WINTER– 18 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. No.	Sub Q. N.	Answer	Marking Scheme
1	A a)	Calibration is the operation of making an adjustment or marking a scale so that reading of an instrument conform to an accepted and certified standard. Calibration is a comparison between a known measurement (the standard) and the measurement using your instrument. Typically, the accuracy of the standard should be ten times the accuracy of the measuring device being tested. Calibration is defined as the comparison of measured value with standard. Why required? **The accuracy of all measuring devices degrade over time. This is typically caused by normal wear and tear. However, changes in accuracy can also be caused by electric or mechanical shock or a hazardous manufacturing environment (e.x., oils, metal chips etc.). Depending on the type of the instrument and the environment in which it is being used, it may degrade very quickly or over a long period of time. The bottom line is that, calibration improves the accuracy of the measuring device. Accurate measuring devices improve product quality.** A measuring device should be calibrated: • According to recommendation of the manufacturer. • After any mechanical or electrical shock. • Periodically (annually, quarterly, monthly)	02M 02M
	b	Range :- The region between the limits within which an instrument is designed to operate for measuring, indicating or recording a physical quantity.	01 mark Each -4M

Hysteresis:-It is the maximum difference for the same measured quantity between the upscale and downscale readings during a full range transverse in each direction.

Drift:-It is an undesired gradual departure of the instrument output over a period of time that is unrelated to changes in input ,operating conditions or load.

Reproducibility:- It is the degree of closeness with which same value of a variable can be measured at different times.

c

Construction:

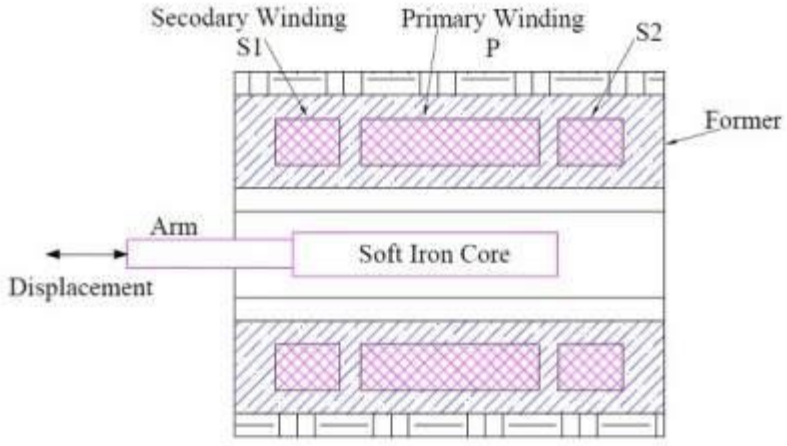
LVDT is a transformer consisting of one primary winding P and two secondary winding S_1 & S_2 mounted on a cylindrical former. The two secondary winding have equal number of turns and placed identically on either side of the primary winding as shown in figure below.

01 mark - construction
02 mark – working

01 mark-

Any one

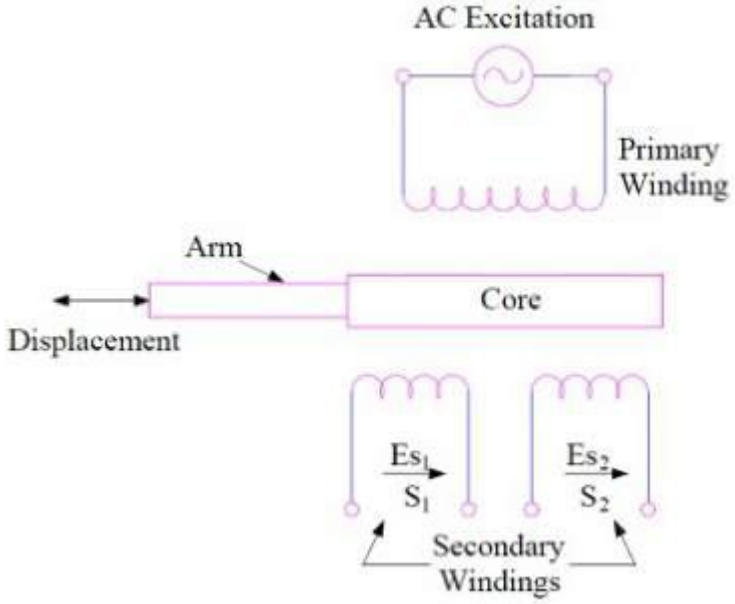
sketch



A movable soft iron core is placed inside the former. Actually the movable core is made of nickel iron with hydrogen annealed. Hydrogen annealing is done to eliminate harmonics, residual voltage of core and thus provides high sensitivity. The movable core also is laminated in order to reduce eddy current loss. The assembly of laminated core is placed in a cylindrical steel housing and end lids are provided for electromagnetic and electrostatic shielding. The displacement to be measured is attached to this movable soft iron core.

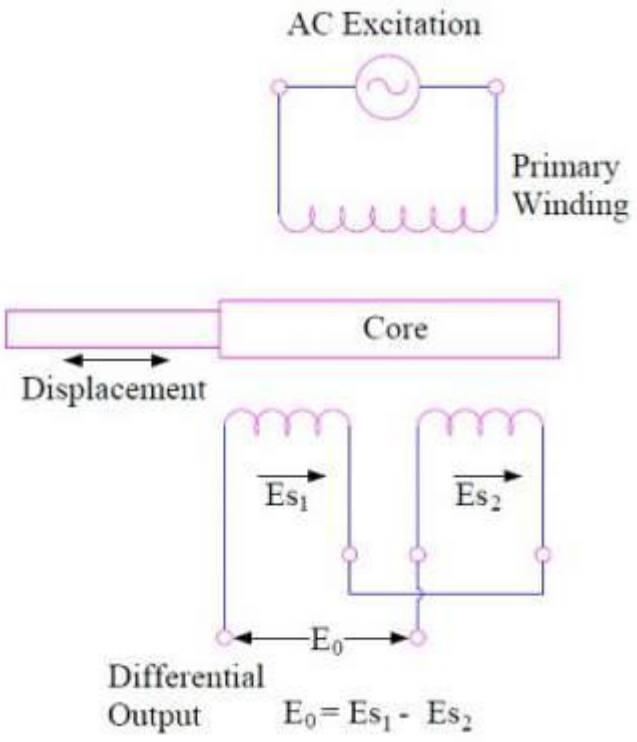
LVDT- Working Principle:

Since the primary winding of Linear Variable Differential Transformer (LVDT) is supplied with AC supply, it produces an alternating magnetic flux in the core which in turn link with the secondary winding S_1 and S_2 to produce emf due to transformer action. The electrical equivalent circuit of LVDT is shown below.



Let us assume that the emf produced in secondary winding S_1 is E_{s1} and that in S_2 is E_{s2}. The magnitude of E_{s1} and E_{s2} will depend upon the magnitude of rate of change of flux ($d\emptyset / dt$) as per the Faraday's Law. The lower the value of 'dt', the more will be the emf induced. But lower value of 'dt' means that core is moving faster. Thus we can say that the faster the movement of core, the greater will be the magnitude of emf induced in secondary windings.

To get a single output voltage from the Linear Variable Differential Transformer (LVDT), both the secondary winding are connected in series but in phase opposition as shown in figure below.



Due to this connection, the net output voltage E_0 of the LVDT is given as below.

$E_0 = E_{s1} – E_{s2}$

Since the secondary windings of LVDT are identical and placed symmetrically on either side of core, therefore under normal position the flux linkage of both the secondary winding S_1 & S_2will be same. This means $E_{s1} = E_{s2}$ and hence net output voltage E_0 of LVDT = 0. This position of soft iron core is called NULL position. Thus NULL position of Linear Variable Differential Transformer is the normal position of movable core where the net output voltage is zero.

d) Ionization Gauge is a device that is used to measure vacuum. In the hot cathode type, a column of gas is introduced into which, a potential difference V is applied with free electron in the space. This causes the electron with a charge e to acquire a kinetic energy Ve. If the pressure range of the gas in the column goes below a certain limit, called the critical pressure, then corresponding to a voltage larger than the critical voltage Vc, the energy Ve may be high enough to initiate ionization, and positive ions will be produced when the electrons collide with the gas molecules.

The value of Vc is smallest for cesium (3.88V) and largest for helium (24.58V), among monoatomic gases or vapours. For diatomic gases like N2, H2 and so on, it is roughly about 15V. This is known as the ionization potential and at this potential the pressure is also important.

