SUMMER – 19 EXAMINATION

Subject Name: Measurement and Control **Model Answer** **Subject Code: 17528**

Important Instructions to examiners:

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

Q.1. Attempt any FIVE of the following: **20 Marks**

a) Define : (i) threshold (ii) Drift (iii) Speed of response and (iv) Overshoot

Ans

(i) **Threshold:** It is the amount of measurement change required before a measuring instrument reacts to a change in measurement output or produces a specified result.

(ii) **Drift:** It is an undesired gradual departure of instrument output over a period of time that is unrelated to change in inputs or load. It is the undesired reading shown by the instrument.

(iii) **Speed of Response:** It is the rapidity with which the instrument responds to the changes in input.

(iv) Overshoot: The overshoot is defined as the maximum amount by which the pointer moves beyond the steady state. It occurs due to mass of inertia.

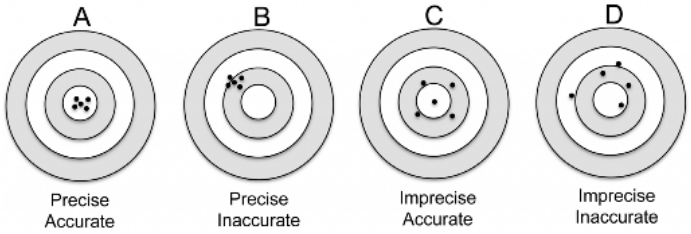
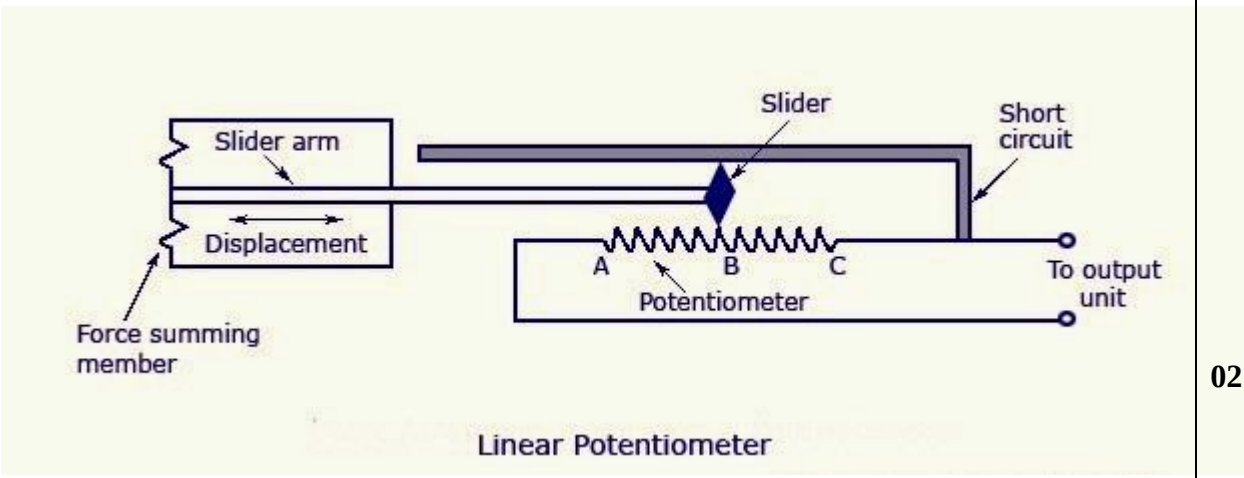
01 mark for each definition

b) Differentiate between accuracy and precision.

Ans

Sr.No.	Accuracy	Precision
1	Accuracy refers to the closeness of a measured value (measurand) to a standard or known value.	Precision refers to the closeness of two or more measurements to each other.
2	Accuracy can be improved.	Precision cannot be improved.
3	Accuracy depends upon simple techniques of analysis.	Precision depends upon many factors and requires many sophisticated techniques of analysis.
4	Accuracy determined by proper calibration	Precision determined by statistical analysis
5	Accurate measurement must be precise	Precise measurement may not necessarily be accurate.

01 mark for each point (Any 4 Points)

		6 	
	c)	**Explain: observational and Environmental Error**	
	Ans	**<u>Observational Error</u>:** • When human factors involved in measurement, the capabilities of individual observers effects the accuracy of measurement. • The observation errors occur due to poor capabilities and carelessness of operators. • Example: Wrong reading, wrong calculations, wrong conversion, wrong recording data, etc. • Parallax error occurs when line of vision is not inline with indicator dial • These errors eliminates by using modern instrument having digital display. **<u>Environmental Error</u>:** • An environmental error is an error in calculations that are being a part of observations due to environment. • Any experiment performing anywhere in the universe has its surroundings, from which we cannot eliminate our system. • The environmental errors have different causes, which are widening with the passage of time, as the research works telling us, including; temperature, humidity, magnetic field, constantly vibrating earth surface, wind and improper lighting.	**02 marks** **02 marks**
	d)	**Explain the procedure with the neat sketch to use wound linear potentiometer for displacement measurement.**	
	Ans	<u>Linear Potentiometer</u>:  Linear Potentiometer • A linear potentiometer transducer consists of a potentiometer, which is short circuited by a slider. • The other end of the slider is connected to a slider arm. • The force summing device on the slider arm causes linear displacement of the slider causing the short circuit of a certain portion of the resistance in the potentiometer. • Let the whole resistance positions on the potentiometer be ABC.	**02 marks** **02 marks**

- Let the resistance position caused by the slider movement be BC. As the movement of the slider moves further to the right, the amount of resistance increases.
- This increase in resistance value can be noted according to the corresponding change in the linear displacement of the slider.
- The change in resistance can be calculated with the help of a Wheatstone bridge.

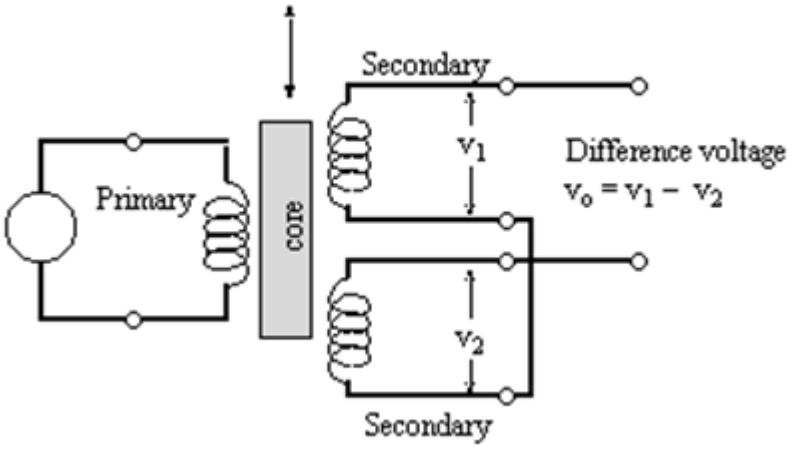
Wire-Wound Potentiometer – The most commonly used resistance elements in this potentiometer are nickel, chromium or nickel copper. They are also very cost effective. The winding of the resistance wire will depend on the different types of resistance changes due to the slider motion like linear, arithmetic, logarithmic and so on.

e) Explain working of LVDT with the help of neat sketch.

Ans

LVDT: Linear Variable differential transducer

Principle of LVDT**:** LVDT works under the principle of mutual induction, and the displacement which is a non-electrical energy is converted into an electrical energy. And the way how the energy is getting converted is described in working of LVDT in a detailed manner.



