_____

<u>**Important Instructions to examiners:**</u>
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No. 01   a) **Difference between accuracy and precision (Any four point 04 marks)**

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 device	It is composed of two characteristics, conformity and no of significant digits
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) **Sensitivity drift and zero drift**

Drift is the undesired change in the measured output. It is defined as the variation of output for a given input caused due to change in the sensitivity of the instrument to certain interfering inputs like temperature changes, components instabilities, etc.   **02 marks**

For example, a strain gauge bridge output without a compensating dummy strain gauge may indicate the output- input characteristics as shown in fig. if the ambient temperature changes after the calibration of the instrument. An ambient temperature change causes the change in resistance of the strain gauge. This results in

the bridge circuit becoming unbalanced and as a consequence of this, there is an output at zero strain which corresponds to zero drift of the instrument.
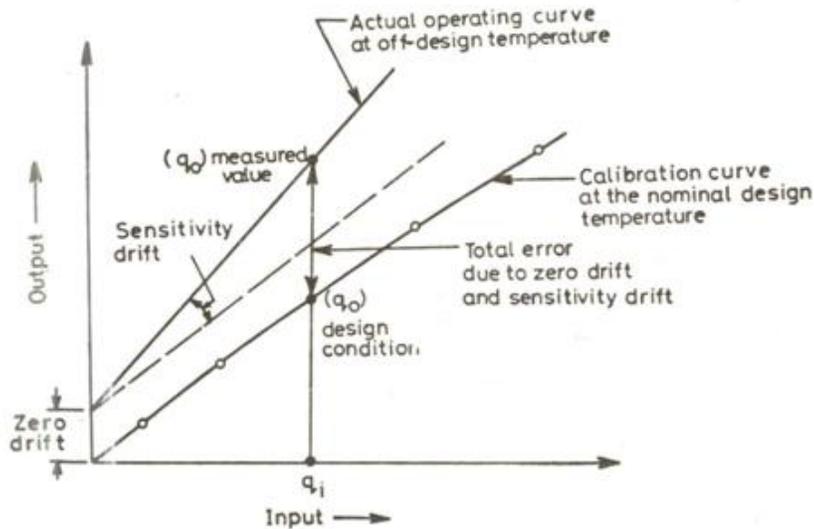

02 marks

c) **Construction and working of LVDT**

LVDT is a displacement measuring device. It is the device which converts the linear displacement in voltage produced and then the voltmeter is calibrated in terms of displacement. The most widely used inductive transducer to translate linear motion into electrical signals is the Linear Variable Differential Transformer (LVDT).

The transformer consists of a single primary winding P_1 and two secondary windings S_1 and S_2, wound on a cylindrical former. The secondary windings have equal number of turns and are identically placed on either sides of the primary winding. The primary winding is connected to an alternating current source.

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. 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.　　　　　　　　　**02 marks**

_____
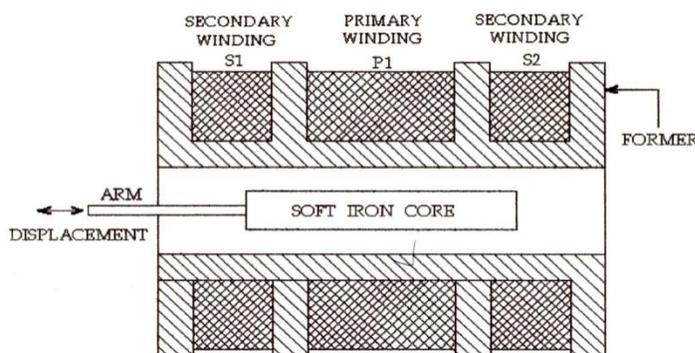
As the core is moved in one direction from the null position, the differential voltage i.e., the difference of two secondary voltages, will increase while maintaining an in phase relationship with the voltage from the input source. In the other direction from the null position, the differential voltage will also increase, but will be 180^0 out of phase with the voltage from the source. By comparing the magnitudes and phase of the output (differential) voltage with that of the source, the amount and direction of the movement of the core and hence, of displacement, may be determined.
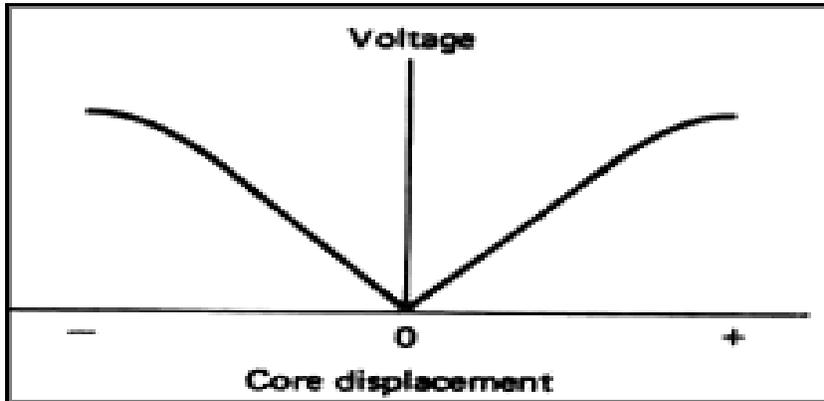
02 marks
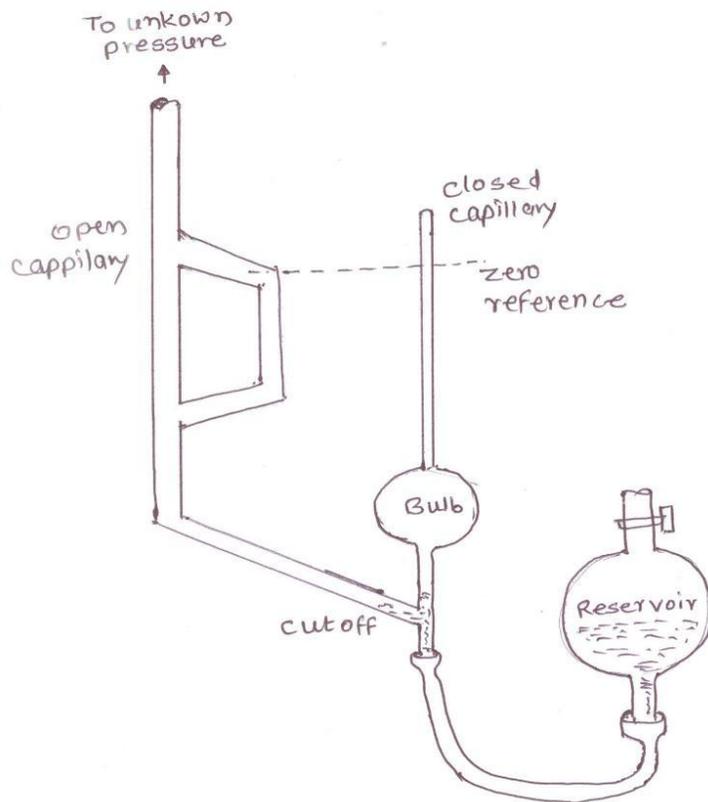
d) **Mcleod Gauge**