Principle -02M

Sketch-02M

At very low pressures, during the intervals of time for transit from the cathode to the plate in a vacuum chamber, more than one collision is unlikely for an electron. Then for a fixed accelerating potential V>Vc, the number of positive ions formed would vary linearly with the value of pressure. Thus, a determination of the rate of production of positive ions for a given electron current should give a measure of the pressure.

Working Principle:-

The construction of a hot cathode type ionization gauge consists of a basic vacuum triode. The figure of hot cathode gauge is shown below.

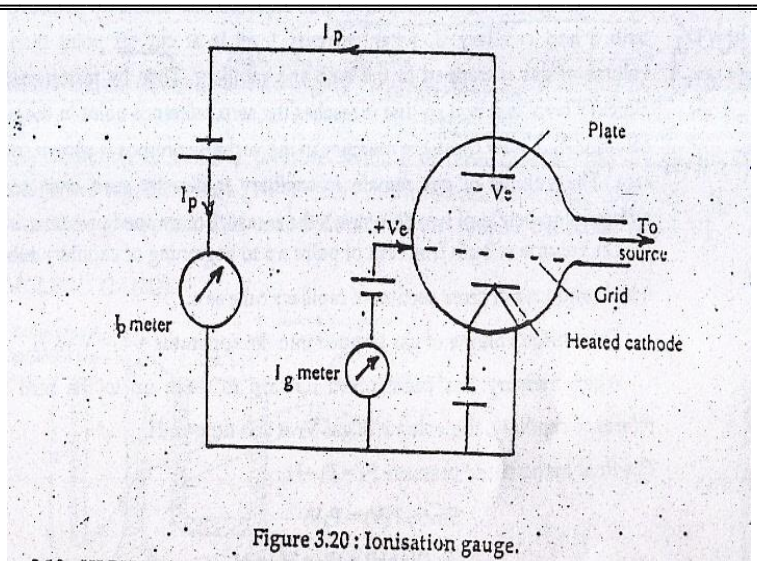


Figure 3.20 : Ionisation gauge.

The grid is maintained at a large positive potential with respect to the cathode and the plate. The plate is at a negative potential with respect to the cathode. This method is also known as the external control type ionization gauge as the positive ion collector is external to the electron collector grid with reference to the cathode. The positive ions available between the grid and the cathode will be drawn by the cathode, and those between the grid and the plate will be collected by the plate.

1 B **a)**

Measurement:- It is the act or the result, of a quantitative comparison between a predetermined standard and an unknown magnitude.

Significance:-

1. In the field of engineering design, research and development programme, the measurements and correct interpretation are the source of great importance and necessary information.
2. In the process industries and power plants and several other production industries, the aim is to achieve quality of product and have maximum efficiency.
3. For this purpose and for the maintenance of proper operation, measurements i.e instrumentation plays an important role.
4. The whole area of automation and automatic controls is based on measurements.

Following are basic requirements of measurement :

1.The standard used for comparison purposes must be accurately defined & should be commonly accepted

2. The apparatus used & the method adopted must be provable.

3. Controlling some variable in process within its specified unit

Def-01M

Significance. -02 M

Any 3 Requirement -3M

4.Specify particular quantity

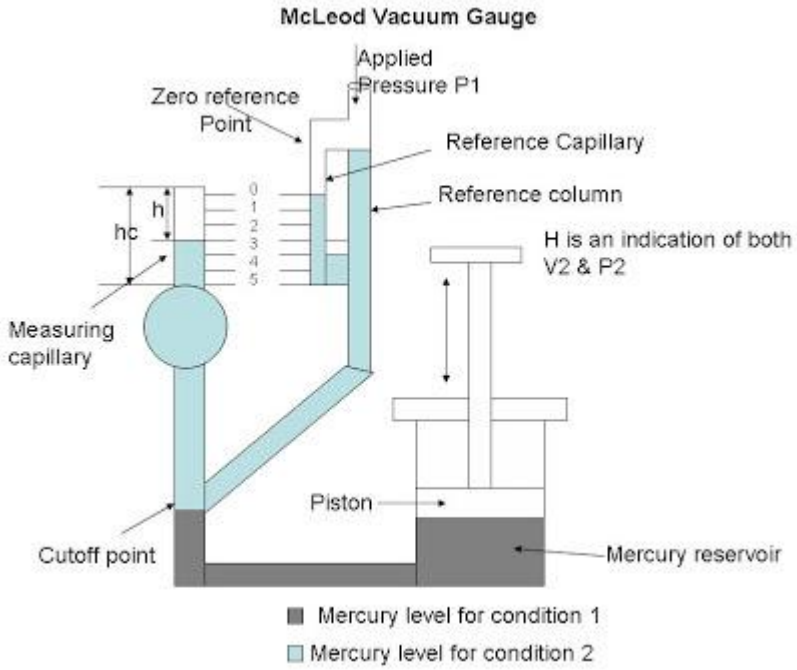
5.For testing quality of products

6. Statistical stability over time.

7. Variability small compared to the process variability. Variability small compared to the specification limits (tolerance)

b)

Construction :- McLeod gauge are as follows:



Construction -2M

Sketch -02 M

Working -02

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 cut off 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..

Working :-

The McLeod gauge is operated as follows:

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 cut off 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

Let the volume of the bulb from the cut off point up to the beginning of the measuring capillary tube = V

Let area of cross – section of the measuring capillary tube = a
Let height of measuring capillary tube = hc.

Therefore, P1 = ah^2/V1

Thus the applied pressure is calculated using the McLeod Gauge.

Q 2 **a) i)** **Eddy current dynamo meter** used to measure engine torque and power. It works on the principle of eddy current generation that oppose the change in magnetic flux. Eddy currents are generated when a conductor moves in changing magnetic flux.

Eddy current dynamo meter consists of

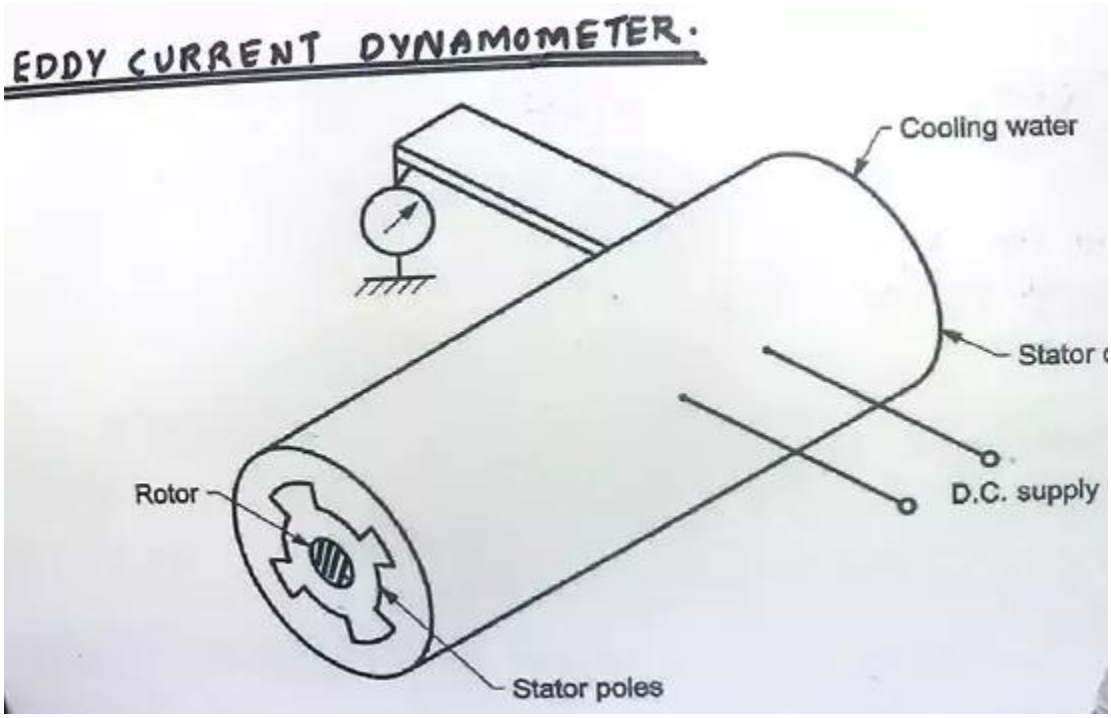
1. **Rotor** at which rotating shaft is connected of which power has to be measured.
2. **Stator poles or Stator notched** between which this rotor rotate.
3. **Stator casing** to which DC voltage is applied to generate magnetic field.
4. An arm with gauge which measure the torque.

