{S1} and is in phase with E_{S2}; i.e., the output voltage of secondary winding S_2.

The amount of voltage change in either of secondary windings is proportional to the amount of movement of the core. Hence, we have an indication of the amount of linear motion.

By observing which voltage output is increasing or decreasing, we can determine the direction of motion. In other words, any physical displacement of the core causes the voltage of one secondary winding to increase while simultaneously reducing the voltage in the other 01 secondary winding.

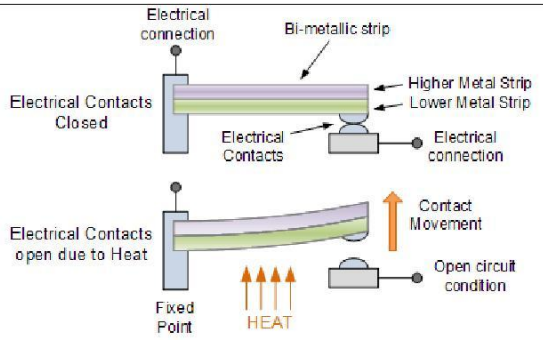
The difference of two voltages appears across the two output terminals of the transducer and gives a measure of the physical position of the core and hence, the displacement.





1M

e) Bimetallic Thermometer



02M

Bulb thermometers are good for measuring temperature accurately, but they are harder to use when the goal is to control the temperature. The **bimetallic strip** thermometer, because it is made of metal, is good at controlling things.

The principle behind a bimetallic strip thermometer relies on the fact that **different metals**

01M

expand at different rates as they warm up. By bonding two different metals together, you can make a simple electric controller that can withstand fairly high temperatures. This sort of controller is often found in ovens. Here is the general layout:

Two metals make up the bimetallic strip (hence the name). In this diagram, the green metal would be chosen to expand faster than the blue metal if the device were being used in an oven. In a refrigerator, you would use the opposite setup, so that as the temperature rises the blue metal expands faster than the green metal. This causes the strip to **bend** upward, making contact so that current can flow. By adjusting the size of the gap between the strip and the contact, you control the temperature.

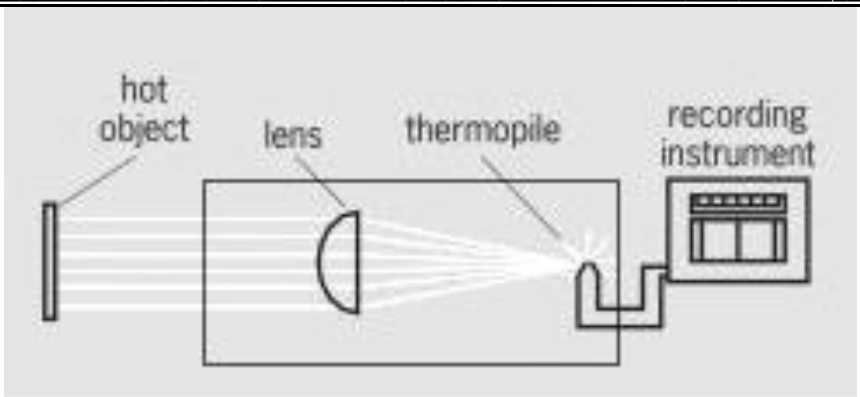
Applications 01M

These are often found long bimetallic strips **coiled** into spirals. This is the typical layout of a backyard dial thermometer. By coiling a very long strip it becomes much more sensitive to small temperature changes. In a furnace thermostat, the same technique is used and a **mercury switch** is attached to the coil. The switch turns the furnace on and off.

f) Explanation of any pyrometer

Radiation or Optical Pyrometer 2M

Pyrometry is a technique for measuring temperature without physical contact. It depends upon the relationship between the temperature of hot body and electromagnetic radiations emitted by the body. When the body is heated it emits thermal energy known as heat radiation. A black surface is very good absorber of heat radiations and very good emitter of such radiations when heated. This method determines the body temperature by measuring its radiations.



Radiation Pyrometer

Principle of radiation pyrometer is based on the measurement of radiant energy by the hot body. It consists of a lens to focus radiated energy from the body, whose temperature is to be measured. This receiving element may have Varity of forms such as resistance thermometer , thermocouple or a thermopile. A thermopile consists of several thermocouples connected in seris. A temperature indicator , recorder or controller is attached with receiving element to indicate the temperature. 02M

When the total energy radiated by the hot body whose temperature is to be measured enters the pyrometer it is focused by the lens on to the detector. The detector is a thermopile whose measuring junctions are are attached to a blackened disc. The disc absorbs the energy when the pyrometer is focused on a hot body and its temperature rises. The reference junction of thermopile is attached to the pyrometer case. The difference in temperature between the measuring junction and the reference junction generates a voltage that is directly related to the temperature of blackened disc which is indicated by recording instrument.