02 marks

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

$P = KHH_o(1 - KH)$ **02 marks**

e) **Temperature measuring instrument**

Non Electrical Methods

- Bimetallic Thermometer in the range 0 to 200 $^{\circ}$C

- Liquid in Glass Thermometer the range -120 to 320 $^{\circ}$C

- Pressure Thermometer the range 30 to 200 $^{\circ}$C

- Vapour Pressure Thermometer the range 30 to 200 $^{\circ}$C

Electrical Methods **02 marks**

- Resistance Temperature Detector (RTD) range -200 to 600 $^{\circ}$C

- Thermistors range -100 to 500 $^{\circ}$C

- Thermocouples -30 to 1200 $^{\circ}$C

Non Contact type temperature measurement

- Radiation Pyrometer range 600 to 2000 $^{\circ}$C

- Optical Pyrometer 600 to 2000 $^{\circ}$C **02 marks**

f) **Flow measuring device** **(each 01 marks)**

Rotameter : Measure Liquid or Gas Flows in refrigeration system

Hot wire anemometer: widely used in research application to study varying flow conditions.

Electromagnetic Flow meter: Obstruction less flow meter used in chemical process plant

Ultrasonic flow meter: Obstruction less flow meter used where high flow rate is to be measured R & D work

g) **Requirements of strain gauge material** **(for two points 01 marks)**

  i.   Strain gauge should be small in size with negligible mass.

 ii.   It should be highly sensitive to strain.

iii.   Strain gauge should have high value of gauge factor.

 iv.   It should be easily attachable to specimen.

_____

v.   It should have high speed of response with negligible time lag.

vi.   It should be capable to indicate static, transient and dynamic strain.

vii.   It should be capable of remote indication and recording.

viii. It should not be sensitive to ambient condition such as temperature, humidity, vibration etc.

ix.   It should be inexpensive, reliable and easily available in various sizes

Q. No: 02   a) Dynamic properties of Measuring instrument   **(Any two properties 2 marks each)**

These are measuring lag, fidelity, speed of response and overshoot

OVERSHOOT:

The overshoot is defined as the maximum amount by which the pointer moves beyond the steady state. Because of mass and inertia, a moving parts, i.e. the pointer of the instrument does not immediately comes to rest in the final deflection position. The pointer goes beyond the steady state i.e. it overshoots.
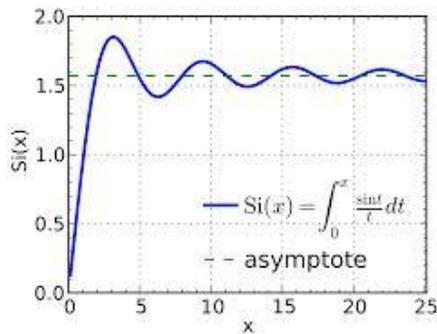
FIDELITY:

It is the degree of closeness with which the system indicates the signal which is imposed upon it. It refers to the ability of the system to reproduce the output in the same form in the input. If the input is a sine wave then for 100% fidelity the output should also be a sine wave.

b) Comparison of Hydraulic and pneumatic system   **(min four points 01 mark each)**

Hydraulic controller	Pneumatic controller
Medium cost	Low cost
Chances of fire hazard	No fire hazard
high speed of response	Medium speed of response
High power gain	Medium power gain

Medium space require	High space require
Not affected by stray magnetic field	Not affected by stray magnetic field
High power gain	Medium power gain

c) PID control action

Proportional control action is good when

> Very fast and settling time is less. If error is zero output is constant Used for steady condition

Not satisfactory when

➢ If load changes are rapid that exists long period

➢ Process rate reaction is very fast

➢ There is considerable dead time   **02 marks**

A proportional controller (Kp) will have the effect of reducing the rise time and will reduce, but never eliminate, the steady-state error.

An integral control (Ki) will have the effect of eliminating the steady-state error, but it may make the transient response worse.

A derivative control (Kd) will have the effect of increasing the stability of the system, reducing the overshoot, and improving the transient response.

Proportional Control

By only employing proportional control, a steady state error occurs.

Proportional and Integral Control

The response becomes more oscillatory and needs longer to settle, the error disappears.

Proportional, Integral and Derivative Control

➢ All design specifications can be reached.   **02 marks**

d) Potentiometers are used for measuring linear and angular displacement

Rotational type Potentiometer

> The rotational resistive elements are circular in shape and used for measurement of angular displacement.
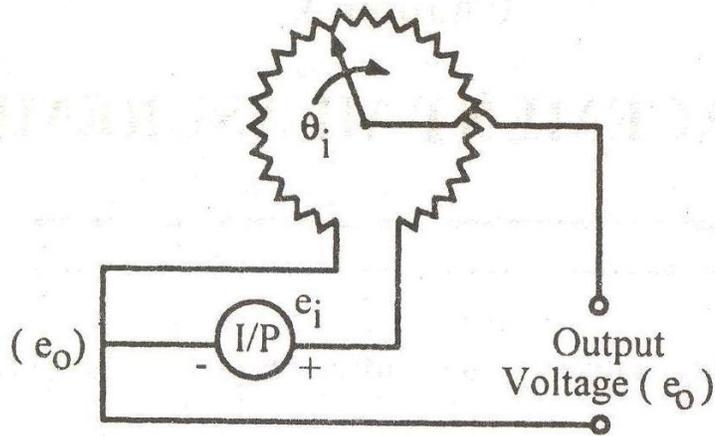
02 marks

linear type Potentiometer

The translatory resistive elements are straight or liner devices used for measurement of liner displacement
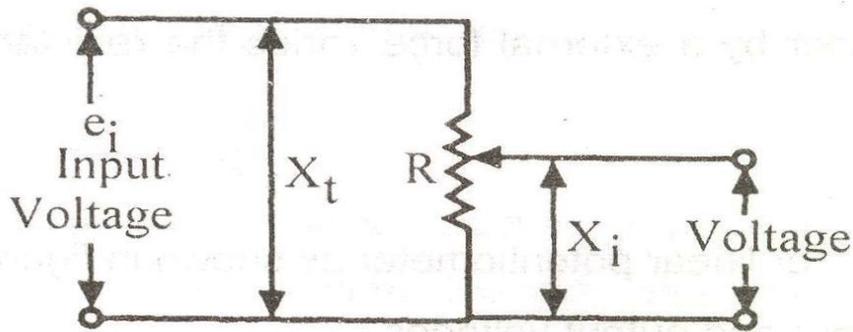
Working Principle

- Positioning of the slider by a external force varies the resistance in potentiometer or a bridge circuit.

- Consider a traslatory or liner potentiometer as shown in previous figure.

- Let e_i and e_o = Input and Output voltages,

- X_t = Total length of liner pot in meter

- X_i= Displacement of wiper from its zero position in meter

- R_p= total resistance of potentiometer.