Principle-03M

Sketch -01M

Working Principle:-

Rotor is rotating with help of engine shaft and voltage is apply to coil or stator casing. Due to this magnetic flux is generated and rotor cut these magnetic flux and hence eddy current will be produced in rotor which oppose the change in magnetic flux. Due to this rotor get opposing force (which try to reduced rpm of rotor). But torque supplied by engine maintain the rpm. That torque is measured by gauge present at end of arm.



ii)

ACTIVE TRANSDUCERS :- These are those that do not require any additional power source to produce their output. Other name "***self generating type*** ".Operate under energy conversion principle.

Examples of these transducers are thermocouple, photovoltaic cells (solar cells) and Piezoelectric crystals.

PASSIVE TRANSDUCERS :- These are those transducers that derive the power required for transduction from an additional power source. Other name is "***externally powered transducers*** ".Operate under energy controlling principles.
Examples of passive transducers are : all resistive, Inductive and capacitive transducers.

Def-02M

Example-02M

b)

Construction of Potentiometer

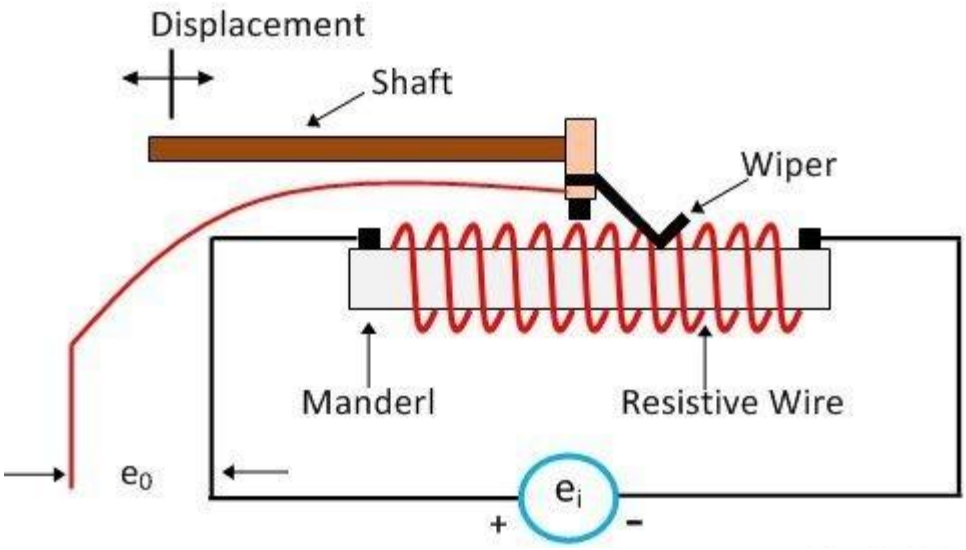
The construction of the potentiometer is categorised into two parts. They are the sliding and non-sliding parts. The sliding contact is a called wiper. The motion of the sliding contacts is either translatory or rotational. Some potentiometer uses both the translatory and rotational motions. Such type of potentiometer uses the resistor in the form of a helix, and hence they are called heliports.

Construction -02M

Working-02M
Sketch-02M

Adv.(Any 2) -01M

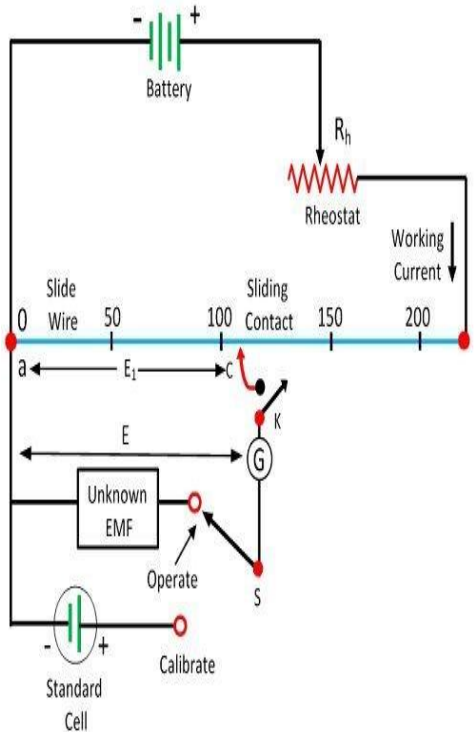
Dis.(Any 2) -01M

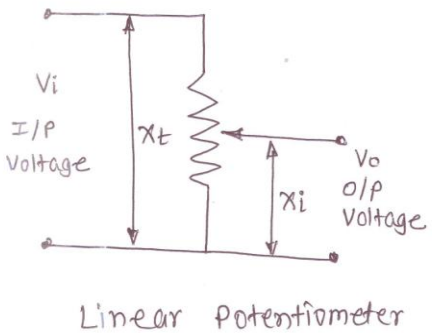


The potentiometer has three terminals, the two terminals are connected to the resistor, and the third terminal is connected to the wiper which is movable with the wire. Because of this moving wire, the variable potential is tapped off. The third terminal is used for controlling the variable resistor. The potential of the third terminal is controlled by changing the applying potential at the end of the resistor. The body of the potentiometer is made up of resistive material, and the wire is wound on it.

Working of Potentiometer

The working principle of the potentiometer is explained through the circuit shown below. Consider S is the switch used for connecting or disconnecting the galvanometer from the potentiometer. The battery through the rheostat and slide wire supply the working current. The working current may vary by changing the setting of the rheostat.





Linear Potentiometer

The method of findings the unknown voltage depends on the sliding position of the contact at which the galvanometer shows the zero deflection. The zero or null deflection of galvanometer shows that the potential of the unknown source E and the voltage drops E_1 across the sliding wires are equal. Thus, the potential of the unknown voltage is evaluated by knowing the voltage drop across the ac portion of the sliding wire.

The slide wire has the uniform cross-section and resistance across the entire length. As the resistance of the sliding wire is known, then it is easily controlled by adjusting the working current. The process of equalising the working voltage as that of voltage drop is known as the standardisation.

Advantages :

1. They are cheap
2. It is easy to use and useful in many application.
3. It gives sufficient output.
4. Efficiency is high

Disadvantages:

1. It requires a large force to move their sliding contacts i.e wiper.
2. Limited bandwidth
3. There is inertial loading.

Construction of Optical Pyrometer

The construction of the optical pyrometer is quite simple. The pyrometer is cylindrical inside which the lens is placed on one end and the eyepiece on the other end. The lamp is kept between the eyepiece and the lens. The filter is placed in front of the eyepiece. The filter helps in getting the monochromatic light. The lamp has the filament which is connected to the battery, ammeter and the rheostat.

c) Working of Optical Pyrometer

The optical pyrometer is shown in the figure below. It consists the lens which focuses the radiated energy from the heated object and targets it on the electric filament lamp. The intensity of the filament depends on the current passes through it. Hence the adjustable current is passed through the lamp.