Sketch-

02 marks

Construction & working:

- LVDT consists of a cylindrical former where it is surrounded by one primary winding in the centre of the former and the two secondary windings at the sides.
- The number of turns in both the secondary windings are equal, but they are opposite to each other, i.e., if the left secondary windings is in the clockwise direction, the right secondary windings will be in the anti-clockwise direction, hence the net output voltages will be the difference in voltages between the two secondary coil.
- The two secondary coil is represented as S1 and S2.
- Esteem iron core is placed in the centre of the cylindrical former which can move in to and fro motion as shown in the figure.

02 marks

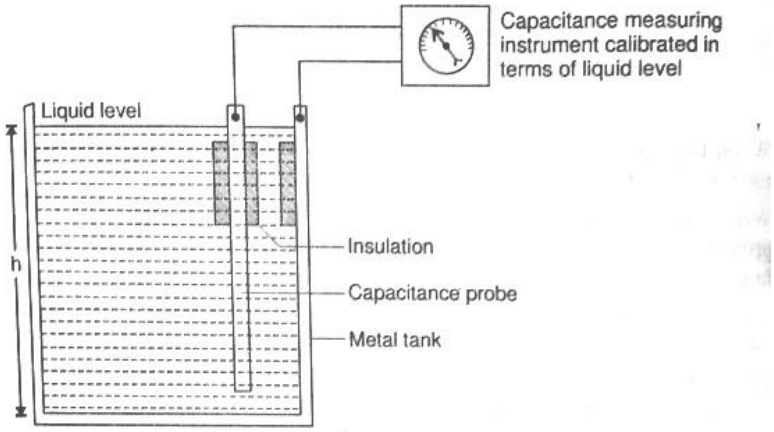
The working of LVDT is as follows.

Case 1: On applying an external force which is the displacement, if the core reminds in the null position itself without providing any movement then the voltage induced in both the secondary windings are equal which results in net output is equal to zero.

i.e., Esec1-Esec2=0

Case 2: When an external force is appilied and if the steel iron core tends to move in the left hand side direction then the emf voltage induced in the secondary coil is greater when compared to the emf induced in the secondary coil 2. Therefore the net output will be Esec1-Esec2.

		Case 3: When an external force is applied and if the steel iron core moves in the right hand side direction then the emf induced in the secondary coil 2 is greater when compared to the emf voltage induced in the secondary coil 1. therefore the net output voltage will be Esec2-Esec1	
	f)	**List the specifications for displacement transducer.**	
	Ans	Following are some specifications of Displacement transducer: • Linearity or Non linearity : 0.2 % rated output • Accuracy +/- 1% • Range & Span : in specific unit • Hysterisis : 0.2 % rated output • Repeatability : 0.1 % rated output • Excitation voltage : 4V (or less) • Safe excitation voltage : 6 v • Rated output : 1.5m v/v +/- 1 %	**1 mark for each specification** **(Any 4 specs)**
	g)	**List the electrical and Non-electrical method for temperature measurement.**	
	Ans	**Following are the Non-electrical methods for temperature measurement:** 1. Bimetal thermometer 2. Liquid in glass thermometer 3. Pressure thermometer **Following are the Electrical methods for temperature measurement:** 1. RTD (Resistance temperature detector) 2. Thermistor 3. Thermocouple 4. Pyrometers	**02 marks** **02 marks**
Q.2.		**Attempt any <u>FOUR</u> of the following:**	**16 Marks**
	a)	**Define transducer. Classify transducers with suitable examples.**	
	Ans	**Transducer**: A transducer is a device that converts one form of energy to another form. It converts the measurand to a usable electrical signal. In other word it is a device that is capable of converting the physical quantity into a proportional electrical quantity such as voltage or current. <u>The transducers can be classified as</u>: There are many principles on which a transducer can work like resistive, inductive, capacitive etc. So Transducer can be categorized on the basis of four thoughts. On the basis of transduction form it`s used, we can go further. 1. Primary and secondary type 2. Analog and digital type 3. Active and passive type 4. Transducer and Inverse type **1. Primary and Secondary Transducer**: Bourdon tube is primary transducer and **LVDT** is secondary transducer. **2. Analog and Digital Transducer**: Transducers converting input quantity to analog output in form of pulses are analog	**Defination-** **01 mark** **Classification-** **01 mark**

		transducers. i.e. **Strain gauge, thermocouple** etc. Digital transducers convert input to electrical output in form of pulses. **3. Active and Passive Transducer**: Active transducers are those which don't need auxiliary power source to produce output. The energy required for production of output signal is obtained from physical quantity being measured. i.e. **piezoelectric crystals, tacho-generators** etc. Passive transducers are those which need an auxiliary power source to produce output. i.e. **linear potentiometer** etc.	**Examples-** **02 marks**
	b)	**Explain with neat sketch procedure to use capacitive transducer for liquid level measurement.**	
	Ans	 **Figure: Capacitive Transducer** **Construction & working**: The principle of capacitive level measurement is based on change of capacitance. An insulated electrode acts as one plate of capacitor and the tank wall (or reference electrode in a non-metallic vessel) acts as the other plate. The capacitance depends on the fluid level. An empty tank has a lower capacitance while a filled tank has a higher capacitance. A simple capacitor consists of two electrode plate separated by a small thickness of an insulator such as solid, liquid, gas, or vacuum. This insulator is also called as dielectric. Value of C depends on dielectric used, area of the plate and also distance between the plates. $C = K.A / d$ C = capacitance in picofarads (pF) K = relative dielectric constant of the insulating material A = effective area of the conductors d = distance between the conductors This change in capacitance can be measured using AC bridge.	**Sketch-** **02 marks** **Construction & working-** **02 marks**
	c)	**Explain Mcleod gauge with neat sketch.**	
	Ans	**Basic Principle of McLeod Vacuum Gauge:** A known volume gas is compressed to a	

smaller volume whose final value provides an indication of the applied pressure. The gas used must obey Boyle's law given by; P1V1=P2V2

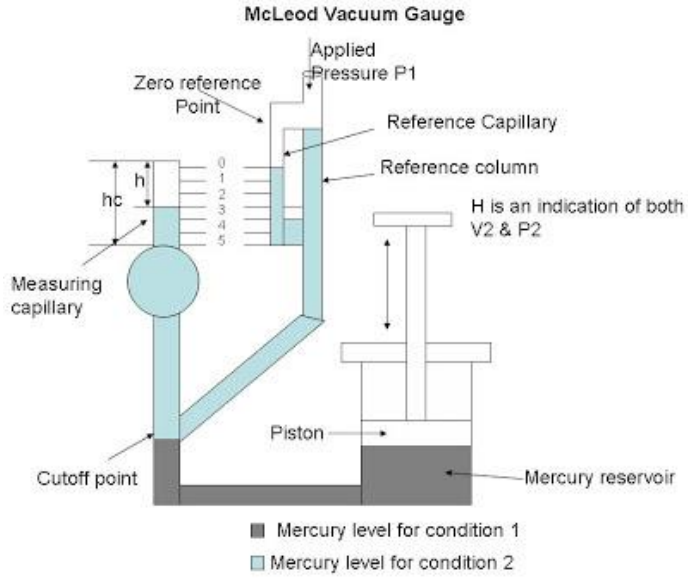


Figure: Mcleod Gauge

Sketch- 02 marks

Explanation- 02 marks

<u>The main parts of McLeod gauge are as follows</u>:

- A reference column with reference capillary tube. The reference capillary tube has a point called zero reference point.
- This reference column is connected to a bulb and measuring capillary and the place of connection of the bulb with reference column is called as cut off point. (It is called the cutoff point, since if the mercury level is raised above this point, it will cut off the entry of the applied pressure to the bulb and measuring capillary.
- Below the reference column and the bulb, there is a mercury reservoir operated by a piston.