3		**Attempt any FOUR**	**4×4=16**
	(a)	**State and explain significance of overshoot and fidelity for measuring instrument** **Solution:** **Overshoot:** 2M It is maximum amount by which pointer moves beyond steady state. It indicates the mass and inertia extent of measuring instrument. • Overshoot represents a distortion of the signal. • In circuit design, the goals of minimizing overshoot and of decreasing circuit rise time can conflict. • The magnitude of overshoot depends on time through a phenomenon called *" damping."*. • Overshoot often is associated with settling time, how long it takes for the output to reach steady state **Fidelity:** 2M It is defined as the closeness with which the system indicates or records the signal which is impressed upon it. It refers to the ability of the system to reproduce the output in the same form as the input. For e.g. if the input is sine wave then the system with 100% fidelity will also produce the sine wave as output.	
	(b)	**Explain capacitive transducer works with one application.** **Ans:**	

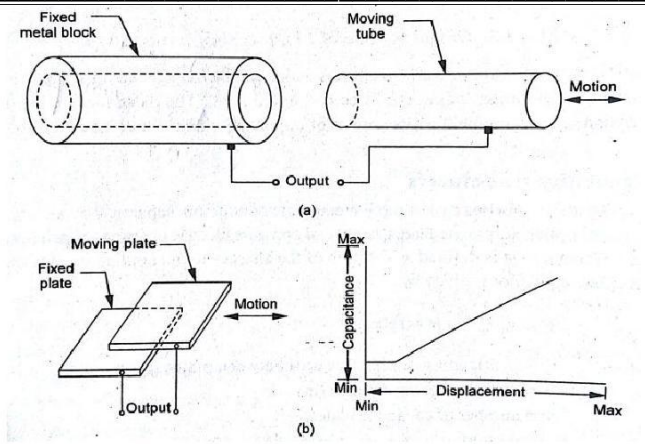


Diagram 1 mark

Acapacitor comprises two or more metal plate conductors separated by an insulator.

As voltage is applied across the plates, equal and opposite electric charges are generated on the plates. Capacitance is defined as the ratio of the charges to the applied voltage and for parallel plate capacitor is given by:

Construction and Working 2 mark

$$C = \frac{\epsilon A}{d}$$

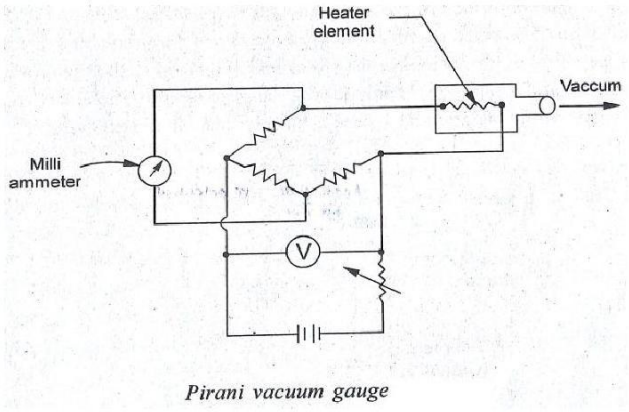
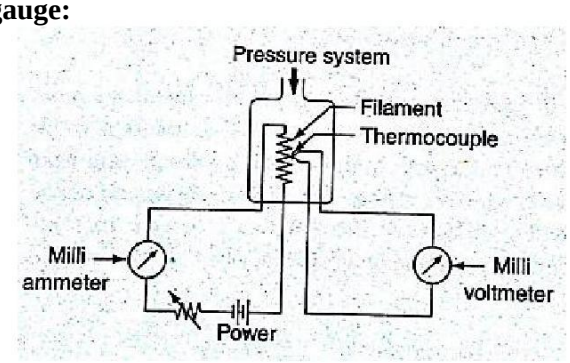
Where; C = capacitance between the plates
= dielectric constant for medium between the plates A = overlapping area of plates
d = distance between the plates

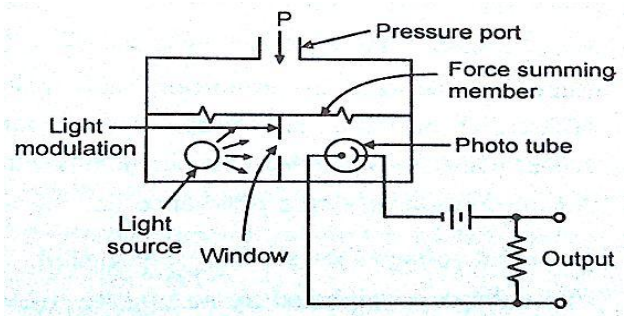
A capacitive pick up operates on the principle of a variation in capacitance produced by the physical quantity being measured.

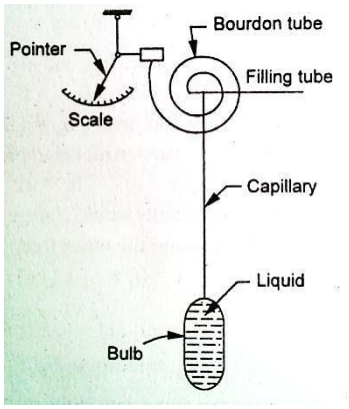
Capacitance can be changes by varying,
= dielectric constant for medium between the plates, or
A = overlapping area of plates or
d = distance between the plates

e.g. Mechanical displacement can be measured by noting the change in capacitance brought about by either change in overlapping area or change in distance between plates as shown in figures. The change in dielectric is used to measure changes in liquid or gas levels...