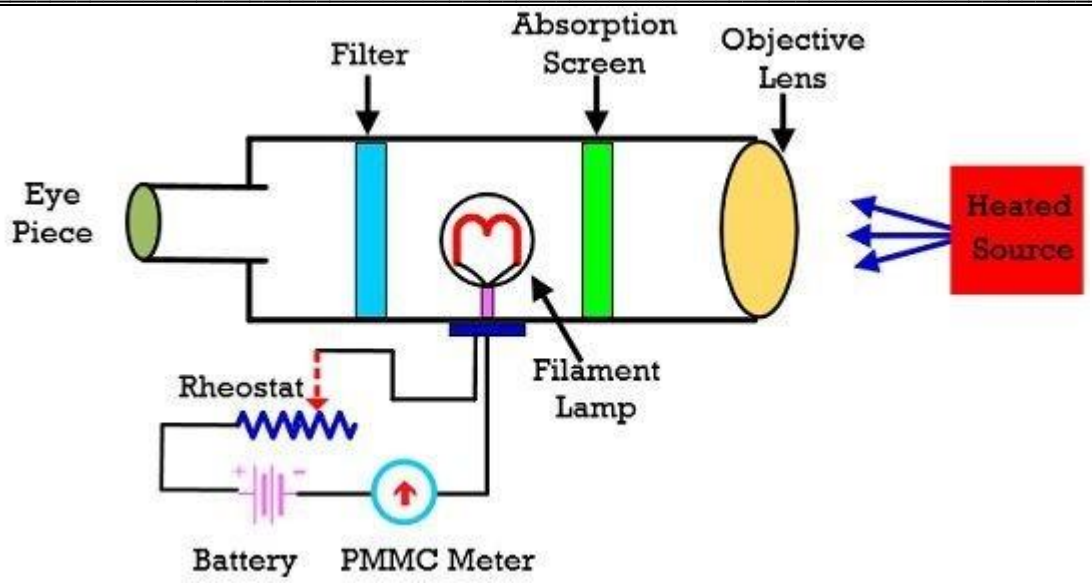
Construction -02M

Working-02M

Sketch-02M

Adv.(Any 2) -01M

Disadv.(Any 2) -01M

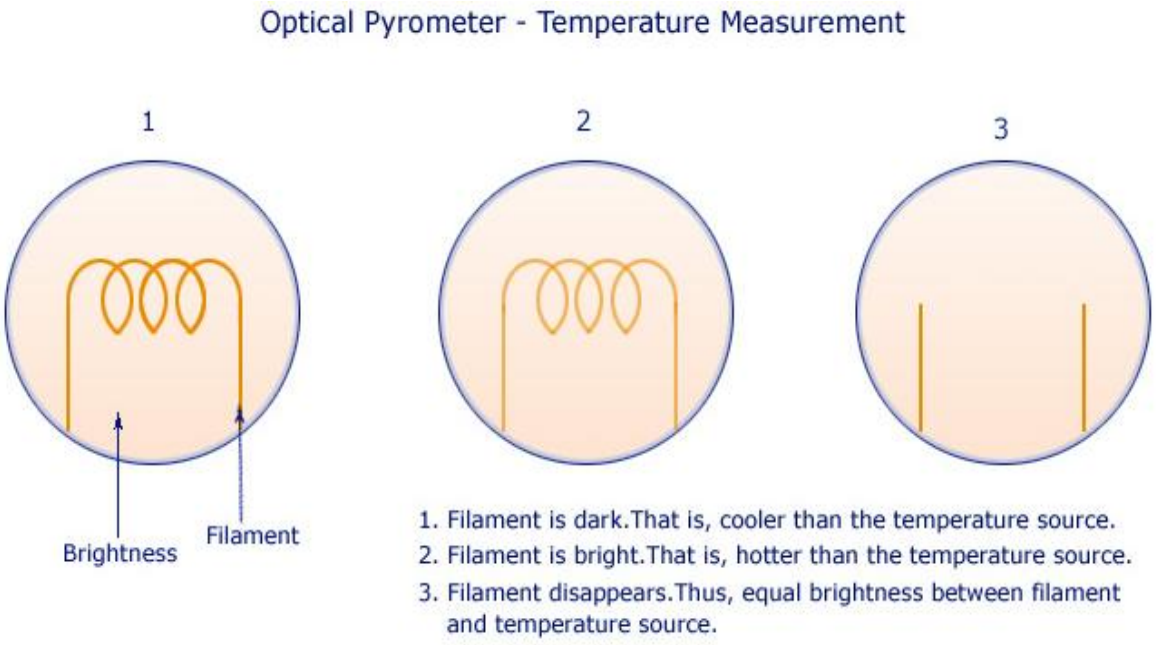


This change in current can be observed in three different ways.

1. The filament is dark. That is, cooler than the temperature source.

2. Filament is bright. That is, hotter than the temperature source.

3. Filament disappears. Thus, there is equal brightness between the filament and temperature source. At this time, the current that flows in the reference lamp is measured, as its value is a measure of the temperature of the radiated light in the temperature source, when calibrated.



Advantages

1.Simple assembling of the device enables easy use of it.

2.Provides a very high accuracy with +/-5 degree Celsius.

3.There is no need of any direct body contact between the optical pyrometer and the object. Thus, it can be used in a wide variety of applications.

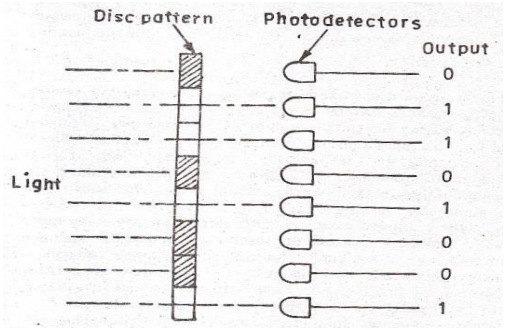
4.As long as the size of the object, whose temperature is to measured fits with the size of the optical pyrometer, the distance between both of them is not at all a problem. Thus, the device can be used for remote sensing.

Disadvantages

1.As the measurement is based on the light intensity, the device can be used only in applications with a minimum temperature of 700 degree Celsius.

2.The device is not useful for obtaining continuous values of temperatures at small intervals.

Q 3 **a)** **Construction and working of encoders.**



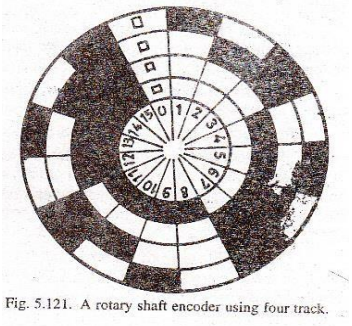


Fig. 5.121. A rotary shaft encoder using four track.

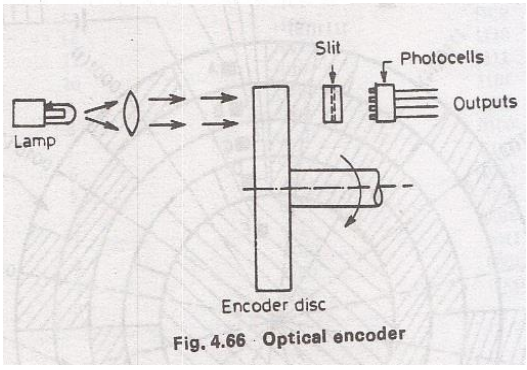


Fig. 4.66 Optical encoder

Sketch: 2 Marks, Explanation: 2 Marks

Shaft encoder is a digital device used for measurement of angular position. There is a necessity of measuring devices that form a basic part whose output is compatible with digital nature of the computer.

The disc is divided into concentric circular tracks & each tack is then divided into segments. For pure binary code the inner track is in two parts, the next quartered & the next divided into 8

parts & so on. Each track has twice as many segments as the adjacent one near the center.

The alternate segments on each track are made transparent & opaque, if transmitted light and photo cells are used. A eight bit absolute optical shaft encoder is shown. The output is derived from independent tracks on the encoder disc corresponding to individual photo detectors.

The disc has transparent and opaque areas, corresponding to the conducting and non-conducting ones respectively.

The photo cell corresponding to a particular track, would produce an electrical output if the transparent portion is in front of the slit and light source, giving state ON(or 1) while no electrical output from a cell would corresponds to OFF(or 0)state.

b) Difference between accuracy and precision.

Accuracy	Precision
It is the closeness with which an instrument reading approaches to the true value of the quantity being measured.	It is the degree of reproducibility among several independent reading of the same true value under specified condition.
It is expressed as the limit of error of a measuring g device	It is 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 guaranty accuracy.
Measurements are dependent on the systematic errors	Measurements are dependent on the random errors
Determined by proper calibration	Determined by statistical analysis.

Any four points – 1 mark each -4M

c) **State laws of intermediate temperature and intermediate metals with neat sketches.**

Law of Intermediate Temperature:

Sketch: 1 mark, Statement: 1 Mark

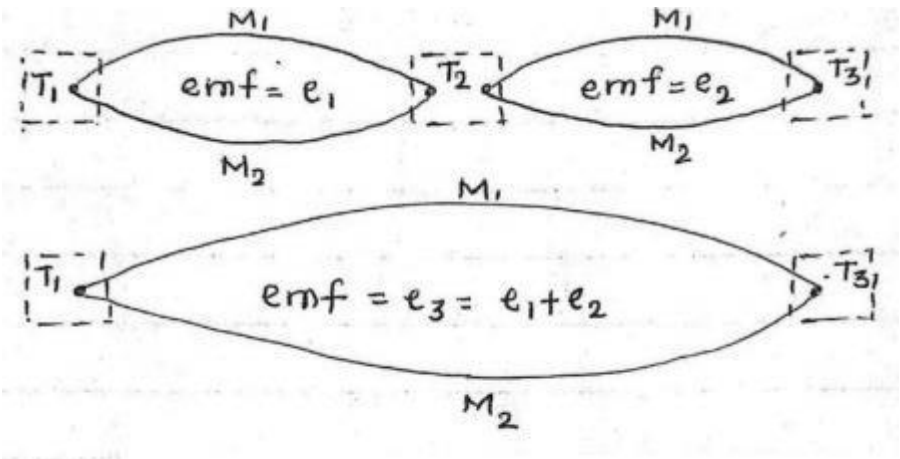


Figure: Law of Intermediate Temperature

If a simple thermocouple circuit develops an emf e1, when its junctions are at temperature T_1 and T_2, and an emf e2 when its junctions are at temperature T_2 and T_3, it will develop an emf e1 + e2 when its junctions are at temperature T_1 and T_3.