<u>Operation of McLeod Vacuum gauge</u>:

- The pressure to be measured (P1) is applied to the top of the reference column of the McLeod Gauge as shown in diagram.
- The mercury level in the gauge is raised by operating the piston to fill the volume as shown by the dark shade in the diagram. When this is the case (condition – 1), the applied pressure fills the bulb and the capillary.
- Now again the piston is operated so that the mercury level in the gauge increases.
- When the mercury level reaches the cutoff point, a known volume of gas (V1) is trapped in the bulb and measuring capillary tube. The mercury level is further raised by operating the piston so the trapped gas in the bulb and measuring capillary tube are compressed.

This is done until the mercury level reaches the "Zero reference Point" marked on the reference capillary (condition – 2). In this condition, the volume of the gas in the measuring capillary tube is read directly by a scale besides it. That is, the difference in height 'H' of the measuring capillary and the reference capillary becomes a measure of the volume (V2) and pressure (P2) of the trapped gas. Now as V1,V2 and P2 are known, the applied pressure P1 can be calculated using Boyle's Law given by; P1V1 = P2V2

	d)	**Compare pressure measuring devices diaphragm and Bellows type on the basis of:** **(i) Construction (ii) Working Principle (iii) Material (iv) Applications**	

Ans

Points for comparison	Diaphragm	Bellows
Construction	A Diaphragm is elastic element can be in the form of flat, corrugated or dished plate forms an elastic capsule by cascading.	The basic way of manufacturing bellows is by fastening together many individual diaphragms.
Working Principle	A diaphragm is a flexible membrane that seals and isolates an enclosure. One pressure applied to the inside and second pressure applied to outside.	Bellows are used in two forms i.e. compressed type, Expanded type. In which The action of compression and expansion takes place by applying pressure to the elastic members.
Material	Non-metallic : polythene, neoprene, animal membrane, silk, and synthetic materials Metallic : stainless steel	Phosphor bronze, Silicon bronze, beryllium copper.
Applications	For measuring high pressure in Food and beverage industry, biotechnology industry, Refrigeration application etc.	For measuring pressure at various processes in chemical industry, also used in fuel and air density controls.

1 mark for each point

e) Explain the working of Bi-metallic Thermometer with neat sketch

Ans

Bi-metallic Thermometer: The bimetallic thermometers are made up of bimetallic strips formed by joining two different metals having different thermal expansion coefficients.

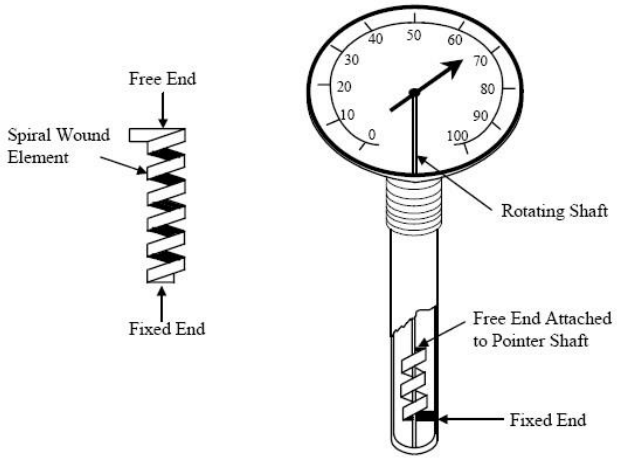


Figure: Bi-metallic Thermometer

Sketch- 02 marks

Construction & Working: A bimetallic strip is made up of two different metals having different coefficient of thermal expansion firmly bonded together. When a temperature change occurs different amounts of expansion occur in the two metals, causing a bending or twisting of the strip. A helical coil of bimetallic material with one end fixed is used in one

Explanation- 02 marks

form of thermometer. The coiling or uncoiling of the helix with temperature change will cause movement of a pointer fitted to the free end of the bimetallic strip. The choice of metals for the strip will determine the range, which can be from — 30°C to +550°C.

Advantages:

- The bimetallic thermometer is easily installed and maintained.
- Wide temperature ranges are available.
- The bimetallic thermometer has good accuracy.
- The cost is very low.
- It has nearly linear response

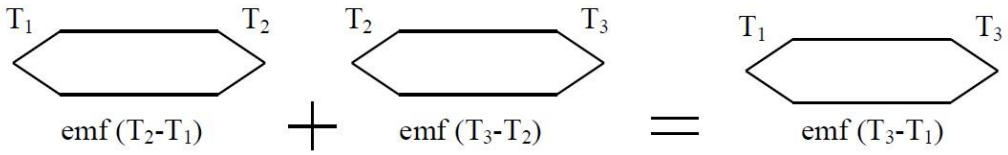
Disadvantages:

- It is suitable at local mounting only.
- Indicators are used to display.
- Calibration is disturbed if roughly handled.

f) Explain the law of (i) Intermediate temperature (ii) Intermediate metal

Ans

(i) Law of intermediate temperature:

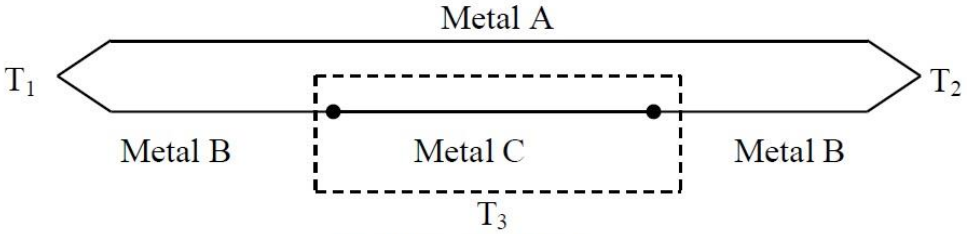


Law of Intermediate Temperatures

- The law of intermediate temperatures states that the sum of the emf developed by a thermocouple with its junctions at temperatures T1 and T2, and with its junctions at temperatures T2 and T3, will be the same as the emf developed if the thermocouple junctions are at temperatures T1 and T3.
- This law, illustrated in above Figure, is useful in practice because it helps in giving a suitable correction in case a reference junction temperature other than 0 °C is employed. For example, if a thermocouple is calibrated for a reference junction temperature of 0 °C and used with a junction temperature of 20 °C, then the correction required for the observation would be the emf produced by the thermocouple between 0 °C and 20 °C.

02 marks

(ii) **Law of intermediate metals**:



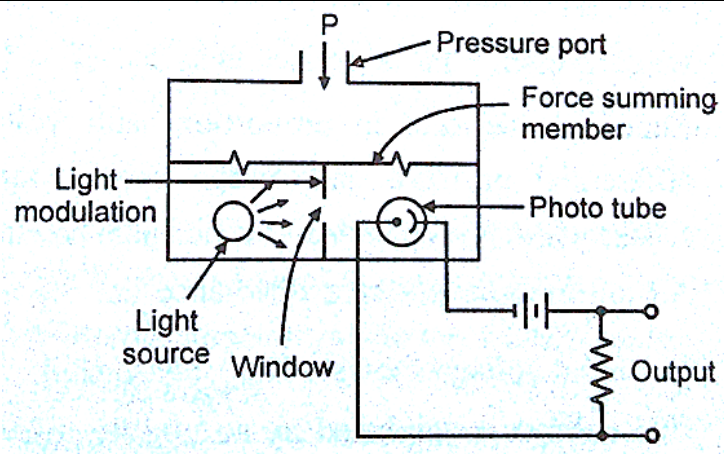
Law of Intermediate Metals

- The law of intermediate metals states that a third metal may be inserted into a thermocouple system without affecting the emf generated, if, and only if, the junctions with the third metal are kept at the same temperature.
- The law of intermediate metals states that the introduction of a third metal into the circuit will have no effect upon the emf generated so long as the junctions of the third metal are at the same temperature, as shown in Above **Figure.**