Application 1 mark

	(c)	**Explain pressure measurement using thermal conductivity gauge with a neat sketch.**	
		Ans: Explanation of either Pirani gauge or Thermocouple vacuum gauge shall be given due credit.	
		These gauges measure pressure through a change in the thermal conductivity of the gas. Their operation is based on a thermodynamic principle that "at low pressures there is a relationship between pressure and thermal conductivity i.e. heat conductivity decreases with decreasing pressure." The temperature of an electrically heated filament depends upon the magnitude of the current and rate of heat dissipation from the element.	Working Principle- 1 mark
		Pirani gauge:	
		 *Pirani vacuum gauge*	Diagram 1 mark
		Construction: -Consists of platinum filament wire enclosed in a chamber connected to unknown pressure source. -Filament forms an arm of W-bridge. -Compensating resistance is placed in opposite arm.	1Mark
		Working: Due to constant current, filament gets heated. -At low pressure, thermal conductivity gets reduces. -Temperature variation leads to resistance variation of filament which unbalances the W- bridge. -Change in resistance of wire filament gives value of unknown pressure. Range is between 10^{-5} mm to 10 mm of Hg.	1Mark
		OR **Thermocouple vacuum gauge:**	
			Diagram- 2M
		Construction: - Consists a heater element. - A thermocouple joined to heater enclosed in a glass tube. - Other end of glass tube is connected to vacuum. - Provision is made to heat the element.	**1Mark**
		Working: - Constant current is supplied to heater element. - Temperature of heater element is function of pressure and is measured by thermocouple. - The output voltage of thermocouple is measured which gives pressure.	1Mark

		- Range – 10^{-4} to 1 torr.	
	(d)	**Explain construction and working of photoelectric pressure transducer.** **Ans:**  **Working Principle:** Amount of incident light falling on phototube is a function of change in pressure. **Construction:Figure** • Consists of phototube and an a. c. light source separated by a small window. • The aperture size is controlled by force summing member of pressure transducer. **Working:** • Applied pressure will be detected by force summing member. • Applied pressure changes the position of force summing member. • This varies the opening of window. • Variation in opening of window causes a change in incident light on phototube. • The change in light intensity varies photo emissive properties at a linear rate with displacement.	Diagram 1 mark Principle 1 mark Construction 1 mark Working 1 mark
	(e)	**Explain working principle of pressure thermometer with neat sketch.** **Ans:** **Working Principle:** Change in temperature will cause change in pressure of fluid. (Pressure is a function of temperature of the fluid in constant volume) Change in pressure can be measured as temperature.	2Marks



Construction 2Marks

- Metal container filled with temperature sensitive liquid or gas or vapor pressure.
- Flexible capillary tube.
- Pressure or volume sensitive device. e.g. bourdon tube, bellows, diaphragms
- Indicating and recording device.
- Flexible capillary tube is connected to bulb and Pressure sensing device as shown in figure

Working-

- Change in temperature causes fluid to expand or contract.
- Effect is transmitted through capillary to bourdon which converts signal to useful form on the indicator as a temperature.
- Mechanical linkage/pneumatic or electrical device transmit signal over a long distance.

(f) Explain the construction and working of RTD.

Ans:

Working Principle:

- As the temperature changes, the resistance of the conductor also changes. Resistance R in ohms of an electrical conductor of resistivity (ohms.c), length L(cm) and cross sectional area (cm^2) is given by $R = \rho \frac{L}{A}$ — Principle 1 mark
- This is due to change in two factors:
  i) Dimensional change due to expansion or contraction and
  ii) Change in the current opposing properties of the material itself.
- This change in resistance due to temperature is calibrated to measure the temperature.

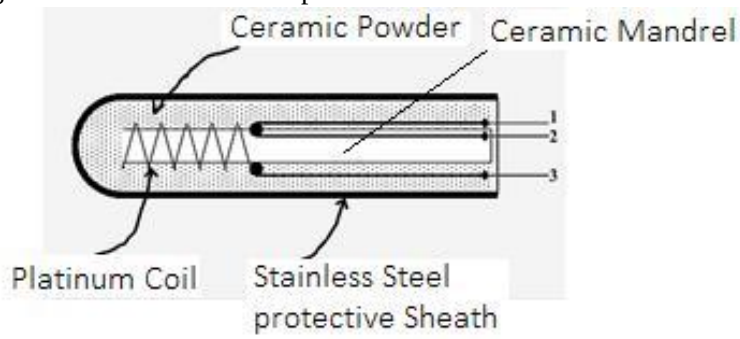
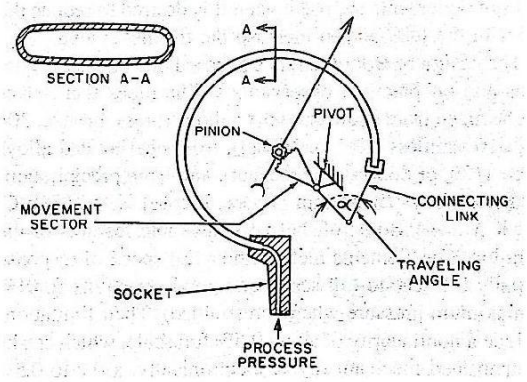
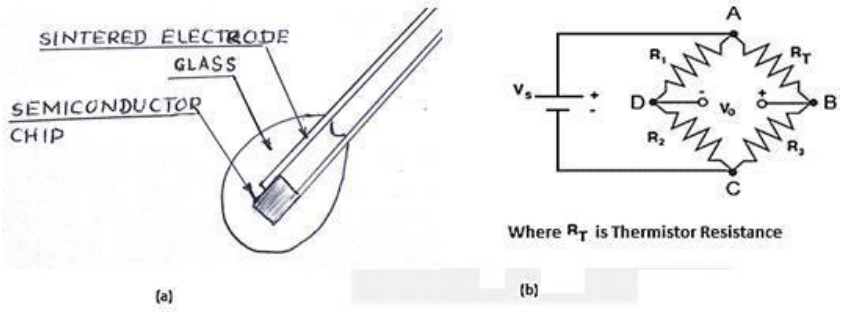
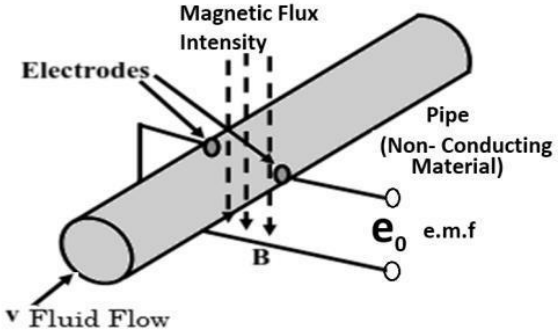