- The movement is linear, so resistance per unit length is R_p / X_i

Hence, output voltage is ,

_____

$$e_0 = (\frac{R_p \times \frac{X_i}{X_t}}{R_p} \times (e_i)) \qquad = \frac{X_i}{X_t} \times (e_i)$$
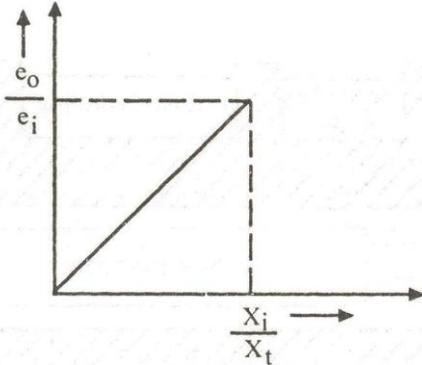
Under ideal circumstances, the output voltage varies linearly with displacement as shown in figure.

02 marks

e) Platinum resistance thermometer (RTD)
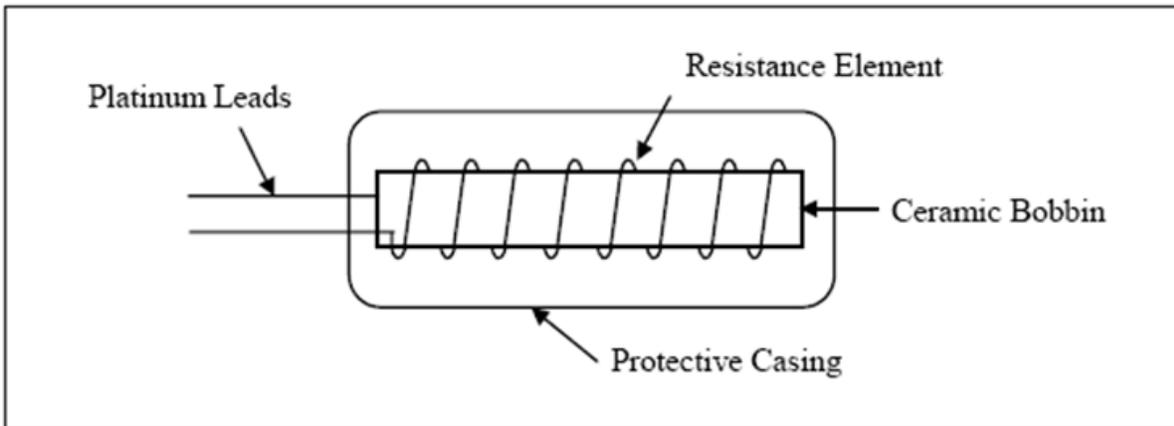
The certain metals changes with temperature change. Resistance thermometer utilizes this property of the material. With the increase in temperature the electrical resistance of the certain material increases in direct proportion to rise the temperature. Therefore if electrical resistance of wire of known and calibrated material is measured the temperature of the wire can be determined. Platinum, copper and nickel are generally used in resistance thermometers

Resistance elements are generally long, spring like wires enclosed in a metal sheath. The resistance element is surrounded by a porcelain insulator which prevents short circuit between wire and the metal sheath. Two leads are attached to each side of platinum wire. When this instrument is placed in liquid or gas whose temperature is to be measured the sheath quickly reaches the temperature of medium. This temperature change causes the platinum wire inside to heat or cool resulting in proportional change in wire resistance. This change in resistance can be directly calibrated to indicate the temperature.

Temperature sensitive resistance element is fabricated in a suitable form to insert in the medium whose temperature is to be determined . It is connected by leads of Wheatstone bridge as shown in fig. The bridge

consists of sensing element resistance X having high temperature coefficient and resistances A, B, and C whose resistances do not alter with change of temperature.

02 marks

In the balanced condition
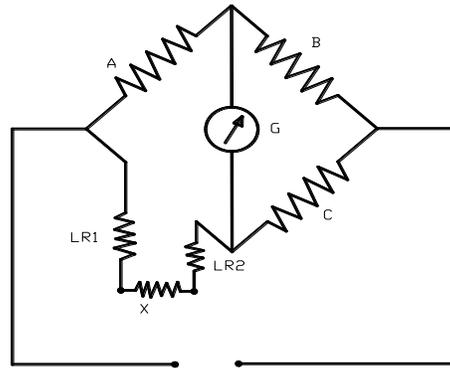
$$A/B = (X + LR_1 + LR_2)/C$$

$$R_t = Ro (1 + \alpha t)$$

When resistance X changes the Wheatstone bridge becomes unbalanced and thus galvanometer will give deflection which can be calibrated to give a suitable temperature scale.

| RTD Material	Temperature Range
Platinum RTD 100 ohm wire	-240 to 650 ^{o}C

02 marks

f) Turbine flow meter

Turbine flow meter is suitable for measurement of flow in tubes and pipes. The rotor is placed in path of moving stream directly. The rotor spins freely at the rate proportional to flow velocity. The permanent magnet is sealed inside the rotor body is polarized at 90 degree to the axis of rotation. As rotor rotates, along with it magnet also rotates and produces rotating magnetic field. This produces an AC voltage pulse in the pick up coil located external to the meter housing. The frequency of this voltage is directly proportional to the rate of flow. Alternatively, the frequency is converted into voltage and is fed to an analog /digital voltmeter to give the rate of flow. In turbine flow meter it is possible to get measurement of total flow as well as rate of flow.

02+02 marks
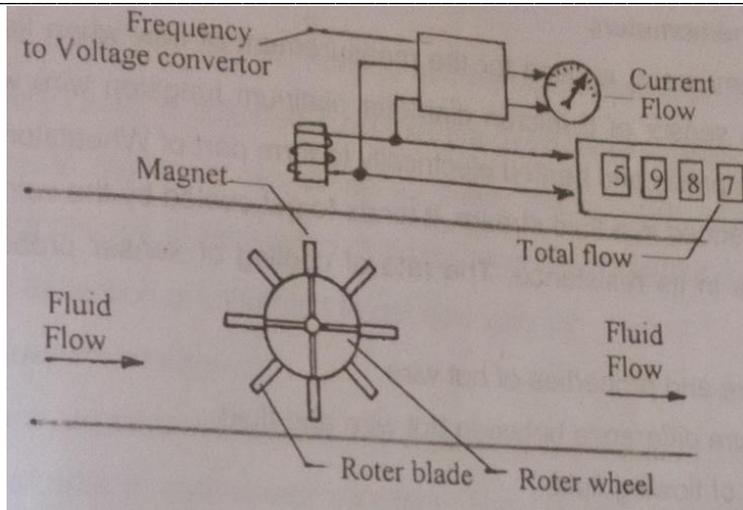
Advantages of Turbine flow meter :   (ADVANTAGES/DISADVANTAGES is OPTIONAL)

➢ Very good accuracy ±1 % over design range.

➢ It has low pressure drop.

➢ Analog as well as digital readings can be obtained.