02 marks

Q.3. Attempt any FOUR of the following: **16 Marks**

a) A thermometer is having a range 0^0C to 200^0C . It has accuracy of $\pm 1\%$ of full scale

		value. Find the error in the reading of 63^0C.	
	Ans	Error $E_s = \pm 1\ ^0$C of full scale value i.e. 200^0C $= \pm \frac{1}{100} \times 200 = \pm 2\ ^0$C Thus a nominal reading of 63 ^{0}C is actually indicates a temperature in the range 61 ^{0}C to 65 ^{0}C.	**01 mark** **02 marks** **01 mark**
	b)	**Explain with neat sketch photoelectric pressure transducer.**	
	Ans	 **Figure: Photoelectric Pressure Transducer** **Working Principle:** Amount of incident light energy received by phototube is a function of change in pressure. **Construction:** • Consists of phototube and an a. c. light source separated by a small window as shown in figure. • The aperture size of window 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.	**02 marks for Diagram** **02 marks for explanation**
	c)	**Explain working of ionization gauge for pressure measurement.**	

Ans

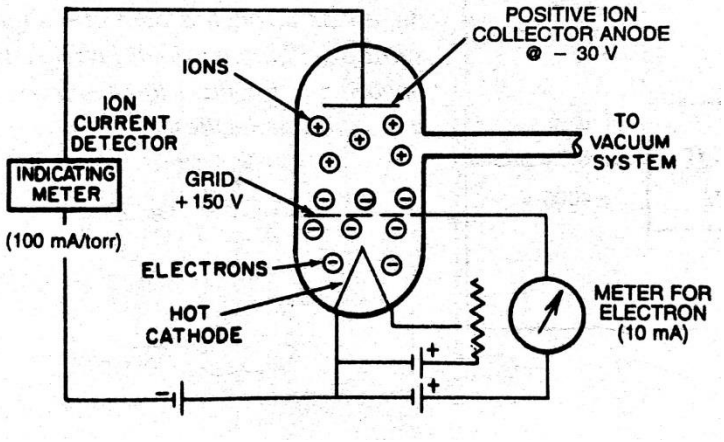


Figure Ionization Gauge

02 marks for Diagram

Working:

(**Reference:** Process Measurement and Analysis Handbook by LIPTAK)

- Heated cathode emits electrons.
- Positive charged grid accelerates these electrons as it passes through the grid.
- Accelerated electrons collide with gas molecules causing ionization.
- Positive ions collect at anode producing plate current i_p.
- Negative ions collect at grid producing grid current i_g.
- Ratio of i_p and i_g gives measurement of vacuum pressure.

$$Pvacuum = \frac{1}{K}\frac{i_p}{i_g}$$

where K = Proportionality constant known as sensitivity of gauge

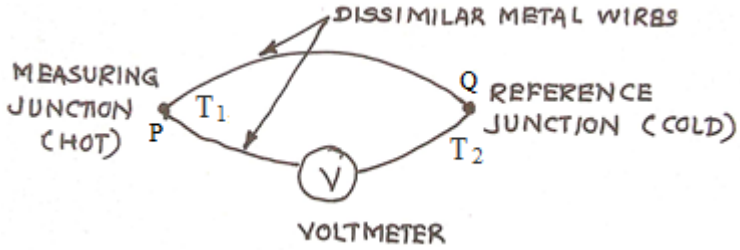
02 marks for explanation of working

d) Differentiate between RTD and thermistor.

Ans

Basis For Comparison	**RTD (Resistance Temperature Detector)**	**Thermistor**
Material	Metals (platinum, nickel, copper, etc.)	Semiconductor
Accuracy	More accurate	Less accuracy
Response Time	Slow	Fast
Temperature Range	-250^0C to 899^0C	The useful range is -100°C to +300°C.(Lower Limit can be -240^0C

1 mark for each point (Any 4 Points)

		Characteristic Graph	Linear	Non-linear at higher range.	
		Sensitivity	Low	High	
		Size	Large	Small	
		Cost	Expensive	Cheap	
		Resistivity	High	Low	
		Hysteresis Effect	Low	High	
		Applications	In industries for measuring high temperature.	For measuring the temperature of home appliances.	
	e)	**Explain with neat sketch working of thermocouple**			
	Ans	 **Figure: Thermocouple**			**02 marks for Diagram**

Working of Thermocouple

- The thermocouple schematic diagram is shown in the below figure.
- This circuit can be built with two different metals, and that are coupled together to form two junctions.
- The two metals are connected by welding.
- In the above diagram, the junctions are denoted by P & Q, and the temperatures are denoted by T_1, & T_2.
- When the temperature of the junction is dissimilar from each other, then the electromagnetic force generates in the circuit.
- If the temperate at the junction end turn into equivalent temperature, and there is no flow of current through it. Similarly, the temperature at the junction end become imbalanced, then the potential variation induces in this circuit.

02 marks for explanation of working

- The magnitude of the electromagnetic force induces in the circuit rely on the sorts of material utilized for thermocouple making and the temperature difference ($\Delta\Theta$) between two temperature junctions.
- The electromagnetic force induced in the circuit is calculated by the following equation
- $e_0 = C_1(T_1 - T_2) + C_2(T_1^2 - T_2^2) \quad \mu V$
- Where $\Delta\Theta$ is the temperature difference among the hot thermocouple junction end as well as the reference thermocouple junction end, C_1 & C_2 are constants for the two different materials used.

f) Explain with neat sketch optical pyrometer.

Ans

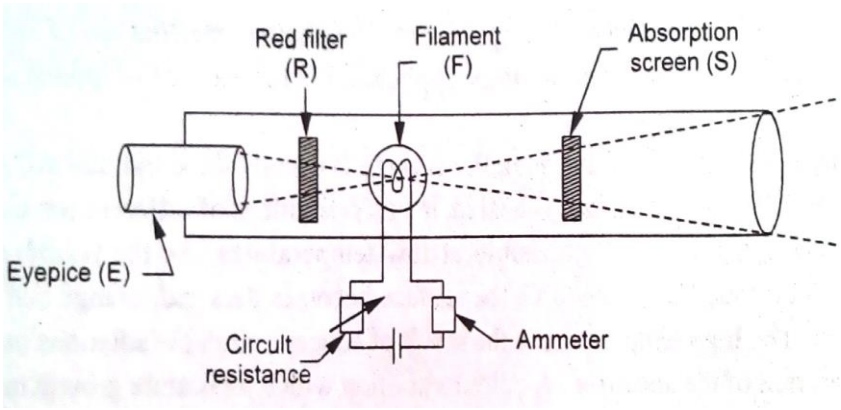


Figure (a) Construction Details of Optical Pyrometer

02 marks for Diagram

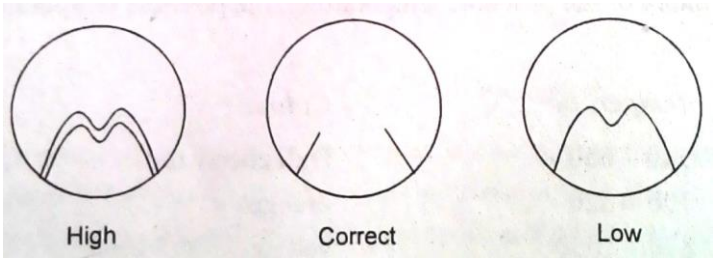


Figure (b) Disappearing filament of optical pyrometer

Principle:

Monochromatic 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.