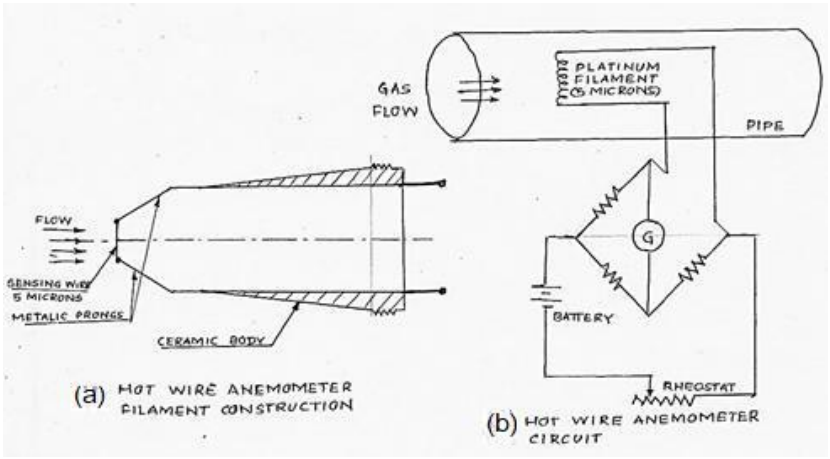
Diagram 1 mark

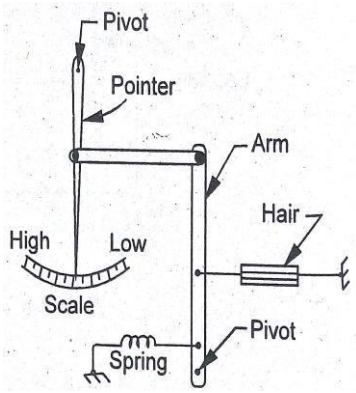
Construction: Figure

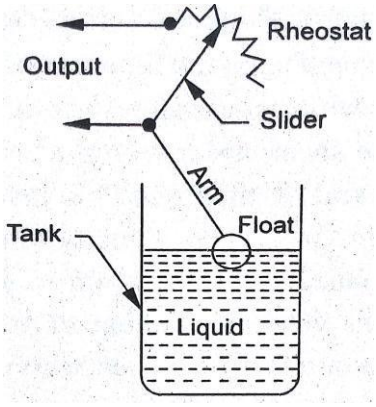
- Platinum filament is coiled on ceramic mandrel.
- Platinum is used due to its linearity with change in temperature and chemical inertness. Constructi

		• Coiled platinum is protected by stainless steel metal sheath. • Ceramic or mica powder insulates the leads. • The leads connected in Wheatstone bridge. • The lead wires are usually of higher diameterthan the diameter of the sensor wire to reduce the lead wire resistance. **Working:** • Steel protective sheath detects the temperature and transfer it to platinum filament. • Temperature is sensed by platinum filament and changes its resistance. • Change in resistance value of Platinum coil is very small with respect to the temperature. So, the RTD value is measured by using a bridge circuit. • Temperature is determined by converting the RTD resistance value using a calibration expression. • Dummy wire reduces impedance effect and so the error.	on 1 mark Working 1 mark
4		**(a) Explain with the neat sketchpressure measurement using Bourdon Gauge. Ans:**  **Working Principle**: If a curved or twisted tube is held and pressurized at its open end, produces movement at its closed end (Tip Travel). **Construction:** • Consists of elliptical c/s bourdon tube bend into arc of circle.(250^0 to 270^0) • Materials for Tube: Brass, Bronze, SS, Monel,Beryllium copper, Inconel X, Ni-Span C, • Bourdon tube can be C shaped, helical, Spiral and twisted tube. • Open end of tube is fixed and pressure is applied to this end. • Closed end is free and connected to mechanical linkages.(Sector & pinion) • Pointer is pivoted on pinion. • Pointer can move on a indicating scale. **Working:** • Applied pressure tends to change cross section of tube from elliptical to circular. • This makes the tube straighten itself with increase in radius of curvature. • This causes free end of tube to move. • Displacement of tube rotates pinion through mechanical linkages and sector of a gear. • Movement of pointer over calibrated scale directly indicates pressure in terms of N/m^2 or PSI or m head of mercury. • High Range (Min span 100kPa to max span 690 MPa) (Min span 1 bar to max span 6900 bar)	Diagram 1 marks Working Principle 1 mark Constructi on 1 mark Working 1 mark
	(b)	**Explain temperature measurementusing thermistor?** **Ans:** **Working Principle:** • Thermistors are essentially semiconductors which behave as resistors with high negative	Working