➢ It gives fast response.

Disadvantages of turbine flow meter :

❖ Bearing maintenance is the problem.

❖ Accuracy drops at low flow rates.

❖ It is costly.

❖ It has very limited application.

❖ It requires line mounting.

Qu.3. Attempt Any FOUR of the following   4X4 Marks

a) **Explain with neat sketch working of any one thermo resistive transducer.**
                    (Fig. with labelling 2 marks & working 2 marks.)

Fig:- RTD
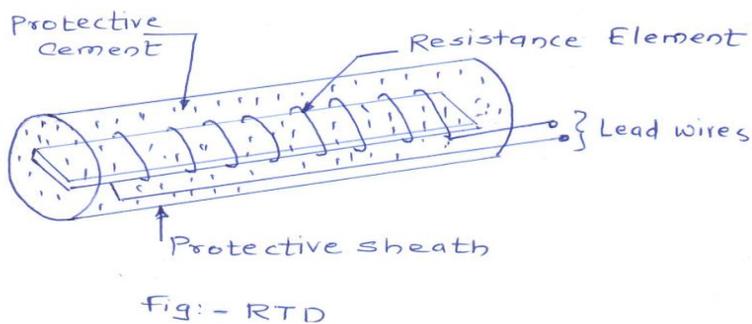
Resistance thermometers or resistance temperature detector works on the principle of positive temperature coefficient of resistance i.e as temperature increases, resistance offered by thermometer also increases.

The resistance element of platinum and iron metal wire is wrapped around an electrically insulating support of glass, ceramic or mica and from the outside, protective sheath of metallic tube can be provided. The lead wires are taken out from the resistance elements which are joined to the circuitry.

The resistance thermometers which are alternatively known as RTD works on the principal that " the resistance of a metal varies with a change in temperature" according to the relation as

$R_T = R_0[1+\alpha(T-T_0)$

R_T : Resistance at temperature (T)

R_0 : Resistance at temperature (0˚C)

α : Temp. coeff.

T: temp(˚C)

T_0 : Initial temp.

To measure the change in resistance bridge network is used.

The resitsance thermometer is connected to one of the arm of Wheatstone bridge circuit when resistance thermometer is subjected to temperature variation, the Wheatstone bridge gets unbalanced.\the galvanometer deflection can be directly calibrated to give temperature.

b) What is psychometer ? Draw a neat sketch of sling psychrometer with proper labelling.

(Definition: 01 mark, Fig. 2 marks & labelling 1 mark)

Psychometer: The equipment used for measuring " Dry Bulb Temperature" and "Wet Bulb Temperature" Simultaneously is known as psychrometer.

The sling psychrometer consists of two mercury thermometers mounted on frame, which has handle provided for rotation of psychrometer. Thus air movement is obtained by whirling the thermometer in air. One bulb among the two is covered with the wet wick to read wet bulb temperature. The velocity recommended for rotation is 5 to 8m/min.

Sling psychrometer

Sling Psychrometer

.
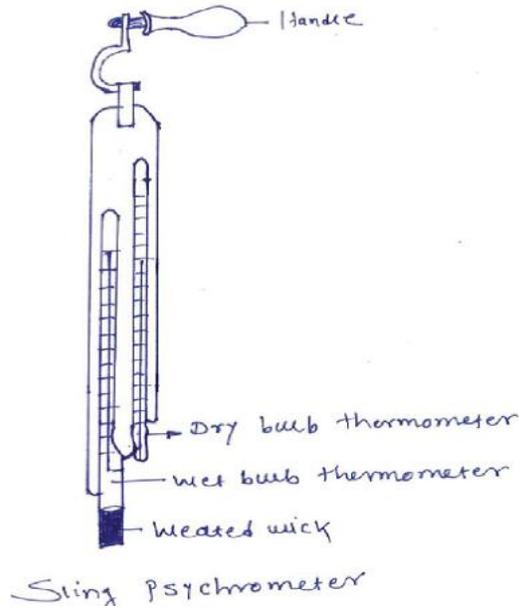
c) **Explain with a neat sketch the float and tape gauge liquid level measurement method.**
(Explanation 2 marks and figure 2 marks)
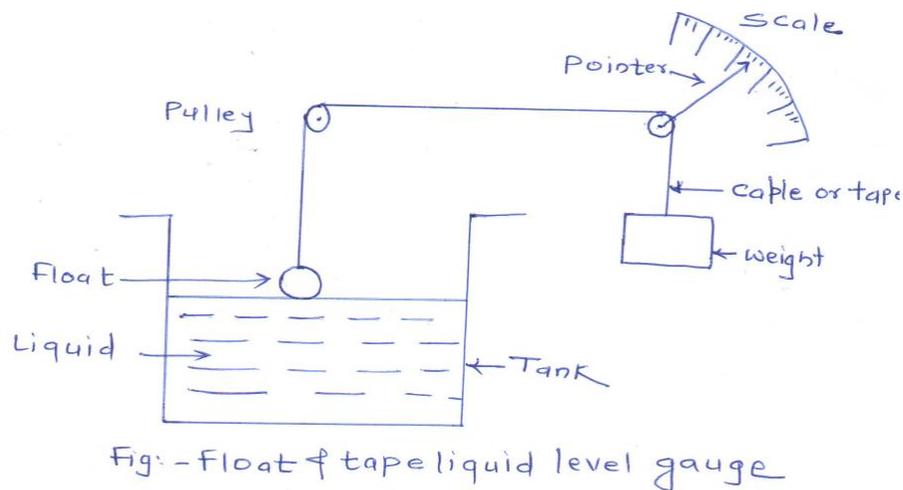
Fig:- Float & tape liquid level gauge

In this, a freely floating body (float) is used for continuous liquid level measurement .the float is attached to the cable /tape which passes over the pulley and then at another end of tape, the weight is applied for counter –balancing of force.

At the center of another pulley, a pointer is attached which transverses along the calibrated scale to give the direct reading of liquid level.

The float used may be hollow metal spheres (disc) shaped synthetic materials.

d) Explain the positive and negative feedback in a closed loop control system with suitable example of each.

_____

Ans: (**Positive feedback 2 marks, negative feedback 2 marks**)

Positive feedback :

Whereas positive feedback tends to lead to instability via exponential growth or oscillation, negative feedback generally promotes stability. Negative feedback tends to promote a settling to equilibrium, and reduces the effects of perturbations. Negative feedback loops in which just the right amount of correction is applied in the most timely manner can be very stable, accurate, and responsive.

In a "positive feedback control system", the set point and output values are added together by the controller as the feedback is "in-phase" with the input. The effect of positive (or regenerative) feedback is to "increase" the systems gain, ie, the overall gain with positive feedback applied will be greater than the gain without feedback.

However, in electronic and control systems to much praise and positive feedback can increase the systems gain far too much which would give rise to oscillatory circuit responses as it increases the magnitude of the effective input signal.

e.g: Refrigerator, air conditioner etc.