Construction:

02 marks for explanation

- Construction of optical pyrometer is shown in **figure (a)**
- An eye piece at one end and an objective lens at the other end.
- A power source (battery), rheostat and millivoltmeter (to measure current) connected to a reference temperature bulb.
- An absorption screen is placed in between the objective lens and reference temperature lamp. The absorption screen is used to increase the range of the

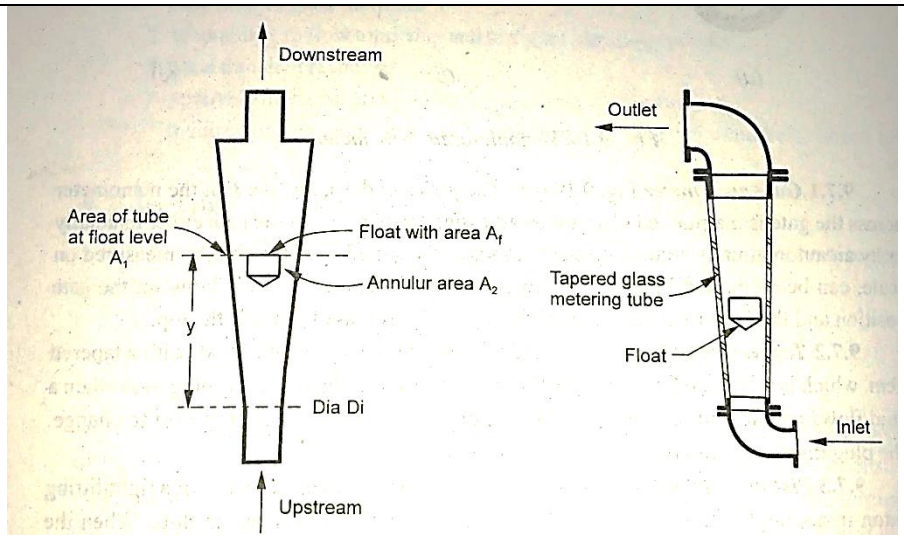
temperature which can be measured by the instrument.

- The red filter between the eye piece and the lamp allows only a narrow band of wavelength of around 0.65mui

Working:

- The current through the lamp filament is made variable so that lamp intensity can be adjusted. The filament is viewed through the eyepiece and filter.
- The current through the filament is so adjusted that filament and image are of equal brightness. When brightness of source and image produced is same, it is assumed 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(b)** (High). And if the temperature of filament is lower , it becomes too dark as shown in **figure (b)** (Low).

Range- 1400 ^{0}C, can be incresed upto 3000 ^{0}C

Q.4.		**Attempt any <u>FOUR</u> of the following:**	**16 Marks**
	a)	**Explain construction and working of rotameter with neat diagram.**	
	Ans	 **Figure: Rotameter**	**02 marks for diagram**
		Working Principle: Constant pressure drop across variable area. • If pressure difference is maintained constant by varying the outflow area of construction meter, then outflow area at any instant would be a measure of flow rate through the device.	**01 mark for construction**
		Construction: (**Figure**) • It consist of a tapered metering glass tube.(Borosilicate, polycarbonate, Al , brass) • Inside which there is a float or bob (Gun metal, stainless steel) will move freely. • The float or bob is free to move inside the tube and is heavier than the fluid it displaces. • Flow rate scale is engraved on glass tube.	**01 mark for working**

Working:

- The fluid flows upward through the gap between the tube and the float.
- As the float moves up or down there is a change in the gap, as a result changing the area of the orifice.
- In fact, the float settles down at a position, where the pressure drop across the orifice will create an upward thrust that will balance the downward force due to the gravity.
- The discharge equation of the Rotameter can be derived from equation of orifice meter as given below,

$$Q_{actual} = \frac{C_d M A_2 \sqrt{2g(P_1 - P_2)}}{\rho g}$$

It can be written as $Q_{actual} = KA_2$

$$where \ K = \frac{C_d M \sqrt{2g(P_1 - P_2)}}{\rho g} = \text{constant}$$

Where A_2 = annular area between float and tube.

Above equation indicates that flow rate in Rotameter is a function of annular area A_2 only.

b) Describe the working of electromagnetic flow meter with schematic Sketch.

Ans

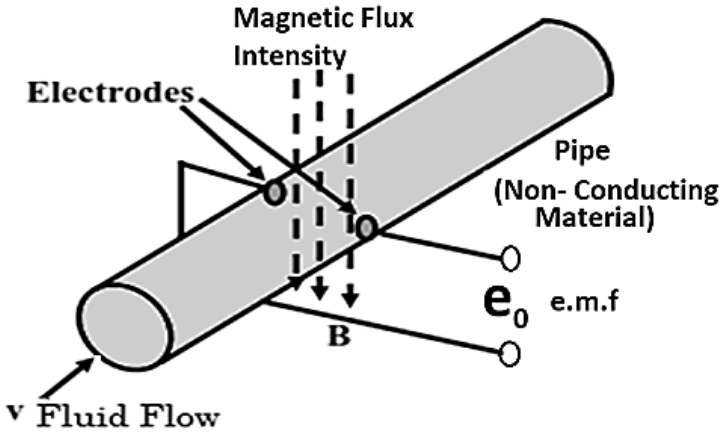


Figure: Electromagnetic Flowmeter

02 marks Diagram

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.

02 marks working

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.

- However, the magnetic field applied is not d.c. if the liquid medium is water or any other polarizable liquid as it will cause electrolysis creating insulating layer over electrodes. This will disrupt the voltage generation process.
- Hence, the magnetic field applied for these cases is a.c., or pulsed d.c. excitation.

c) State the suitable devices for flow measurement of:

(i) Wind flow **ii) Paper pulp**

(iii) Flow rates in R and D work **iv) Slurries**

Ans

(i) Wind flow - Anemometers

(ii) Paper pulp - Ultrasonic Flow meter

(iii) Flow rates in R and D work- Electromagnetic flow meter

(iv) Slurries - Electromagnetic flow meter,

Ultrasonic Flow meter

01 marks for each correct answer

d) Explain construction and working of piezoelectric microphone with neat sketch.

Ans

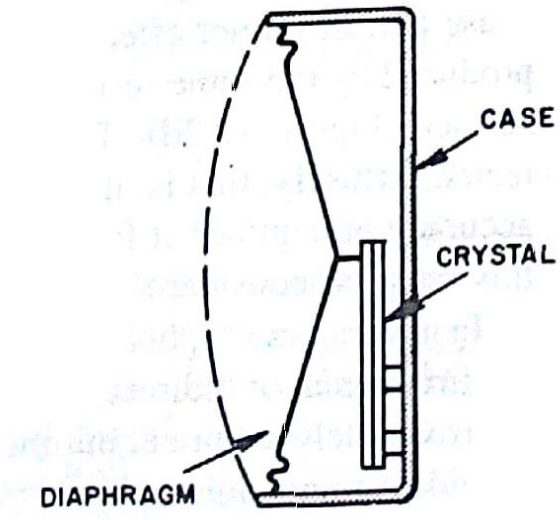
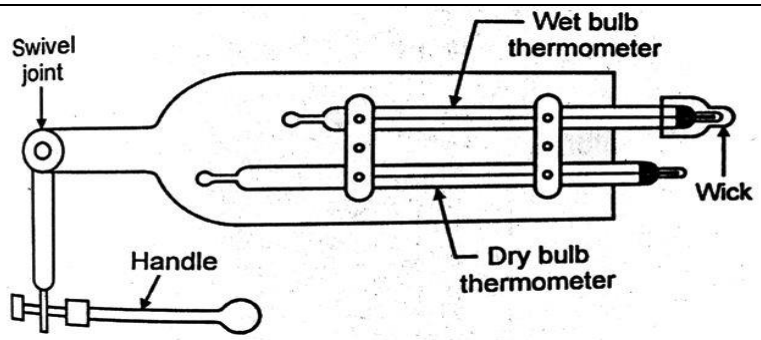