Law of intermediate metal :

Any one Sketch: 1 mark Statement: 1 Mark

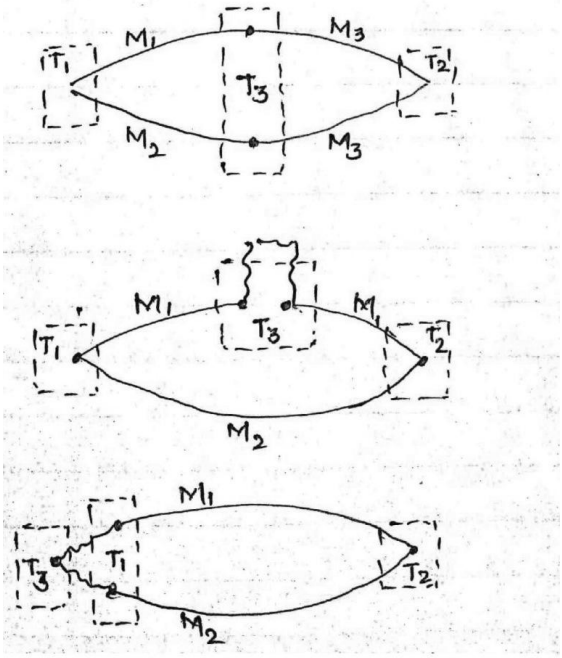


Figure: Law of Intermediate Metal

It states that insertion of an intermediate metal into a thermocouple circuit will not affect the net emf provided the two junctions introduced by the third metal are at same temperature.

d)	**Desirable and four undesirable characteristics of measuring instrument.** **Desirable characteristics:** Accuracy, Precision, Sensitivity, Reproducibility, Repeatability, Resolution etc. **Accuracy**: it is the closeness or agreement of measurement value with true value. **Precision:** the difference between two consecutive reading measured by instrumentation system is known as Precision. High precision means tight cluster of repeated results and low precision means broad scattering of results. **Sensitivity:** it is the ratio of the magnitude of the output signal to the magnitude of the input signal or quantity being measured. **Reproducibility:** the closeness or agreement between independent results is obtained with the same method on identical test material but under different conditions. **Resolution:** it is the smallest measurable input to cause measurable change in output. **Undesirable characteristics:** drift, measuring lag, dead zone, dead time, hysteresis, overshoot, backlash etc. **Drift:** drift is the undesirable change or a gradual variation in output over a period of time that is unrelated to change in input, operating conditioning, or load. **Measuring lag:** it is the retardation or delay in the response of a measuring system to change in measured quantity. **Dead zone:** it is range of values of a measured variable to which instrument does not respond. E.g. the input applied to the measurement may not be sufficient to overcome friction. **Dead time:** it is the time required by the measurement system to begin to respond to a change in the measurand. **Backlash:** the maximum distance or angle through which any part of of a mechanical system may be moved in one direction without applying appreciable force or motion to the next part in a mechanical system is called backlash.	**Any Four:½ marks for each characteristics -2M** **Any Four:½ marks for each characteristics-2M**
e)	**A PT 100 thermometer has a resistance 100 Ω at 25 ^{0}C. Determine its resistance at 65 ^{0}C. Also, determine it's temperature if it had resistance 150 Ω. Assume it's resistance temperature coefficient is 0.00392 /^{0}C.** **/^{0}C.** Given: Resistance of R_1=100 Ω at t_1=25 ^{0}C and Resistance temperature coefficient or sensitivity α = 0.00392 /^{0}C.	

i) Determine resistance R_2 at t_2=65 ^{0}C

$$R_2 = R_1[1 + \alpha(t_2 - t_1)]$$

$$R_2 = 100[1 + 0.00392(65 - 25)]$$

$$R_2 = 107.84\ \Omega$$ ----------

2M

ii) Determine Temperature t_3 at R_3 150 Ω

$$R_3 = R_1[1 + \alpha(t_3 - t_1)]$$

$$150 = 100[1 + 0.00392(t_3 - 25)]$$

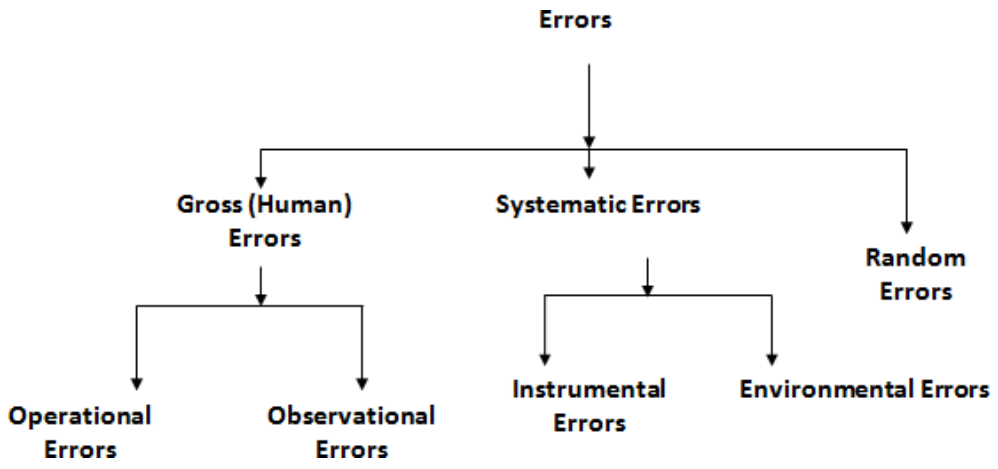
$$t_3 = 280\ ^0C$$----------

2M

Q 4) **A a)** **Explain the different sources of errors in measurements and measuring instruments.**

(Any four errors out of Operational error, Observational error, Instrumental error, Environmental error, Random error)

1 Mark each -4M



<u>Gross Error or Human Error</u>

This class of errors mainly covers human mistakes in reading instrument, in recording and calculating measurement results. The responsibility of the mistakes wholly lies with the operator.

Gross errors are further classified in to two types:

Observational Errors

There are many sources of observation errors. As an example, the pointer of a voltmeter rests slightly above the surface of the scale. Thus an error on account of parallax will be occurred unless the line of the observer is exactly above the pointer.

Operational Errors

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

Systematic error Instrumental errors:

These errors arise due to the following reasons:

Due to inherent shortcoming in the instrument

- Zero error
- Calibration error

Environmental errors:

These errors are due to conditions external to the measuring device, i.e. in the area surrounding it. These may be effects of temperature, pressure, humidity, dust, vibrations or presence of external magnetic or electro static fields.

Consider mercury-in glass thermometer being used for the measurement of air temperature.

The instrument will located wrongly if during measurements the sun happens to be shining on the thermometer bulb. Also, if the thermometer is place too close to a window then the bulb would indicate an effect of heat radiation due to window.

In the above case the thermometer will give a high temperature reading.

Random Error:

Even after removing all the systematic errors measurement results show variation from one reading to another.

The quantity being measured is affected by many factors throughout the universe.

Out of these much factors we are aware about very few factors.

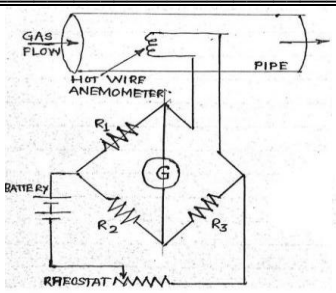
The factors about which we are unaware are known as “Random or Residual”, and the error occurs due to these factors are called “Random or Residual errors”

b) **How flow is measured by hot wire anemometer.**

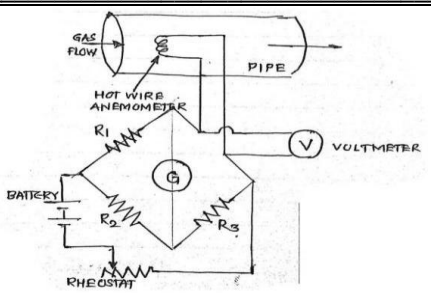
Hot wire anemometer measure the mean and fluctuating flow of **gases**.
The sensor is a 5 micron diameter platinum-tungsten wire welded between the two prongs.
This wire heated electrically as part of a wheat-stone bridge circuit.
When the probe is introduced into the flowing fluid, it tends to be cooled by instantaneous velocity. So, tendency for the electrical resistance to diminish.