Negative feedback

Negative feedback occurs when some function of the output of a system, process, or mechanism is fed back in a manner that tends to reduce the fluctuations in the output, whether caused by changes in the input or by other disturbances. Negative feedback is widely used in mechanical and electronic engineering, but it also occurs naturally within living organisms,[1][2] and can be seen in many other fields from chemistry and economics to physical systems such as the climate. General negative feedback systems are studied in control systems engineering.

E.g :D.C MOTOR speed controller

e)   Explain with a neat sketch the construction and working of thermocouple .what are the different materials used for developing thermocouple.

(Figure : 1 mark, construction : 1 mark, working 1 mark, material : 1 mark)

fig: seeback effect (Thermocouple)
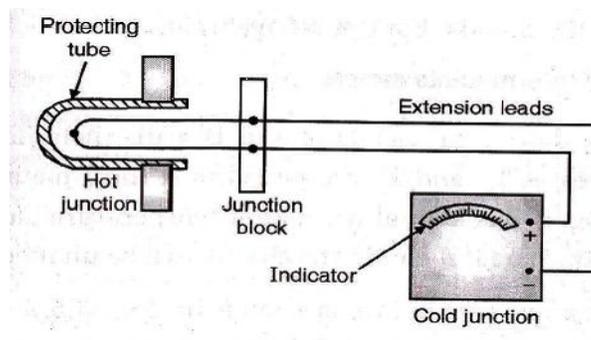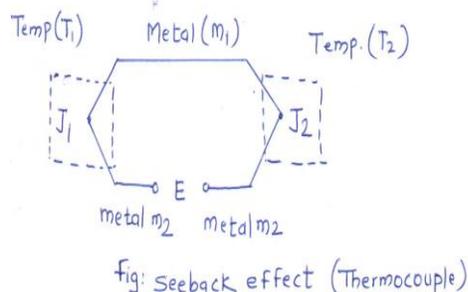
Construction:

_____

When two dissimilar metals m1 & m2 are joined together to form a loop, it is called as thermocouple and if two unequal temperature T1& T2 ae imposed at two junctions J1 & J2,then an electric current flows through the loop and this is called as "Seeback Effect"

Working: When a junction (J1) is kept at a hot body and another junction (J2)is kept at some constant known temperature ,then the EMF generated is proportional to the temperature difference imposed and this forms the basis of temperature measurement.

Different material used In thermocouple:

Copper: Constantan

Iron: Constantan

Chromel: Alumel

Chromel : Constantan

Platinum: (90% platinum + 10 % Rhodium) (95% Tungsten +5% Rhenium) –(80% Tungsten +20% Rhenium) etc.

f) Explain the working of Rotameter with neat sketch

(Explanation 2 marks and figure 2 marks)
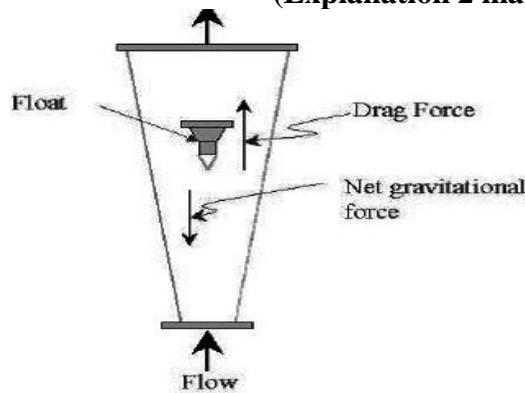
Fig. Rotameter

The rotameter consists of three basic elements:
1) A uniformly tapered flow tube,   2) a float, and   3) a measurement scale.
A control valve may be added if flow control is also desired. In operation, the rotameter is positioned vertically in the fluid system with the smallest diameter end of the tapered flow tube at the bottom. This is the fluid inlet. The float, typically spherical, is located inside the flow tube, and is engineered so that its diameter is nearly identical to the flow tube's inlet diameter.
When fluid like gas or liquid is introduced into the tube, the float is lifted from its initial position at the inlet, allowing the fluid to pass between it and the tube wall. As the float rises, more and more fluid flows by the float because the tapered tube's diameter is increasing. Ultimately, a point is reached where the drag force exerted by the fluid is balance by weight of float and gravitational force. The float is now stationary at that level within the tube as its weight is being supported by the fluid

_____

forces which caused it to rise. This position corresponds to a point on the tube's measurement scale and provides an indication of the fluid's flow rate.

QU.4 Attempt any four of the following

a)List advantages and disadvantages of capacitive transducer used for measurement of displacement

Ans: (Advantages 2 pt: 2 marks, Disadvantages: 2 marks)

Advantages

- It produces an accurate frequency response to both static and dynamic measurements.

- Working principle is very simple

They are inexpensive

Disadvantages

- An increase or decrease in temperature to a high level will change the accuracy of the device.

- As the lead is lengthy it can cause errors or distortion in signals

b)Compare pressure gauge measurement devices ,diaphragm, and bellows on the basis 1) Working principal 2) construction 3) Pressure range 4) applications

Sr. No	Parameter	Diaphragm	Bellow
1	**Working Principal**	The deflection of diaphragm is proportional to applied pressure.	A Bellow guage contains an elastic element that is a convoluted unit that expands and contracts axially with changes in pressure. The pressure to be measured can be applied to the outside or inside of the bellows.
2	**Construction**	**A thin member of sheet metal made to precision dimensions either in shape of memebrane or circular disc.**	bellows gauges are made of brass, phosphorbronze, stainless steel, beryllium-copper, or other metalthat is suitable for the intended purpose of the gauge
3	**Pressure Range**	**0 to 6.7 KPa**	Pressures up to 800 psig, their primary application aboard ship is in the measurement of low pressures or small

			pressure differentials.
4	**Application**	Ind. process pressure measurement, Manifold pressure measurement	Abroad Ship, also some type of recording device

Each difference Point : 1mark

c) Explain working of turbine meter for flow measurement with neat sketch.

(Figure with labelling: 2 marks , Working 2 marks)

Fig. Turbine flow meter
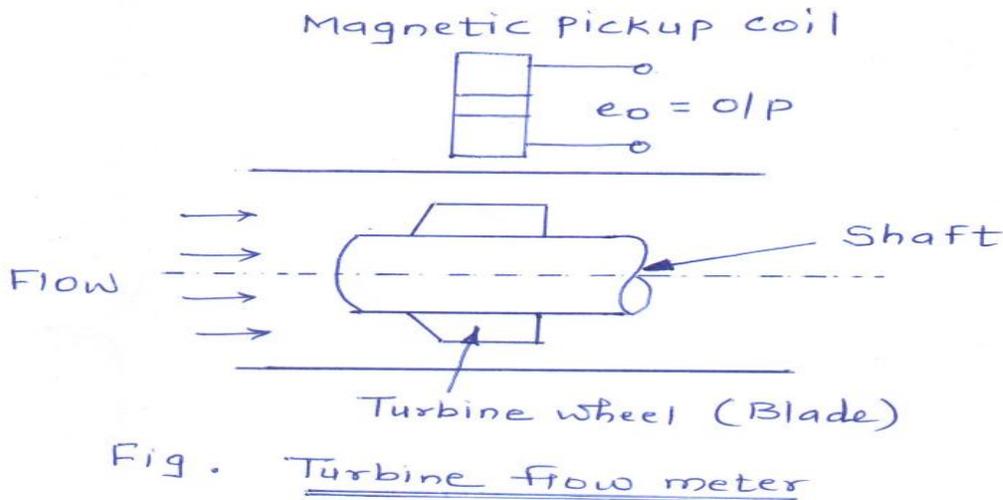
The turbine flow meter works on the principle of turbine. if the losses are kept minimum the turbine speed varies linearly with flow rate i.e flow rate can be measured by measuring the speed of the turbine. When the blade passes by pick up coil, it interrupt magnetic field and produces a pulse. The rate of pulse gives flow rate and total number of pulses gives a measure of the total flow.