Figure : Piezoelectric Microphone

Working Principle:

02 marks for diagram

		• Piezoelectric microphones depends on a specific behavior of some crystalline materials- that a deformation of the crystal will cause electrical potentials to appear on the surface of the crystal, • The magnitude of the potential is in proportion to the force that is causing the deformation. **Construction:** • The construction is shown in the **figure** • It consists of a diaphragm which can sense the sound wave force. • This diaphragm is fixed to piezoelectric crystal. • These elements are enclosed in a housing and leads are taken out from crystals. **Working:** • Diaphragm receives the sound waves and applies their force on piezoelectric crystal , causing it to bend. • Due to the force application piezoelectric crystal generates electrical potential which can calibrated in terms of sound intensity.	**01 mark for construction** **01 mark for working**
	e)	**Explain with neat sketch sling psychrometer for humidity measurement.**	
	Ans	 **Figure : Sling Psychrometer** **Construction:** • It consist of two thermometer for measurement of dry bulb and wet bulb temp. • It measures dry and wet bulb temp. simultaneously. • These two thermometers are mounted on a suitable frame and arranged with swivel mounted handle. • Sensing bulb of one thermometer is covered with knitted or woven cotton wick which is moistened with pure clean water. **Working:** • The readings are taken after swinging the psychrometer in a smooth circular path for about 15 to 20 second. • To get accurate and better measurements fast movement of air past the moistened wick is necessary. • To attain proper temp. the necessary air motion 5 m/s to 10 m/s. • Operator can read the dry as well as wet bulb temp. and refer the relative humidity chart to measure the relative humidity.	**02 mark for Diagram** **01 mark for construction** **01 mark for working**
	f)	**Draw the block diagram of automatic control system. Explain function of each block.**	
	Ans		

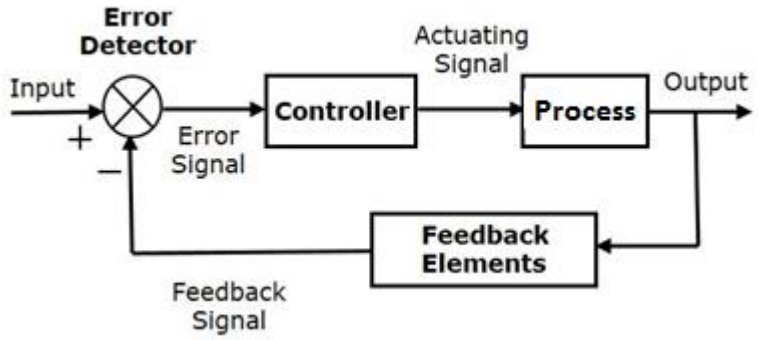


Figure : Automatic Control System

02 marks for construction

Error detector or comparator: It produces an error signal, which is the difference between the input and the feedback signal.

Feedback Element: Evaluates the feedback signal) by considering the output of the overall system as an input to this block. Instead of the direct input, the error signal is applied as an input to a controller.

Controller: Produces an actuating signal which controls the process. In this system, the output of the control system is adjusted automatically till we get the desired response.

Plant/Process: A system where the output is the variable to be controlled.

02 marks for functions of 4 elements

Q.5.		**Attempt any <u>FOUR</u> of the following:**	**16 Marks**
	a)	**Describe Ultrasonic flow measurement. Explain with neat sketch.**	
	Ans	In ultrasonic flow meters, the measurement of flow rate is determined by the variation in parameters of ultrasonic oscillations. **Principle:** The difference in transmit times of ultrasonic pulses is linearly proportional to flow velocity.	**01 mark for principle**

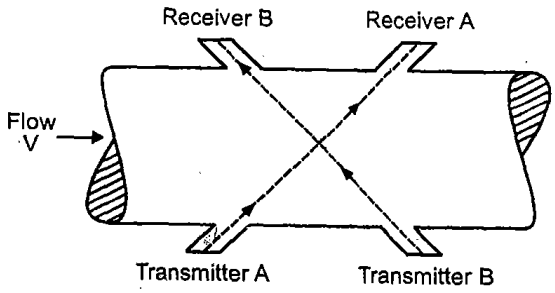


Figure: Ultrasonic Flow Meter

01 mark for diagram

• In this device, time taken by ultrasonic wave to cross the pipe along the direction of flow and opposite to the direction of flow is measured.

• Ultrasonic transducer is mounted at an angle or parallel to the pipe wall.

• When ultrasonic waves pulsed for very short duration one transmitted across the fluid, the velocity of the ultrasonic waves is increased or decreased by the fluid velocity depend upon

2 marks for construction and working

the direction of fluid flow.

• A and B are piezoelectric devices transmitting the short duration ultrasonic signals through the fluid that is flowing through the pipe at a velocity V, similar types of crystals are used as receivers to respond to the pressure fluctuations.

• Due to the fluid velocity V, avoiding the transmission, the velocity of the ultrasonic signal from transmitter A to receiver A is increased to a value C + V cos θ, where C is velocity of sound through the fluid in the pipe.

θ - Angle between the path of sound and pipe wall.

Repetition frequency of the received pulse,

$$f_A = \frac{C + V \cos \theta}{l}$$

l is distance between transmitter and receiver. The velocity the ultrasonic signal transmitted by the transmitter B and received by receiver B will reduced by the fluid velocity causing a retardation of V cos θ, and its pulse repetition frequency f, will be,

$$f_B = \frac{C - V \cos \theta}{l}$$

The difference of frequency is given by,

$$\Delta f = f_A - f_B = \frac{2 V \cos \theta}{l}$$

$$\text{Time direction, } \Delta T = \frac{l}{2 V \cos \theta}$$

• This formula indicates that measurement of flow is independent of sound velocity. For such type of flow meter fluid must be free from solids to air.

b) Explain with neat sketch vortex type flow meter.

Ans

Principle:

Within the flow meter, as a fluid moves across a tiny strut or "bluff body", vortices are also shed but on a smaller scale. The vortices form alternately, from one side to the other, causing pressure fluctuations.

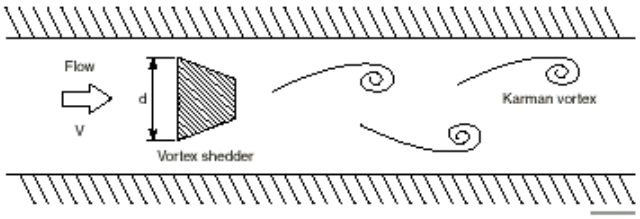


Figure: Vortex Flow Meter

Construction and Working

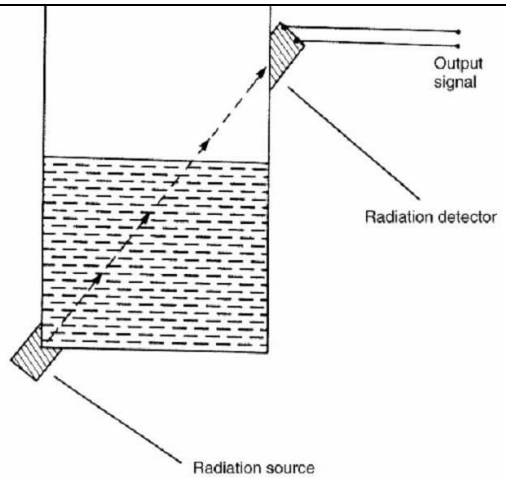
• An everyday example of a vortex shedding phenomenon is a flag waving in the breeze: the flag waves due to the vortices shed by air moving across the flag pole.