Figure Any one: 2 Marks

Explanation of any one



Constant Current Method



Constant Temperature Method

The rate of cooling of wire depends upon the -

→ Dimension and physical properties of wire
→ Diff. of the temp. between wire and the fluid
→ Physical properties of the fluid
→ Stream velocity under measurement

First three conditions are effectively constant and the instrument response is then a direct measurement of the velocity change.
Depending on the electronic equipment, hot wire may be operated in two ways;

→ Constant current mode:
→ Constant temperature mode:

a) Constant current mode:

The heating current i.e. voltage across the bridge is kept constant.
Initially the circuit is adjusted such that the galvanometer reads zero when the heated wire lies in stationary air.
When the air flows, the hot wire cools and resistance changes and the galvanometer deflects.
The galvanometer deflection are amplified, measured and correlated with air velocity by calibration.

b) Constant temperature mode:

Temperature of filament is kept constant.
Hot wire loses heat (decreases temperature) by the flowing fluid.
The external bridge voltage is applied to the wire to maintain a sensibly constant temp.
The bridge voltage is varied so as to bring the galvanometer needle to zero.
The reading on the voltmeter is recorded and correlated with air velocity.

mode: 2 Marks

c) **Show that gauge factor of resistance strain gauge is F =1+2μ, where μ is Poison's ratio.**

The change in resistance is measured and correlated to strain or physical effect causing strain.

$$R = \frac{\rho L}{A}$$

Where R is resistance of conducting wire material

P is resistivity of the conducting wire material

Derivation :

4 marks

L is length of conductor

A is cross sectional area of conductor

Taking logarithms: $\log R = \log \rho + \log L - \log A$

Upon partial differentiating : $\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dL}{L} - \frac{dA}{A}$

The area may be related to square of some transverse dimension, such as diameter D of conductor

$A = CD^2$ and $\frac{dA}{A} = \frac{2dD}{D}$

Where C is constant; its value being unity for a square cross- section of dimension D and $\frac{\pi}{4}$ for a circular cross section of diameter D. Thus:

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dL}{L} - \frac{2dD}{D}$$

Dividing above equation by $\frac{dL}{L}$; we get,

$$\frac{dR/R}{dL/L} = \frac{d\rho/\rho}{dL/L} + 1 - \frac{2dD/D}{dL/L}$$

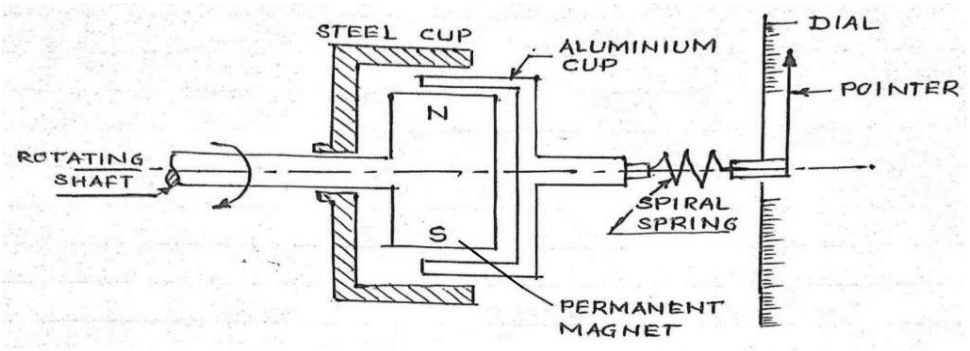
$\frac{dR/R}{dL/L} = \frac{d\rho/\rho}{dL/L} + 1 + 2\mu$ where $\mu = -\frac{dD/D}{dL/L}$

$$Strain\ Sensitivity\ or\ Gauge\ factor\ F = 1 + 2\mu + \frac{d\rho/\rho}{dL/L}$$

For many metals, resistivity does not change with strain, i.e. piezo-resistive term vanishes and then F is a function of $\boldsymbol{\mu}$ only.

Hence **Gauge Factor F = 1 + 2μ**

d) Draw a neat sketch of eddy current or drag cup tachometer. Explain it's working.



Eddy Current of Drag Cup Tachometer

It is electrical type tachometer, which works on eddy current.

The shaft whose speed is to be measured is connected to permanent magnet at its end.

A nonmagnetic cup generally made of aluminium is provided very close to magnet, which is connected to pointer through spring.

Due to rotation of magnet, induced voltage in to cup which thereby produce circulating eddy current in cup material.

This eddy current interacts with the magnetic fields to produce a torque on the cup in proportion to the relative velocity of magnet and cup.

This causes cup to turn through small angle.

Low torque measuring transducer is used to measure torque. It can be calibrated to find the speed of shaft.

Sketch: 2 Marks

Explanation: 2 Marks

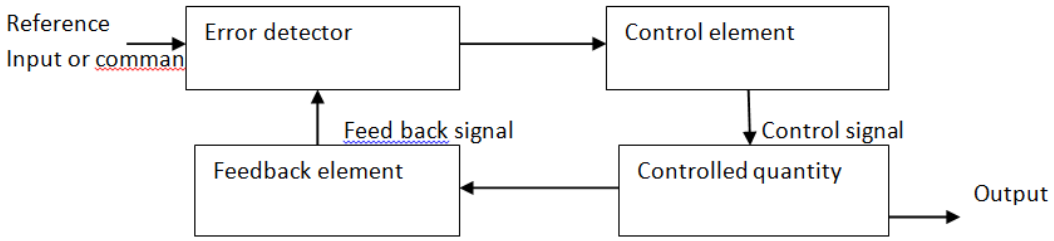
B a) Attempt any **ONE:**

Compare hydraulic, Pneumatic and Electronic Control Systems.

Comparison of hydraulic, pneumatic and electronic controller			
Pneumatic controller	**Hydraulic controller**	**Electronic controller**	
Low cost	Medium cost	High cost	
No fire hazard	Chances of fire hazard	Chances of fire hazard	
Medium speed of response	high speed of response	high speed of response	
Medium power gain	High power gain	High power gain	
High space require	Medium space require	low space require	
Not affected by stray magnetic field	Not affected by stray magnetic field	Affected by stray magnetic field	
Medium power gain	High power gain	low power gain	

Any Six Points: 1 Marks Each

b) Explain servomotor mechanism with neat sketch.



Any One sketch : 2 Marks, Explanation: 4 Marks,

By servo-mechanism or simply a servo, we mean a system which is used to automatically control the output mechanical position, or time derivative of position, velocity or acceleration of the output member in response to variation of input signal. As such a servo system is used to position a final control element in a generalized instrumentation system. Actuators are used to operate the final control element such as a valve, heater, etc.It is an important element of servomechanism. A servo mechanism is a closed loop system that moves or changes the position of the controlled object so that it agrees with the position of a control device. The error detector compares the feedback signal with the reference input or command. Control element receives and amplifies the actuating signal so that large external power is applied to restore the desired position of the controlled object.

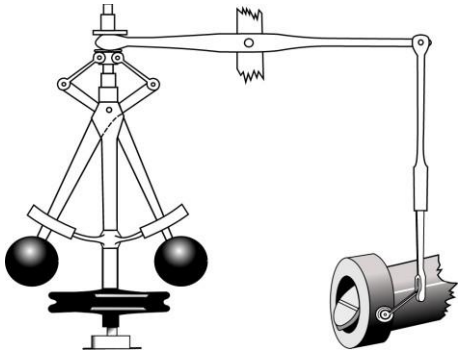
Actuator corrects the system error by causing the right change in controlled quantity. In servo mechanism this actuator must produce motion, either linear or rotary. Therefore some type of thrust device or motor is required so that it can work as an actuator.

OR

Servo Motor Mechanism

It is a complete system that provides automatic position control of an object or quantity as desired. Such a system may include many electrical, mechanical or hydraulic devices.

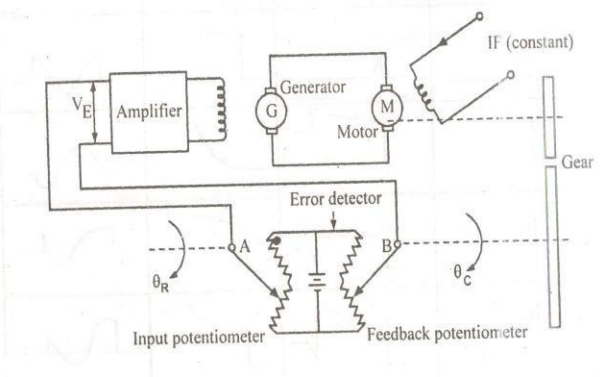
It is a closed loop system that moves or changes the position of the controlled object so that it will fallow or agree with the position of a control device.



OR

D.C. Servomechanism

This controls the position of mechanical load in accordance with the position of reference shaft. Load shaft is driven by a motor through gear system. The driving motor is geared to the load to be moved. The motor develops a torque which is transmitted to the output shaft through a gear train.



5) **a)** **Sound:** sound is a vibration that propagates as a typically audible mechanical wave of pressure and displacement, through a medium such as air or water.