d) What are thermistors? Explain the principal of operation and give its advantages

Thermistor: It is thermally sensitive variable resistor. These are a temperature measurement device that has a negative temperature coefficient. **Def: 1mark**

Principle of Operation: **principle: 2 marks**
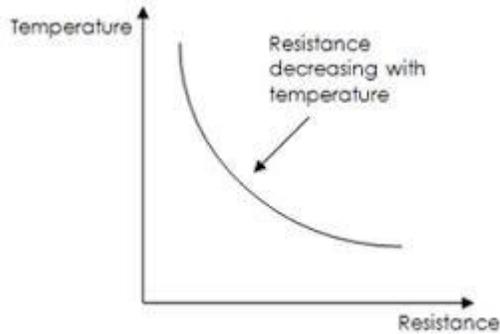
These are made up of ceramic like semi conducting materials like copper oxide ,manganese oxide ,nickel oxide, cobalt oxide, Lithium oxide and titanium oxide.

These oxides are blended in a suitable proportional and compressed into the desired shapes from the mixed power and heat treated to recrystallize them, resulting in the dense ceramic body with the required resistance temperature characteristics.

For the thermistor, as the temperature increases ,its resistance decreases and vice versa and this is called as negative temperature characteristics" of thermocouple.

The thermistor is a very non linear instrument,wheras resistors such as platimum ,copper,tungstaen are quite linear.the resistance temperature relation for thermistor is as under

.

$$R = R0e^{\wedge}(\beta\left\{\frac{1}{T}\right\} - \frac{1}{T0}]$$

Where,

R-Resistance at any temperature (T) in ˚K

R_0 Resistance at the refernace " Temperature(T0) in ˚K

B = Constant = 3000 K to 4500 K, depending on its composition.

The practical operating range of thermistors lies between -100 to +300 ˚C.

Advantages: **Advantages: 1 mark**

       1) Simple in construction & working

       2) More durable

e) Explain with the neat sketch strain gauge transmission dynamometer

                                  (Fig. 2m & Explanation 2m)
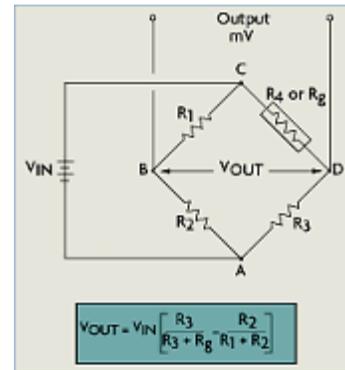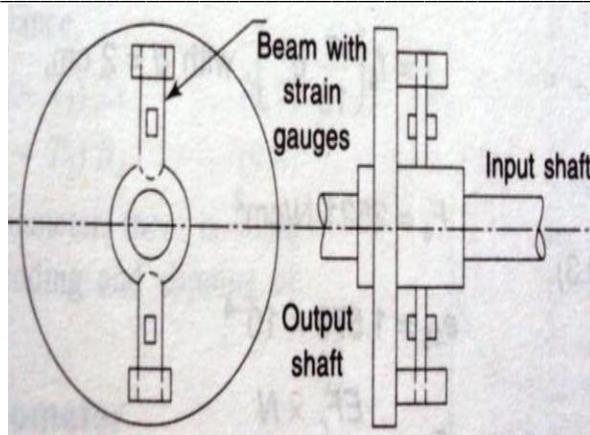
The principle involved in transmission dynamometer is that the power being transmitted either to or from the dynamometer is not absorbed or dissipated. The power after measurement is available in useful mechanical or electrical means. However, a small power is dissipated on account of friction. Strain gauge transmission dynamometer is used to measure bending strains rather than strains due to torque at 450 and so an arrangement using beams (as shown in fig.) may be employed, in which the transmitted torque results in bending the beams.

The strain gauge transmission dynamometer utilizes the bonded strain gauges which are applied to a section of torque transmission shaft.

This is inline rotating torque sensor which measures torque.

This dynamometer is used as a coupling between driving machine and driven machine or between any two portions of the machine. Here strain gauges are fitted at 45˚ to shaft axis as shown in fig.

In this type of arrangement, 2 strain gauges are subjected to tensile stress and while other is subjected to compressive stress.

Strain gauge 1 & 3 must be diametrically opposite to strain gauge 2 & 4.Due to torsion, strain gauge senses compressive as well as tensile formation. Further these strain gauges are connected to Wheatstone circuit. the output of Wheatstone bridge is proportional to torsion and hence to applied torque on shaft. The bridge power and output of bridge is connected to the sensor through slip ring and brushes .

Advantages: 1) It is sensitive to torque.

2) it gives an instantaneous results.

3) it has full temperature compensation

4) it provides automatic compensation for bending and axial loads

Disadvantages:

The device is expensive

Initial setting need skill and is time consuming.

---

f) Draw the block diagram of feed forward control system and state its advantages

(Figure : 2 Marks , Advantages 4 pts: 2 Marks)
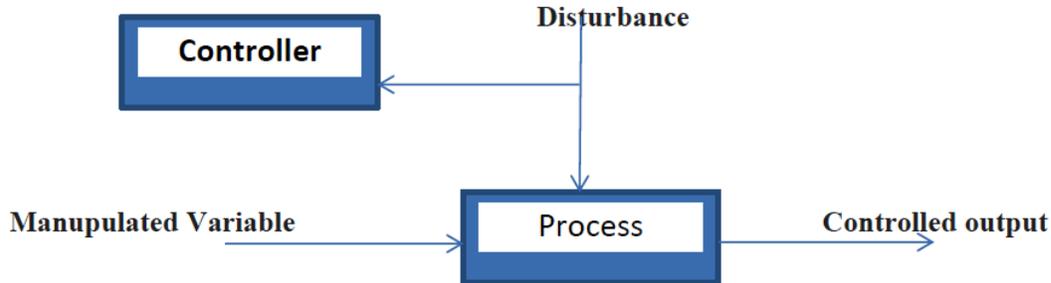
Fig. Feed Forward control system

Advantages:

1) In this system, corrective action is taken for a change in a input before it affects the control parameter.