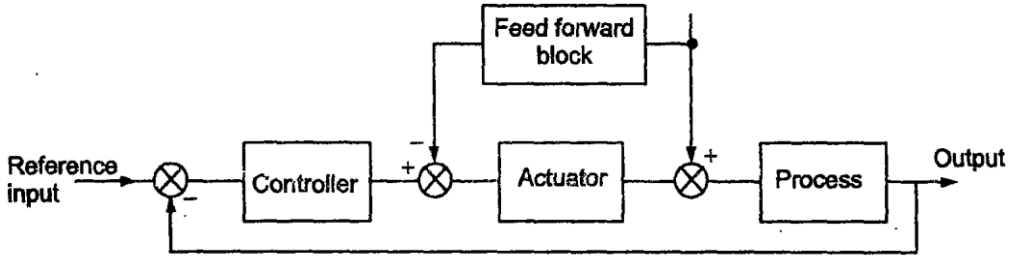
Principle:

01mark

Diagram:
01 mark

Construction and Working

		• In the case of a vortex meter, the bluff body is the shedder bar, typically shaped like a square, rectangle, T, or trapezoid as shown in figure , and is submerged in a flowing fluid.  • As the fluid passes the bluff body, alternating whirl vortices are generated in the backward stream referred to as a Karman vortex street and illustrated in Figure. • Frequency detection can be accomplished by using different techniques including piezoelectric, differential pressure, or capacitance, and is directly proportional to the flowing velocity and demonstrated with the following formula; $$\text{Vortex frequency (f)} = \frac{\text{Strouhal number (St)} \times \text{Flow velocity (v)}}{\text{Vortex shedder width (d)}}$$	**02 marks**
	c)	**Explain Construction and working of Gamma ray liquid level sensor with neat sketch.**	
	Ans	 **Figure: Gamma ray liquid level sensor** **Construction:** • It consists of tank in which liquid is filled whose level is to be measured. • A gamma ray source holder is placed at one of top side of tank and receiver is placed exactly opposite bottom side of tank to receive the gamma rays emitted by source. • The gamma ray source holder is mounted such that it covers the entire wall of tank. When gamma ray source holder is switched 'ON' it transmits the thin band of gamma rays, which covers the entire tank wall and passes through medium in tank. • A radiation detector is placed parallel to the tank wall, which will detect a radiation level of gamma rays. It converts the radiation level into its equivalent electrical signal, which will be measured by measuring device. • The reading shown by measuring device is directly calibrated in terms of liquid level. **Working:**	**01 mark diagram** **1.5 marks for construction** **1.5 marks for working**

		• When tank is empty, then gamma rays pass through air in the tank and tank wall. As a result of this, its energy level decreases and detector detects the radiation energy level. • When liquid level is to be measured, gamma rays passes through liquid and tank wall, due to which radiation level will again decrease which is detected by detector. • Therefore the difference between the two readings shown by detector is directly proportional to the rise of liquid level in tank.	
	d)	**Refer question paper.**	
	Ans	i)Tangential force=800 N ii)Axial force=100 N iii)Speed of spindle=300 rpm iv)Feed rate=0.8 mm per resolution v)Mean diameter of cut=100 mm = 0.1m and 1) **Power absorbed in rotating the work piece is given by** $= 2\pi nT$ $= F \times r \times 2\pi n$ Where F=Tangential force=800 N r = mean diameter of cut/2=100/2=50mm n = spindle speed = 300rpm **Power absorbed in rotating work piece** $=800 \times 2 \times \pi \times (300/60) \times 0.05$ **=1256 W** 2) **Power absorbed in feeding the tool along the work piece** $= F \times \nu$ (ν =feed mm/rev) $= 100 \times 0.8 \times 10^{-3} \times (300/60)$ **= 4 W**	**1 mark** **1 mark** **1 mark** **1 mark**
	e)	**Explain feed forward control system with the help of neat sketch.**	
	Ans	i. Unlike the feedback systems, a feed forward control configuration measures the disturbance (load) directly and takes control action to eliminate its impact on the process output. ii. Hence, feed forward controllers have the theoretical potential for perfect control.  **Figure: Feed Forward Control System** iii. The Fig. shows the general form of feed forward control system. It measures the disturbance directly and then it changes effect that it will have on the process output. Subsequently, it changes the manipulated variable by such an amount as to eliminate completely the impact of the disturbance on the process output (controlled variable). iv. Control action starts immediately after a change in the disturbance has been detected. Feedback acts after the fact in a compensatory manner, whereas feed forward acts	**Diagram-02 marks** **Explanation-02 marks**

beforehand in an anticipator manner.

v. The feed forward control system can be developed for more than one disturbance. The controller acts according to which disturbance changed value. With the exception of the controller, all the other hardware elements in a feed forward loop are the same for a feedback loop.

f) Compare hydraulics and electronics control system.

Ans

Parameter	Hydraulic System	Electronic System
Operating Medium	Medium for transmission of energy is liquid i.e. oil.	Electricity is operating medium.
Speed of Response	Low speed and small displacement in operation.	Extremely high speed of response.
Reliability	More rugged and reliable.	Less reliable.
Accuracy	Less accurate when compared with pneumatic and electronic system.	Very good accuracy.
Working Environment	Not susceptible to hazardous environment,	Susceptible to hazardous environment.
Electrical Noise	Unaffected by electrical noise	Susceptible to noise pick-ups.
Maintenance	Leakage problems high maintenance cost.	Less maintenance cost.
Signal Transmission	Transmission of signals to remote place is a problem.	Signal transmission over long distances is possible.

1 mark for each points (Any 4 Points)

Q.6. **16 Marks**

a) Describe speed measurement by using stroboscope.

Ans

Stroboscope

• The stroboscope utilizes the phenomenon of vision when an object is viewed intermittently.

• The human sense of vision is slow to react to light that is unable to separate two different light impulses reaching the eye within a very short period of time (less than 0.1 sec.)

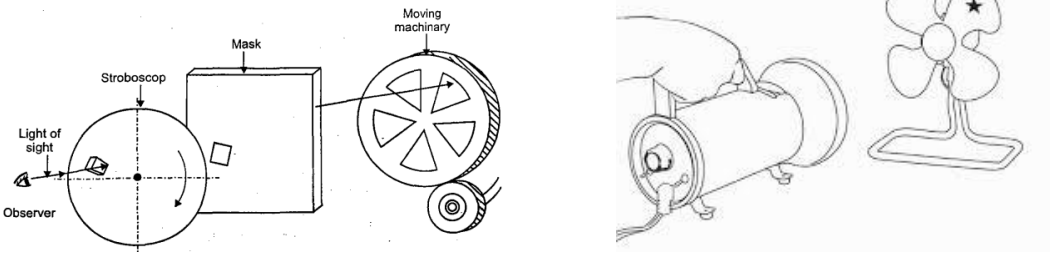


Figure: Stroboscope

Sketch- 01 Mark

Description- 03 Mark

Construction:

• The stroboscope is a simple, portable manually operated device which may be used for measurement of periodic or rotary motions.

• Basically, the instrument is a source of variable frequency flashing brilliant light, the flashing frequency being set by operator.

• An oscillator is provided so that the moving object (target) is visible at specific intervals.

• If strong light is caused to flash on moving object, the object will appear stationary.

• The stroboscope consists of a source of flashing light whose frequency can be varied and controlled.

• This source is called a strobotron.

• The tube has capacity to flash 300 flashes per second.

Working:

• The flashing light is directed on rotating member, which usually has some spoke, gear teeth or some other features.

• The frequency of lamp flashing is adjusted until the target appears stationary.

• Under this condition, speed is equal to flashing frequency. The scale of stroboscope can be calibrated to read the speed directly.

• If there are several marks on shaft, various errors in measurement arise.

• If disc has m number of marks, then disc will appear stationary,

$$\text{The speed (n)} = \frac{F}{m}$$

Where F = Number of flashes per sec.

m = Number of marks on disc

• Single line image is obtained by flashes.