		temperature coefficient. • As the temperature increases, the resistance goes down and vice-versa. • Very high sensitivity to temperature changes (decrease in resistance as much as 6% for each 10C rise in temp.) makes it useful for precision temperature measurement.  **Construction: Figure (a)** • Thermistors are composed of sintered mixture of oxides and manganese, nickel, cobalt, iron and uranium. • These metallic oxides are milled, mixed un appropriate proportions, are pressed into the desired shape with appropriate binders and finally sintered. • Electrical terminals are either embedded before sintering or baked afterwards. • Electrical characteristics are controlled by varying the type of oxide used and physical size and the configuration of thermistor. • May be shaped in the form of beads, disks, washers, rods. **Working:** • Thermistors form one of the resistances of Wheatstone bridge as shown in **figure b.** • Change in resistance due to change in temperature is negative i.e.as the temperature increases, the resistance goes down and vice-versa. • Change in resistance is measured by Wheatstone bridge which is directly calibrated as value of temperature.	Principle 1 mark Diagram 1 marks Construction 1 mark Working 1 mark
	(c)	**Explain flow measurement using electromagnetic flow meter with neat sketch.** **Ans:** **Working Principle:** • Electromagnetic Induction i.e. when a conductor moves along a magnetic field perpendicular to the direction of flow, a voltage would be induced perpendicular to the direction of movement as also to the magnetic field.  **Construction:** • It consists of a permanent magnet or electromagnet. • Either alternating current (if the liquid medium is water or any other polarizable liquid) or direct current supplied to a non-conducting pipe.	Principle 1 mark Diagram 1 mark Construction 1 mark

		• Two electrodes placed at right angles to the magnetic field for picking up the induced emf. • Fluid flow in the pipe which is right angles to plane of magnetic field and induced emf direction. • The magnet, pipe for conducting liquid and electrodes are mutually perpendicular to each other. **Working:** • The flowing liquid acts like a conductor. • External magnetic field is applied perpendicular to the direction of the flow and two electrodes are flushed on the wall of the pipeline as shown • Conducting liquids cuts the magnetic flux lines and hence emf is induced in it. • The expression for the voltage induced is given by: $$e_o = B\,l\,v$$ where , e_o = Induced e. m. f. B = Magnetic Flux Density l = Length of conductor (diameter of Pipe) v = velocity of conducting fluid • The e. m. f. induced is picked up by two electrodes. • This induced e. m. f. is directly proportional to the velocity of fluid as B = Magnetic Flux Density and l = Length of conductor (diameter of Pipe) is constant. • The e. m. f. induced is calibrated to give the value of fluid flow rate.	Working 1 mark
	(d)	**State and Explain construction and working of hot flow anemometer.** **Ans:** • The temperature of an electrically heated filament depends upon the magnitude of the current and rate of heat dissipation from the element. • Change in temperature of filament due to change in fluid flow rate will cause to change the resistance of the filament. • Variation in resistance of heated filament is directly proportional to velocity of fluid. **Construction** • Hot wire anemometer measure the mean and fluctuating flow of gases. • The sensor is a 5 micron diameter platinum-tungsten wire welded between the two prongs. • These prongs are housed in a ceramic body as shown in figure (a). • This wire heated electrically forms one of the resistances wheat-stone bridge circuit.Fig.(b)  **Working:** • When the probe is introduced into the flowing fluid, it tends to be cooled by instantaneous velocity. So, tendency for the electrical resistance to diminish.	Principle 1 mark Diagram 1 marks

		• The rate of cooling of wire depends upon the - - Dimension and physical properties of wire - Diff. of the temp. between wire and the fluid - Physical properties of the fluid - Stream velocity under measurement • First three conditions are effectively constant and the instrument response is then a direct measurement of the velocity change. • As the velocity of fluid will change, it will vary the heat carried away from the heated filament. • This will cause to change the temperature of filament and resistance. • Change in the value of resistance will be calibrated to measure the flow rate by using Wheatstone bridge.	Constructi on1 mark Working 1 mark
	(e)	**Explain the instrument used for measurement of humidity.** **Ans:** **Working Principle:** Change in the moisture content cause a change in the physical and chemical characteristics of certain materials. Hygroscopic materials like human hair, animal membrane, wood and paper undergo changes in the linear dimensions when they absorb moisture from the atmosphere. This absorption is dependent on the temperature and partial pressure of atmosphere and hence on the humidity. Instrument used for measurement of humidity is Absorption hygrometer. **Construction:** It consists of a sensor which comprises of strands of hair. Different hair strands, arranged in a parallel beam, are sufficiently separated from each other to give free access to the atmosphere. For proper functioning, the element is maintained under light tension by a spring. The change in the length of hair strand can be transmitted to the indicating dial by a suitable mechanism as shown in figure.  **Working:** When the moisture content of atmosphere surrounding the hair strand changes, the length of the hair strand changes. This change in length is transmitted to the pointer by the mechanism which directly gives the value in terms of moisture content or relative humidity.	Principle 1 mark Constructi on 1 mark Diagram 1 mark Working 1 mark