2) It prevents accidents before they occur.

3) It useful for processes with large time constants or/and long time delays.

3) It is easy to be accepted and implemented

Q.No.5 Attempt any FOUR……………………… 04 Marks × 04 = 16 Marks

a)　　Difference between systematic and random errors…………..(1 mark each)

| Sr.	Random Errors	Systematic Errors
1	Accidental, small and independent	Repeated consistantly with the repetition of experiment
2	Caused due to inconstant factors such as spring hysteresis, stickiness, friction , noise and threshold limitations.	Caused due to sensitivity effects , zero offset and known non linearity.
3	Magnitude and direction cannot be predicted from knowledge of measurement system.	Way to locate these errors is to have repeated measurements under different conditions or with different equpment and if possible by different method.
4	Errors are assumed to follow the law of probabilities.	Cannot be determined by the direct and repetitive observations of the measurand made each time with the same technique.

_____

b) **Advantages of Pirani gauge**………………………......**(1/2 mark** each of following)

- More accurate than thermocouple gauges.
- Wide pressure reading range (10^{-5} to 1 Torr)
- Fast response to pressure changes.
- Possibility of process control and remote reading.

Disadvantages of Pirani gauge

- Expensive than thermocouple gauges.
- Lineariry dependent on the part of the range used.
- Need for individual and frequent calibration for different gases.
- Requires electrical power.

c) **Optical Pyrometer**
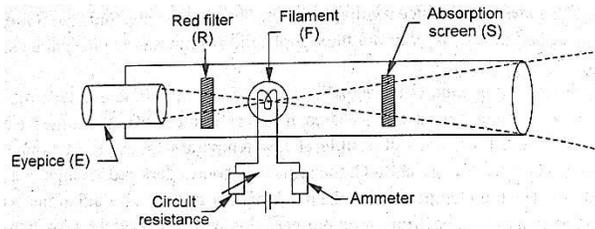
…Labelled diagram. **1 mark**
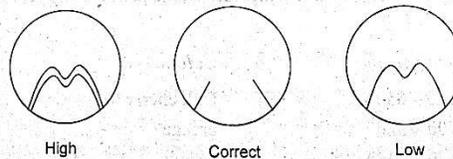
….Filament diagram **1 mark**

Disappearing –filament optical pyrometer

Principle:

Monocromatic radiation wavelength of a fixed color from a hot surface of body whose temperature is to be measured, is compared with a standard filament light wavelength.

Working:

The current through the lamp filament is made variable so that lamp intensity can be adjusted. The filament is viewed the eyepiece and filter. The current through the filament is so adjusted that filament and image are of euqal brightness. When brightness of source and image produced is same , we can say that both temperatures are same.

If the temperature of filament is higher than that required for equal brightness, filament become too bright as shown in figure. (**High**). And if the temperature of filament is lower , it becomes too dark as shown in figure (**Low**).

Range- 1400^{0}C, can be incresed upto 3000^{0}C…………….(Correct Explanation-**2 marks**)

d) **Eddy Current dynamometer.**
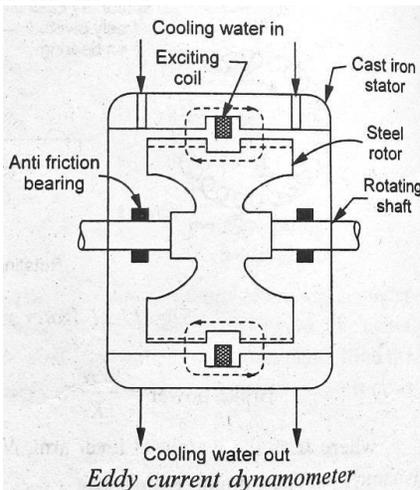
…Labelled diagram. **2 marks**

Eddy current dynamometer

**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……………… …………….(<u>Correct Explanation-**2 marks**</u>)

e)   **Air Conditioner:**

...<u>Labelled diagram. **2 mark**</u>

Representation of Control system for air conditioner.
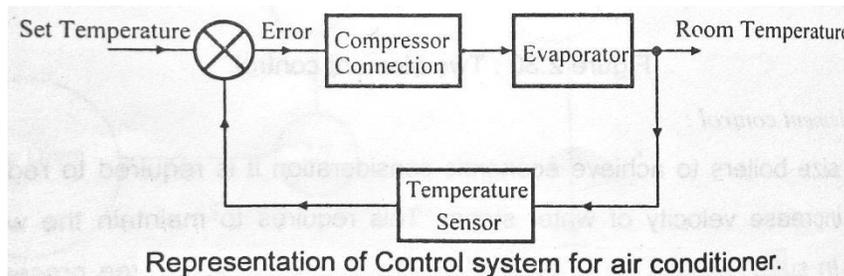
Components – Controller, Compressor, Evaporator (Room temp), Temperature sensor, (Condensor not shown in fig. outside temp source.)

-Air conditioner works on the feedback control system.

-The componenets are shown in the figure.

-Air conditioner maintains the room temperature and humidity at some preset values.   -

-Temperature sensor continuosly monitors the room temperature and signals the controller.

-When the room temperature is more than the set value it switch ON the compressor which hwlps to absorb the excessive heat inside the room. On reaching the preset value of temperature and humidity it switch OFF the compressor.

Note: If the student is drawing and writing about humidification and dehumidification using humidifier and heater, shall also be given due credit……………..... <u>Correct Explanation-**2 marks**</u>

f)   **ON-OFF control system.**
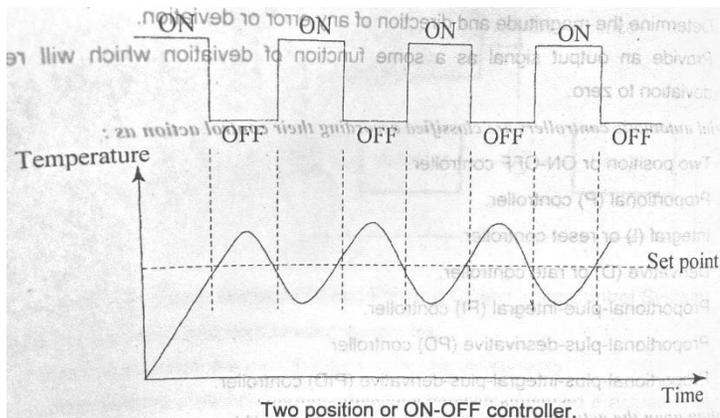
...<u>Labelled diagram. **1 mark**</u>

.....<u>Triangular form diagram **1 mark**</u>

Two position or ON-OFF controller.

_____

- Simplest type of controller and also called as two position controller.
- ON-OFF controller keep measured variable within certain tolerance band of desired value or the set point.
- Figure shows time- temperature response of ON-OFF controller in heating application.
- Ideally ON –OFF controller, should be ON when measured variable is below set point and should be OFF when measured variable is above the set point.
- Actually the process lag or the dead time delays the switching ON and OFF at the exact set point values.
- This gap where controller output does not change although it is supposed to, is called the 'differential gap' or 'dead zone'
- Suitable for room heaters, refrigerators and liquid level control applications.