• The flashing rate is gradually reduced and flashing frequencies are noted for all single line image.

• If single line image are obtained at m different flashing rates, say F1, F2, F3, . . . Fm.

Then,

$$\text{Speed of shaft (n)} = \frac{F_m F_1 (m-1)}{F_m - F_1}$$

Where, F_1 = Lowest flashing frequency, F_m = Highest flashing frequency, m = Number of flashing points or frequencies

b) Explain Load measurement by using load cell with neat sketch

Ans

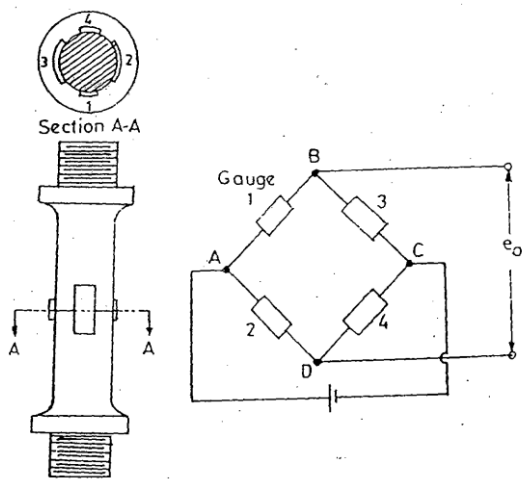


Figure: Load cell

Sketch- 01 mark

Construction & Working:

Explanation- 03 marks

• Load cells utilize an elastic member as the primary transducer and strain gauges as secondary transducer.

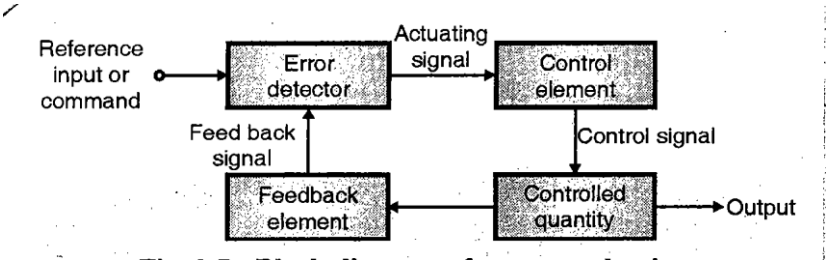
• Strain gauges may be attached to any elastic member on which there exists a suitable plane area to accommodate them.

• This arrangement may then be used to measure loads applied to the member. When the strain gauge elastic member combination is used for weighing it is called a load cell.

• Fig. shows a tensile-compressive cell which is a cylinder. This arrangement uses four strain gauges each mounted at 90^0 to each other. Two of strain gauges experience tensile stresses while the other two are subjected to compressive stresses.

• An axial compressive load causes a negative strain in the vertical gauges, and a positive strain in the circumferential gauges.

• The two strains are not equal. This force transducer is calibrated experientially. In case all

		the gauges are similar, temperature compensation is obtained as all the gauges. • Load cell is a type of strain gauge, which is used to weight extremely heavy load	
	c)	**Explain servomotor mechanism with neat sketch. State its application**	
	Ans	In automatic control system, the word 'servo' deals with the control of position.  **Figure: Servomotor Mechanism** • A servo mechanism is an automatic control system in which the, controlled variable is a mechanical position (displacement) or a time derivative of displacement such as velocity and acceleration. • The output is designed to follow a continuously changing input or desired variable (i.e. demand signal). • The servo mechanisms are naturally fast acting and usually employ electric and hydraulic actuation. • These systems are used to control the position or speed of a mechanism which is either to heavy or too remote to be controlled manually. **Application:** 1) Power assisted steering Mechanism. 2) Automation machine tools together with programmed instruction 3) Control in large cars, aircrafts, ships.	**Sketch-** **01 mark** **Explanation-** **02 marks** **Application any 2-** **01 mark**
	d)	**Explain PID Control Action**	
	Ans	1) In a proportional control action, there is a continuous linear relation between the controller output m and the actual error signal e. 2) The control value or the regulating unit can take up any position i.e. from the fully open to fully closed. The proportional control follows the law. $m(t) = k\,e(t) + M$ 3) This control action is also referred as reset control action with integral control, the controller output (m) is proportional to the integral of the error signal (e). Mathematically it can be represented as,	**1 mark** **1 mark**

$$m = \frac{1}{T_i}\int_0^t e\,dt + K$$

4) In this control action, the controller output (m) is proportional to the time rate of change of the error signal at any instant of time.

Mathematically,

$$m = T_d \frac{de}{dt} + K$$

1 mark

5) It is the composite control action of proportional, Integral and derivative control mode. It combines the advantages of these three control actions. In this system the output (m) is a linear combination of input e, the time rate change of input and the time integral as input.

Mathematically it is given by,

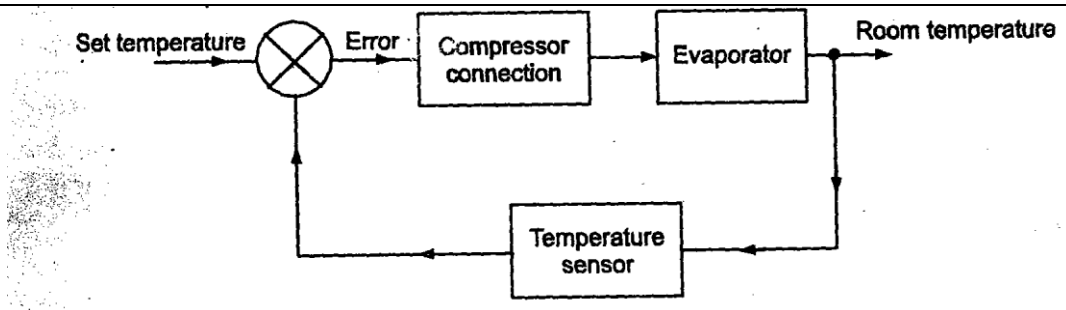
$$m = K_p e + \frac{K_p}{T_i}\int e dt + K_p\, Tde + K$$

1 mark

The PID control mode is best suitable for systems where close control is required because of large and sudden fluctuations.

e) Explain control system for air conditioner (AC).

Ans



02 marks

Figure: Control system for air conditioner

1. There is comparison between the actual temperature (controlled) and the desired value of the temperature variable.

2. To accomplish the output signal is fed back and the loop is completed.

3. The error signal (deviation between the reference temperature and the feedback signals temperature) then actuates the control element to minimize the error and bring the system output to the desired temperature.

4. The system operation is continually correcting any error that may exist, As long as the output does not coincide with the desired temperature.

02 marks

5. Air-conditioner maintains the room temperature at some predetermined (Set) value. When room temperature is more than set value it switch ON compressor to start cooling of room. On reaching the set value of temperature in room it disconnects compressor connections.

f) Compare between open loop and close loop control system.

	Ans		SR.NO.	PARAMETER	OPEN LOOP SYSTEM	CLOSED LOOP SYSTEM	1 mark for each points (Any 4 Points
			1	Feedback	No Feedback	Feedback is present	
			2	Construction	Easy to Built	It is difficult to build	
			3	Specification	Process specifications should be well known to us	Not necessary to know the process specifications	
			4	Disturbances	Disturbances occurring in the process are not controllable	Disturbances do not affect the process, besides they can control automatically.	
			5	Stability	It is more stable	It is less stable	
			6	Response	Response is slow	Response is fast	
			7	System Accuracy	Accuracy is good	Not so accurate	
			8	Cost	Cost effective	Expensive	
			9	Application	Applications two way traffic control, domestic applications	Process control like boilers, chemical and fertilizers, etc.	