Characteristics of sound:-

1. **Sound Frequency:** The number of cycles per unit of time is called the frequency. For convenience, frequency is most often measured in cycles per second (cps) or the interchangeable Hertz (Hz) (60 cps = 60 Hz) — 01
2. **Sound Power:** Sound power is the energy rate - the energy of sound per unit of time (J/s, W in SI-units) from a sound source.
3. **Sound Intensity:** Sound intensity is amount of energy flowing per unit time through a unit area that is perpendicular to the direction in which the sound waves are travelling. Sound intensity or acoustic intensity (I) is defined as the sound power (Pac) per unit area (A). — 01
4. **Sound Pressure:** The Sound Pressure is the force (N) of sound on a surface area (m_2) perpendicular to the direction of the sound. The SI-units for the Sound Pressure are N/m_2 or Pa. — 01

01

b) ## Bubbler or purge system:

Construction: 1. Bubbler systems are comprised of a source of compressed air, air flow valve, bubble tube and pressure gauge.

2. The bubbler system bubble tube is installed directly in the process or basin and is connected to the pressure gauge and air supply through a flow pipe or Rotameter.

3. The depth of fluid is determined by the pressure required to displace the liquid inside the sensing or bubbler tube and is measured by the fluid depth above the open end of the bubbler tube.

Working: 1. Initially the hydrostatic pressure is more than the air pressure so air is unable to escape from tube, when we increase the air pressure & it exceeds than hydrostatic pressure then

bubbles come out. 2. The pressure gauge reading at that point is recorded and converted into suitable level of liquid. 3. In an application of measuring liquid level for only the top part of a tank or basin, the sensing/bubbler tube does not need to extend to the bottom of the tank or basin.

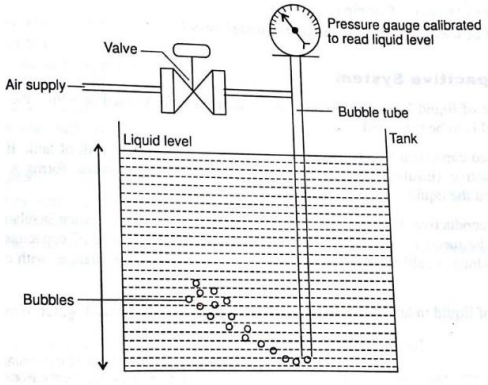


Fig. Bubbler or purge system

Sketch-2Mark

Working -2Mark

c)

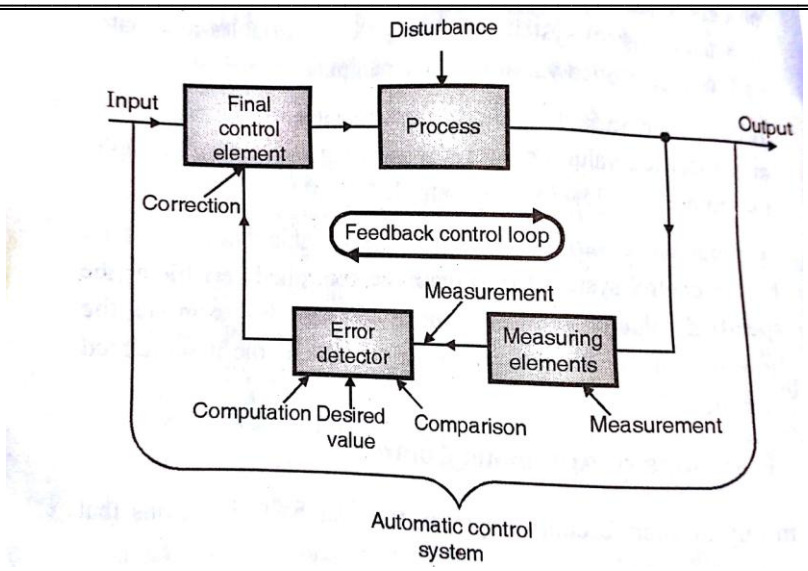
Sr. No.	Open Loop System	Closed Loop System
1	Feedback element is absent.	Feedback element is present.
2	It is easier to build.	It is difficult to build.
3	It is economical system.	It is costly system.
4	It is inaccurate and unreliable.	Highly accurate and reliable.
5	It is stable system.	It is unstable system
6	Highly sensitive to the disturbances.	Less sensitive to the disturbances.
7	Bandwidth is small	Bandwidth is large.
8	Examples. Hand Drier, Traffic Signal	Examples. Robot control, Automatic washing machine

½ each point

=1/2x8=4 Mark

d) **Automatic Control system:** In an automatic control system human operator determines the goal and set up of the system, subsequently the target output is achieved or maintained automatically. Only the reference input is provided and the necessary corrections are applied by mechanical (non human) devices and that essentially forms the essence of automatic control.

01Mark



01Mark

Advantages of Automatic Control system:

Advantages -01 Mark

1. Increase Production rate.
2. Increase in quality and uniformity of product.
3. Elimination of Human error.
4. Increase efficiency of plant and saving in energy requirements.

Applications of Automatic Control system:

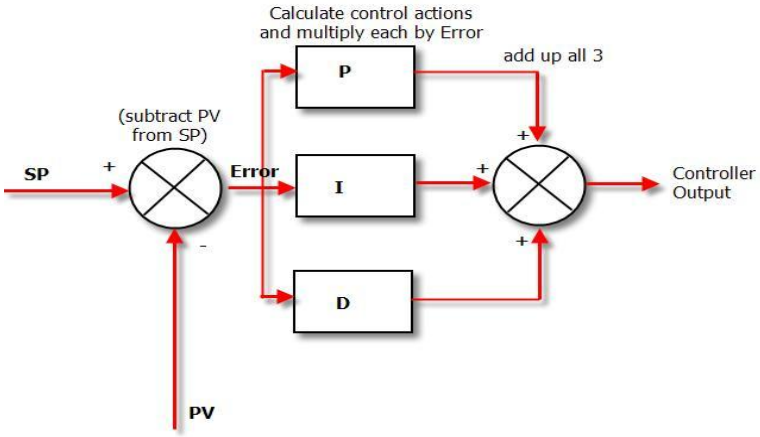
Applications -01 Mark

1. It controls Temperature, Pressure, Humidity, Viscosity, Flow rate etc. in Oil refineries, Chemical Industries, Automobile industries etc..
2. Aerospace and Transport.
3. Space vehicle controls.
4. Robotics and Manufacturing etc.

e) Electronic PID Controller (Proportional Integral Derivative controller)

Diagram -02 Marks

Explanation -02 Marks



1. PID is a control loop feedback mechanism widely used in industrial control system.
2. a PID controller continuously calculate an error value e(t) as the difference between a desired

set point (SP) and measured process variable (PV).
3. It is really simple in operation; the process variable is subtracted from the set point to create the error.
4. The error is simply multiplied by one, two or all of the calculated P, I and D actions.
5. Then the resulting error x control actions are added together and sent to the controller output.
Mathematical equation of PID controller is as shown below:

$$m(t)=kp*e(t)+ki \int e(t)\,dt + kd * de(t)/dt$$

f) **Feed forward control system:**

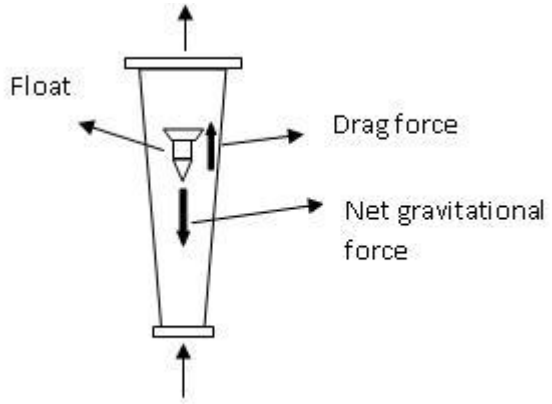
Advantages: 1. It takes corrective actions before the process is upset.
2. Theoretically capable of perfect control.
3. Does not affect system stability.
4.It is good for systems with large time constant or dead time.

Advantages -02M

Disadvantages: 1. It cannot compensate for all disturbances that enter the process.
2. Disturbances must be measured.
3. Required more knowledge of the process to be controlled.
4. In this system there is no monitoring on the controlled variable.

disadvantages -02M

Q 6) **a)** **Rotameter:**



Sketch-02M

Explanation -02M

Construction: 1. Rotameter is a variable area meter.
2. Consists of gradually tapered glass mounted vertically in a frame with the large end up.
3. Fluid flows upward through the tapered tube and suspends freely a float (which is submerged in the fluid)
4. The tube is marked in divisions, and the reading of the meter is obtained from the scale reading at the reading edge of the float, which is taken at the largest cross section of the float.