	(f)	**Explain float and resistance type of instrument used for liquid level measurement.** **Ans:** **Working principle;** Change in the float level moves the slider over a rheostat causing change in resistance. This change in resistance is calibrated as the liquid level.  **Construction:** Consists of float whose arm is connected to slider of rheostat. Arm of a float and slider forms a lever as shown in figure. **Working:** When the liquid level changes it moves the float up and down. Float displacement actuates slider to slide over the resistance coil of rheostat, This changes the length of resistance coil in the circuit changing the value of resistance. This change in resistance changes the output current which is calibrated as the liquid level.	Principle 1 mark Diagram 1 mark Construction 1 mark Working 1 mark
5	a)	**Working of turbine meter:** • The turbine flow meter consists of a multi blade rotator which is placed at right angle to the axis of flowing fluid. • The rotor is supported by ball bearing on a shaft . This is free to rotate about its axis . • A magnetic pickup coil is placed near the table . It is used to measure the speed of blade. • **The turbine flow meter works on basic principle of turbine** .. • Turbine flow meter consists of a freely rotating wheel (rotor or propeller) with multiple blades. • The rotor is supported by ball or sleeve bearings and is located centrally in the pipe along which the flow occurs. • Flowing fluid impinging on turbine blade imparts a force on blade surfaces and set the rotor in motion with angular speed which is proportional to the fluid velocity. • The rotor speed is measured with mechanical counter or with an electro –magnetic pick up. • The rate of pulse gives flow and total number of pulses gives a measures of the flow . **Application** : i) It is used for measurement of liquid , gas and very low flow rates. ii) To measure wind speed/velocity	**Explanation: 2 M & Diagram 2 M**

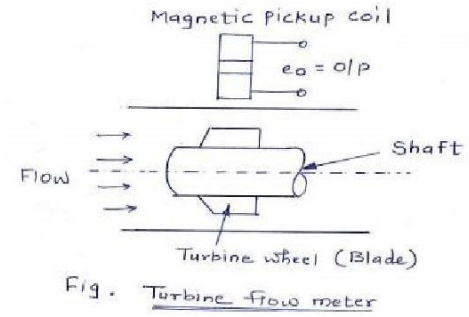
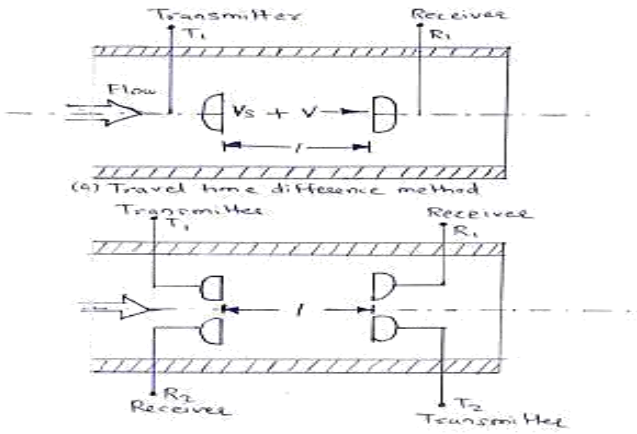


Fig. Turbine flow meter

5 **b)** **Working of Ultrasonic flow meter:**

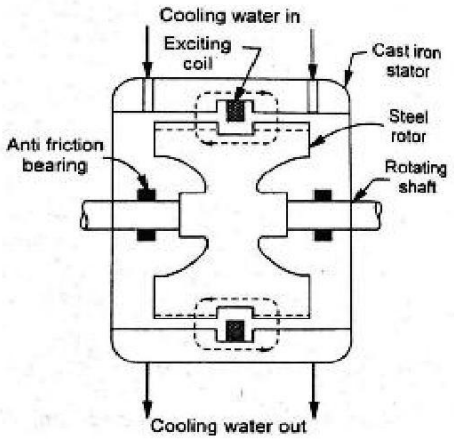


Explanation: 2 M & Diagram 2 M

Ultrasonic flow meters measure the difference of the transit time of ultrasonic pulses propagating in and against flow direction. This time difference is a measure for the average velocity of the fluid along the path of the ultrasonic beam. By using the absolute transit times both the averaged fluid velocity and the speed of sound can be calculated. Using the two transit times and the distance between receiving and transmitting transducers.

An ultrasonic flow meter is a type of that measures the velocity of a fluid with ultrasonic flow meter to calculate volume flow. Using ultrasonic transducers, the flow meter can measure the average velocity along the path of an emitted beam of ultrasound, by averaging the difference in measured transit time between the pulses of ultrasound propagating into and against the direction of the flow or by measuring the frequency shift from the Doppler effect. Ultrasonic flow meters are affected by the acoustic properties of the fluid and can be impacted by temperature, density, viscosity and suspended particulates depending on the exact flow meter.

5 **c)** **Eddy Current dynamometer:**



Explanation: 2 M & Diagram

2 M

Principle: When an isolated conductor moves through the magnetic flux, voltage is induced and local currents flow in a short circular path (eddy currents) within conductor. These induced eddy currents get dissipated in the form of heat.

Working: • It consists of toothed nonmagnetic solid metallic rotor connected to the shaft whose power is to be measured.

• Nonmagnetic rotor rotates inside cast iron stator.

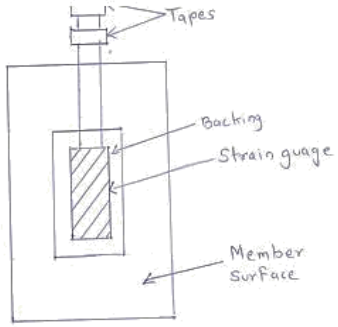
• Stator consists of D.C. supply excited coil. The stator is mounted such that it permits free swing about its axis and is provided with torque arm, which measures torque.