……………………… (Correct Explanation-**2 marks**)

Q.No.6   **Attempt any FOUR……………………………………04 Marks × 04= 16 Marks**

(a) Difference between active and passive transducer. (Any four points- 1 mark each)

Active Transducer	Passive Transducer
Operates under energy conversion principle	Operates under energy controlling principle.
Develop their own voltage or current.	Derive the required power for energy conversion from an external power source.
Energy required is absorbed from the physical quantity being measured.	May absorb a little energy from the process variabel being measured.
Generate equivalent output signal without energizing source.	Measurand is converted into passive parameter such as resistance, inductance, capacitance which needs external energy source so as to get equivalent electrical signal.
e.g.Thermocouples and thermopiles, piezoelectric pickup, photovoltaic cell	e.g. resistance thermometers and thermistors, potentiometric devices, photo emmissive cell

(b)   Incremental encoders:
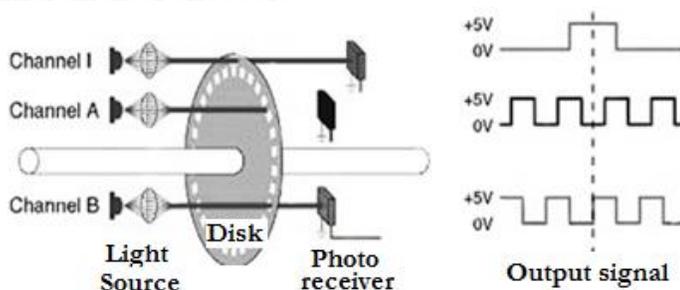
………Labelled diagram. **2 marks**

_____

-Also referred to as a quadrature encoder.

-Utilizes sensors that use optical, mechanical or magnetic index counting for angular measurement.

-Utilize a transparent disk which contains opaque sections that are equally spaced to determine movement.

-A light emitting diode is used to pass light through the glass disk and is detected by a photo detector.

-Encoder generates a train of equally spaced pulses as it rotates.

-The output of incremental rotary encoders is measured in pulses per revolution which is used to keep track of position or determine speed.

………………………(Correct Explanation-**2 marks**)

(c)   **Comparison between thermocouple and thermistor.** (Any four correct differences- **4 marks**)

	Thermocouple	Thermistor
Construction	Rugged,simple	Complex
Temperature Range	-270^0C to 2700^0C	-100^0C to 300^0C
Size	Comparatively large	Very small
Sensitivity	Poor	Excellent
Cost	Cheaper	Expensive
Effect of ambient condition	Accuracy gets affected	Accuracy is unaffected

(d)   **Electromagnetic flow meter.**

Schematics of an electro-magnetic flow meter
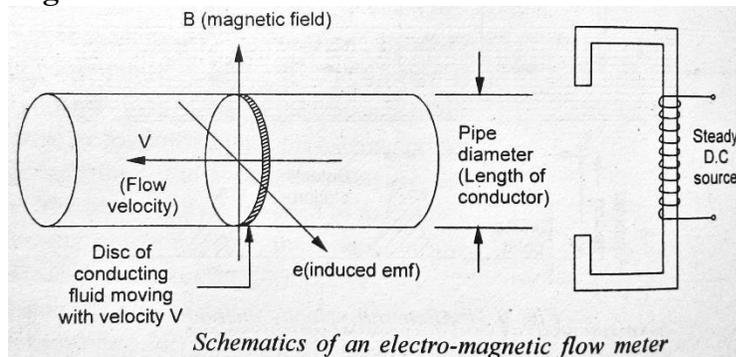
...Labelled diagram. **2 mark**

Limitations:
- Relatively high cost.
- Suitable for the fluids having conductivity at least of the order of 0.05 µ mho/cm.
- Not suitable for low velocities ………………….(Any two correct limitations- **2 marks**)

_____

(e)   **Semiconductor Strain gauge.**

..Labelled diagram. **2 mark**

Semi-conductor strain gauges
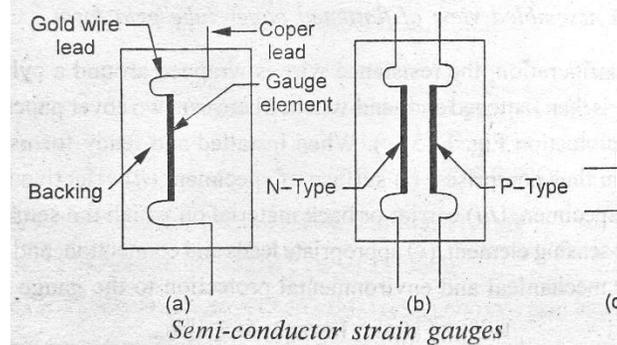
These gauges are produced from silicon and germanium crystals in which a certain amount of special impurities are added to impart certain characteristics.

Two types   a) Negative or n-type, whose resistance decreases in response to tensile strain
   b) Positive or p-type, whose resistance increases in response to tensile strain.

Breaking stress of material rises as the cross sectional area decreases.

The gauge is in the form of single rectangular filament about 0.05 mm thick and 0.25 mm wide and 1.5 mm to 12 mm in length. ………...………………………(Correct Explanation-**1 mark**)

Advantages:
- Very high sensitivity in comparison of metal gauges.
- High gauge factor in range of 100 to 200.
- Low hysteresis……………………………...…………..(Any two correct advantages- **1 mark**)

(f)   **Domestic air conditioner using feedback control system.**

...Labelled diagram. **2 mark**

Representation of Control system for air conditioner.
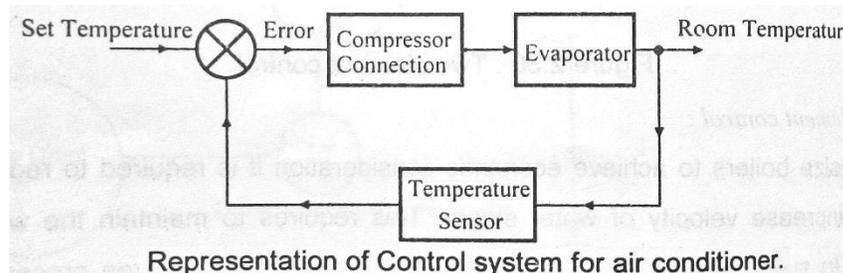
-Figure shows air conditioner which works on the feedback control system.
-The componenets are shown in the figure.
-Air conditioner maintains the room temperature and humidity at some preset values.   -
-Temperature sensor (feedback element) continuosly monitors the room temperature and signals the controller.
-When the room temperature is more than the set value it switch ON the compressor which hwlps to absorb the excessive heat inside the room. On reaching the preset value of temperature and humidity it switch OFF the compressor……….(Correct Explanation-**2 marks**)