Working: 1. As the flow enters in the Rotameter float get lift vertically.
2. Float is the indicating element, and the greater the flow rate, the higher the float rides in the tube.
3. A calibration curve must be available to convert the observed scale reading to flow rate.

b) Electromagnetic flow meter:

Principle of Operation: 1. The operation of an Electro-magnetic flow meter is based upon Faraday's Law, which states that the voltage induced across any conductor as it moves at right angles through a magnetic field is proportional to the velocity of that conductor.

2. E is proportional to B x L x V where:

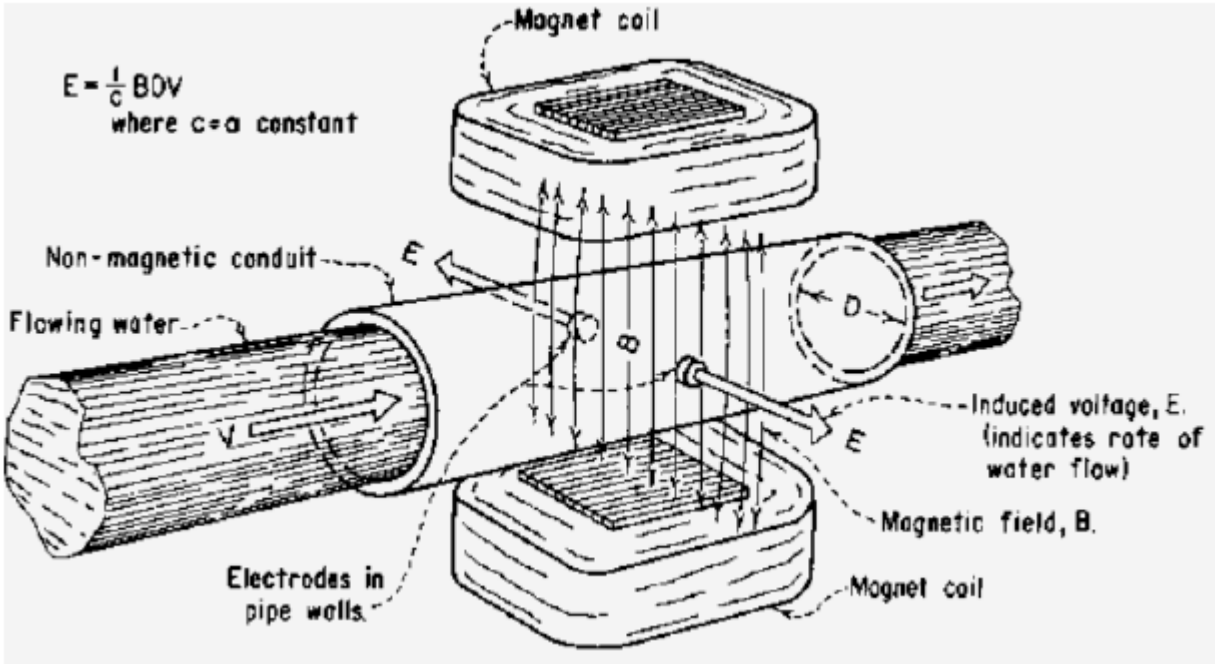
E = B x L x V

E = The voltage generated in a conductor

B = The magnetic field strength

L = The length of the conductor

V = The velocity of the conductor



Construction & Working: 1. It consists of a pair of Electrodes mounted in opposite direction of a non-conducting, non-magnetic pipe carrying liquid whose flow is to be measured.

2. It is surrounded by an electromagnet which produces a magnetic field.

3. The conductive fluid is passed through the pipe.

4. As the fluid passes, its motion relative to field produces an e.m.f. proportional to velocity according to Faradays law.

5. This output e.m.f. is collected by the electrodes and is given to external circuit.

6. The e.m.f. or voltages produced are small especially at low flow rates.

7. The pipe must be non-conductive, non-magnetic.

Working-02M

Principle-01M

Sketch-01M

c)

Principle of Contactless Tachometer: 1. Tachometers of this type produce pulses from a rotating shaft without being mechanically connected to it.

2. As the energy produced by these devices is not sufficient to actuate an indicator directly, amplifiers of sufficient sensitivity are employed.

The various types of contactless tachometers are based on the following type of pick-ups.

a. Electromagnetic pick up
b. Optical pick up
c. Capacitive pick up

Principle-01M

Sketch of Any one contactless

tachometer

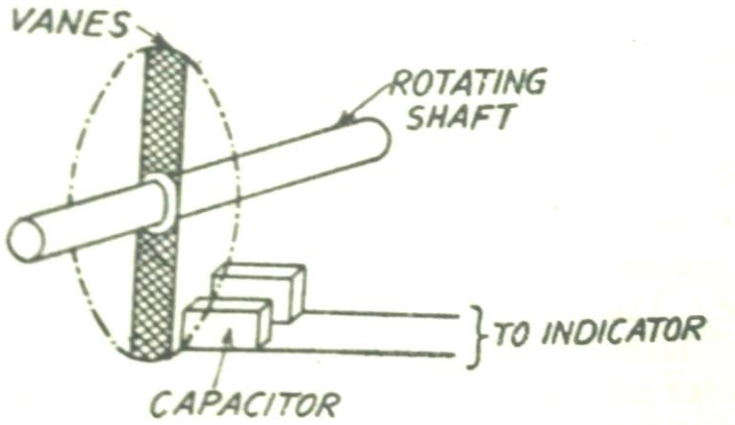
-1 M

Working of Any one contactless tachometer

-2 M

Capacitive Pick up Tachometer:

Construction and working: 1. In the capacitive pick up, vanes are attached at the end of a shaft whose speed is to be measured.
2. Two plates are placed on either side of the vanes, forming a capacitor. When shaft rotates, the capacitance to ground is changed.
3. The capacitor forms a part of an oscillator bank so that the number of frequency changes per unit of time is a measure of shaft speed.
4. The pulses thus produced are fed to amplifying, pulse forming, triggering circuits where they are converted into constant amplitude signals, and provide an analog DC output



d)

Strain gauge is a device used to measure strain of an object. The gauge is attached to the object by a suitable adhesive. As the object is deformed, the foil also gets deformed, causing its electrical resistance to change. The resistance change is commonly measured using a wheatstone bridge.

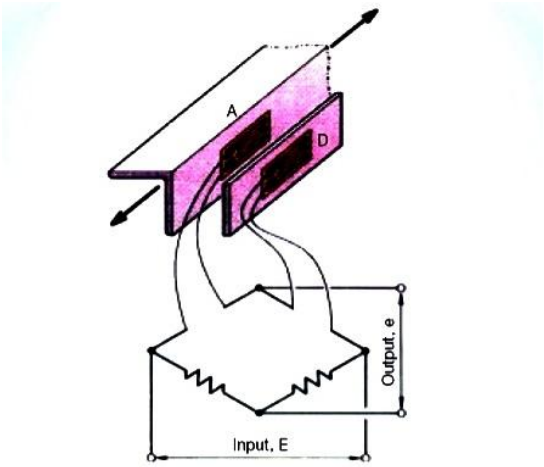
Need of Compensation of Strain gauge: 1.For accurate measurement of static strains compensation of strain gauge is essential.
2. Measurements are performed with strain gauge in mechanical stress analysis to examine loading and fatigue.
3. In addition to the desired measurement signal indicating mechanical strain, each strain gauge also produces a temperature-dependent measurement signal. This signal called the apparel strain, is superimposed on the actual measured value.
Various effects contribute to the apparent strain:
Thermal expansion of the measurement object.
Temperature dependent change in the strain gauge resistance.
Thermal contraction of the strain gauge measuring grid foil.
Temperature response of the connection wires

02Marks

Method of Temperature Compensation of Strain gauge:
1.Active dummy method
2.Self compensation method
3.Full bridge
Active dummy method: The active dummy method uses two gauge system where an active gauge (A) is bonded to the measuring object and a dummy gauge (D) is bonded to a dummy

02Marks

block which is free from the stress of the measuring object but under the same temperature condition as that affecting the measuring object. The dummy block should be made of the same material as the measuring object.



e)

The Speed is given by –

$$\mathbf{n = F_m . F_L (m-1) / F_m - F_L}$$

Here,

Highest flashing frequency. 01Mark

$F_m = 5259$ rpm

Lowest flashing frequency

$F_L = 3000$ rpm

number of flashing points or frequencies

$m = 3$

therefore,

Speed of Rotating disc = 5259 x 3000 (3-1) / (5229 – 3000)

= 13968 rpm

03Mark