• To dissipate the generated heat, water is supplied in stator casing. •

During operation, rotor turns and causes constant change in flux density at all points of stator, resulting formation of eddy current, which opposes the motion of rotor. This opposing resistance is measured by brake drum in the form of torque.

• Apprx. Speed limit = 6000 rpm. • Usual power limit = 250 kW

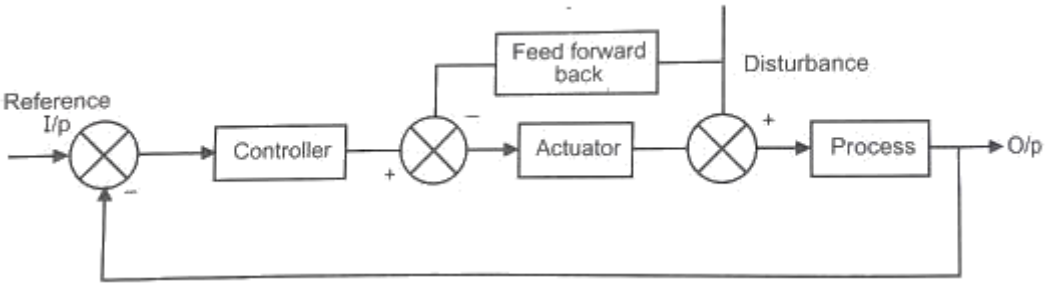
5 **d)** **Bonded type Strain Gauge :**

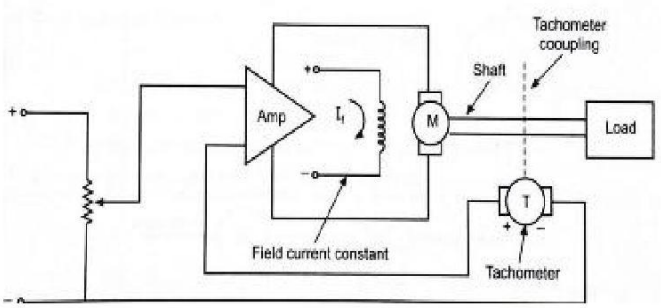


Explanation: 2 M & Diagram

2 M

- Bonded strain gauges are metallic or semiconductor filaments cemented on a paper backing or epoxy resin backing. These gauges(metallic or semiconductor) are bonded or cemented directly onto the surface of structural member which is being examined.
- Strain gauge filaments forms the four resistances of Wheatstone bridge circuit. Any

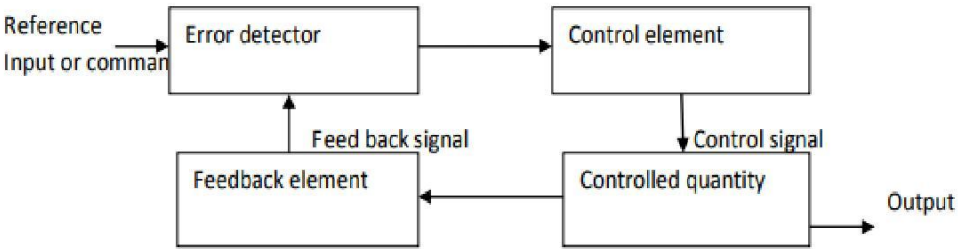
		deflection/deformation of structural member on which the strain gauges are mounted, will result the change in length of any one or all the four resistances of Wheatstone bridge circuit. • This change in resistance can be calibrated to measure the strain or the measured. • **Applications:** i) Determination of maximum stress values. ii) Force/ Thrust measurement,e.g. Load cells iii) Pressure Measurement iv) Torque measurement e.g. strain gauge torsion meter. v) For experimental verification of strain in complex physical systems	
5	**e)**	**Feed back control system with examples:**  • In feedback system the disturbance must show up in the error before controller can take corrective action. • If the disturbance is measurable then the signal can be added to controller output to modify activating signal. • Thus , a corrective action is initiated without waiting for the effect of disturbance to show error. • Thus, undesirable effects of measurable disturbances by approximately compensating before they affect the output. Such system in which corrective action is taken before disturbance affect the output are called feed forward system. • **Example: Heat exchanger, Boiler**	**Explanation:2M** **Dia-1M** **Examples 1M**
5	**f)**	**Control system used for motor speed control:** • The D.C. shunt motor is used where the field current is kept constant and armature voltage is changes to obtain desired speed. The feedback is taken by speed tachometers. • This generates voltage proportional to speed which is compared with voltage required to the speed. • This difference is used to change the input to the controller which cumulatively changes the speed of the motor as required.	**Explanation:2 M & Diagram-2M**



6

a) Attempt Any FOUR

Servo motor mechanism:



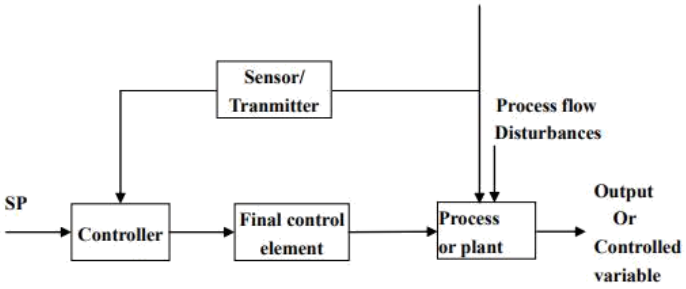
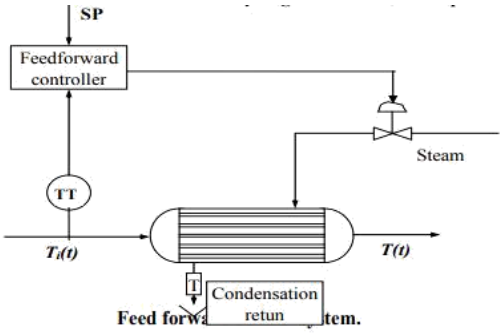
Explanation: 2 M & Diagram

2 M

It is employed to provide a position output proportional to input electrical signal. The stator has two distributed windings which is called reference winding and control winding. The main winding (also called the reference or fixed phase) is supplied from a constant voltage source of 110 V and 50 Hz.

The other winding (also called the control phase) is supplied with a variable voltage of the same frequency as the reference phase but is phase-displaced by 90° (electrical). The control- phase voltage is controlled by an electronic controller. The speed and torque of the rotor are controlled by the phase difference between the main and control windings. Reversing the phase difference from leading to lagging (or vice-versa) reverses the motor direction. Since the rotor bars have high resistance, the torque-speed characteristics for various armature voltages are almost linear over a wide speed range particularly near the zero speed. The motor operation can be controlled by varying the voltage of the main phase while keeping that of the reference phase constant.

Importance of servo mechanism in control system • A servomotor is a rotary actuator that allows for precise control of angular position , velocity and acceleration • They are small in size but pack a big punch and are very energy efficient

	6 **b)**	**Feed forward control system:**  In feed forward control system, disturbances are measured and compensated for them before the controlled variable deviates from set point. In control system, it is considered that the disturbance affect the o/p adv Rsly and considerably. If these disturbances are measurable , then this signal can be added to the controller output to modify the actuating signal. Thus a corrective action s initiated without waiting for the effect of the disturbance affect the output is called feed forward control system. Feed forward controller makes the decision about how to manipulate the actuating element steam valve to maintain the controlled variable at set point. Example:  	**Explanation: 2 M & Block Diagram 1 M** **Example 1M**
6	**C)**	**Different modes of control action :** - On-off control - Proportional control - Proportional plus integral control - Proportional plus derivative control - Proportional plus integral plus derivative control Significance:1) Suitable for P,PI,PD,PID control. 2) suitable for manual control. 3)multiples I/P & O/P. 4) Transient control.	**Any four Modes— 2M** **signi-2M**

6 **d) Difference Between Open loop & closed loop control system:**

Sr.No	Open loop control system	Closed loop control system
1	Feedback is absent	Feedback is present
2	Simple and economical	Complex and costlier
3	More stable	Less stable
4	It is Not reliable	It is reliable
5	Accuracy is less	Accuracy is more
6	Cost effective	expensive
7	Easy to built	Difficult to built
8	Response is slow	Response is fast
9	Application: traffic control ,domestic application	Applications: Boilers, chemical and fertilize

ANY 8 :

1 / 2 EACH

6 **e) Inductive Pick up Tachometer :**

Explanation:2M
Diagram-2

Construction: The inductive pick up Tachometer is based on the principle of inductance. It consists of a small permanent magnet with coil round it as shown in the figure. This is placed near a metallic toothed rotor whose speed is to be measured.

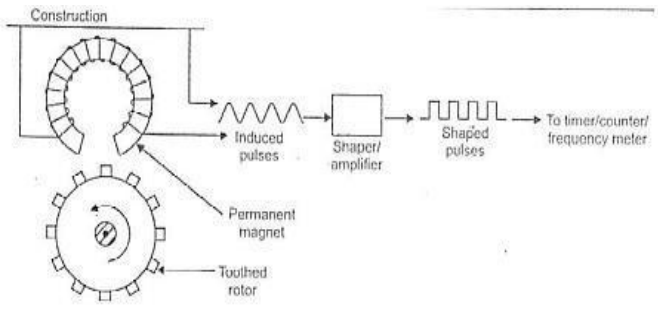


Fig . Inductive Pick up Tachometer

Working: The inductive pick up Tachometer is based on the principle of inductance As the shaft rotates, the teeth pass in front of the pick-up and produce a change in the reluctance of the magnetic circuit. The field expands or collapses and a voltage is induced in the coil. The frequency of the pulses depends upon the number of teeth on the wheel and its speed of rotation. Since number of teeth is known, the speed of rotation can be determined by measuring the pulse frequency and it

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6	**f)**	is given as Speed (rpm)= No. of pulses per min./number of teeth N=(P/T) X 60 RPM Given Data: Range: o to 500 KN/m^2 Span= 500 – 0 = 500 KN/m^2 & Accuracy: 1.5% of FSD To find: Possible reading for a true value of 95 KN/m^2 **Solution:** Step 1) Maximum Limiting Error = [Fractional form of accuracy x span of instrument] = [0.015 x 500] KN/m^2 =7.5 KN/m^2 Step 2) Possible reading for true value =[95±7.5] KN/m^2 = 87.5 KN/m^2 & 102.5 KN/m^2	Step 1)2M &Step 2)2M