Q.1 Attempt any TEN from the following : **[20]**

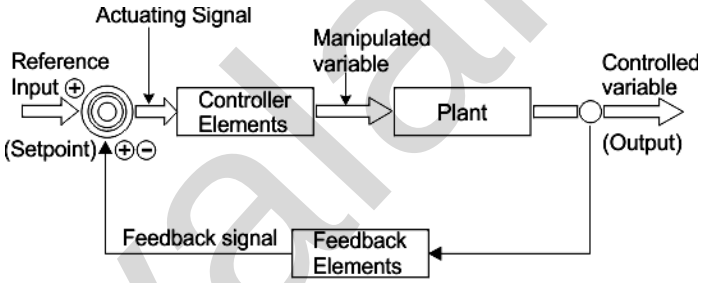
Q.1(a) Define the term threshold and resolution. **[2]**

(A) Threshold: It is particular case of resolution. [1 mark]
It is defined as the minimum value of input below which no output can be detected.

Resolution: It is defined as the smallest increment in the measured value that can be detected with certainty by the instrument. [1 mark]

Q.1(b) Draw the block diagram of a feedback control system? **[2]**

(A)
- A feedback is a common and powerful tool when designing a control system.
- Feedback loop is the tool which take the system output into consideration and enables the system to adjust its performance to meet a desired result of system.
- In any control system, output is affected due to change in environmental condition or any kind of disturbance.
- So one signal is taken from output and is fed back to the input. This signal is compared with reference input and then error signal is generated.
- This error signal is applied to controller and output is corrected. Such a system is called feedback system. Figure below shows the block diagram of feedback system.



Q.1(c) Define the term range and span. **[2]**

(A) **Range** : It can be defined as the measure of the instrument between the lowest and highest readings it can measure. [1 mark]
Example : A thermometer has a scale from -40°C to 100°C. Thus the range vanes from -40°C to 100°C.

SPAN: It can be defined as the difference of reading from the minimum to maximum scale value. [1 mark]
Example : In the case of a thermometer, its scale goes from -40°C to 100°C. Thus its span is 140°C. It is actually a deviation from true value expressed as a percentage of the span.

Q.1(d) What is function of transducer? Differentiate between active and passive transducer. **[2]**

(A) **Transducer:** A transducer senses the desired input in one physical form and converts it to an output in another physical form. [1 mark]

Active transducer are those which does not required power supply for its operation examples-Piezoelectric crystal, tachogenerator, photovoltaic cells.
Passive transducer:-are those which required external supply for its operation. Examples-Strain gauge, Potentiometer, resistance thermometer etc. [1 mark]

Q.1(e) What is thermoelectric effect? **[2]**

(A) The working principle of thermocouple depends upon the thermoelectric effect. If two dissimilar metals are joined together so as to form a closed circuit there will be two junctions where they meet each other. If one of these junctions is heated then a current flows in the circuit which can be detected by a galvanometer. The amount of current produced depends on the difference temperature between two junction and on the characteristics of two metals. This is also known as Seebeck effect. [2 marks]

Q.1(f) Which instrument is used for measuring temperature of 1400 °C furnace and exhaust valve of engine? **[2]**

(A) For measuring the temperature above 1400 degrees thermocouples, thermisters, are used. Rradiation pyrometer may be used for measurement of furnace temperature. Whereas thermisters can be used for exhaust valves temperature. [2 marks]

Q.1(g) Define sensitivity drift and zero drift? **[2]**

(A) **Sensitivity**

It is the ability of the measuring instrument to detect the small variations in a quantity being measured.

Zero drift.

A zero drift is defined as the deviation in the instrument output with time, from initial value, when the measured variable conditions are constant.

Q.1(h) List any four low pressure measuring instrument. State its range. **[2]**

(A) Low Pressure Measurement is done using the instruments [Any four 1/2M each]

Mcleod Gauge : 10^{-1} to 10^{-5} torr, Pirani gauge : 10^{-5} to 10^{1} torr, Ionization Gauge : 10^{-3} to 10^{-11}torr, Bourdon Gauge : upto 10 torr, Bellows :upto 10^{-2} torr (Torr OR mm of Hg)

Q.1(i) Define overshoot and measuring lag. **[2]**

(A) **Overshoot**

The overshoot is defined as the maximum amount by which the pointer moves beyond the steady state.

Measuring lag

It is the retardation or delay in the response of a measurement system to changes in the measured quantity.

Q.1(j) Describe the significance of measurement. **[2]**

(A) (i) various process of engineering such as design, production, manufacturing derives their primary source of information through measurement.

(ii) The quality of the product and the efficiency of the process can be quantified based on the results from the measurement.

(iii) The dawn of the mass production as resulted into the need of Automated manufacturing which is primarily depended on the accurate measurement of different process.

(iv) Various test in the labs to determine the quality standards requires proper measurement.

Q.1(k) Define span and range. **[2]**

(A) **Span**

The span represents the algebraic difference between the upper and lower limits of the instrument.

Range

The range is defined as the region between the limits within which an instrument is designed to operate for measuring, indicating or recording a physical quantity.

Q.1(l) State advantages of stroboscope. **[2]**

(A) Following are the advantages of stroboscope :

(i) It requires no special attachment with the shaft.
(ii) This method imposes no load on shaft.
(iii) It is very convenient to use a stroboscope for sopt check on machinery speeds and for laboratory work.
(iv) This method particularly useful where it is impossible to make contact with the shaft.

Q.1(m)Define control system? State any two examples of control system. **[2]**

(A) A control system is a device, or set of devices, that manages, commands, directs or regulates the behaviour of other devices or systems.

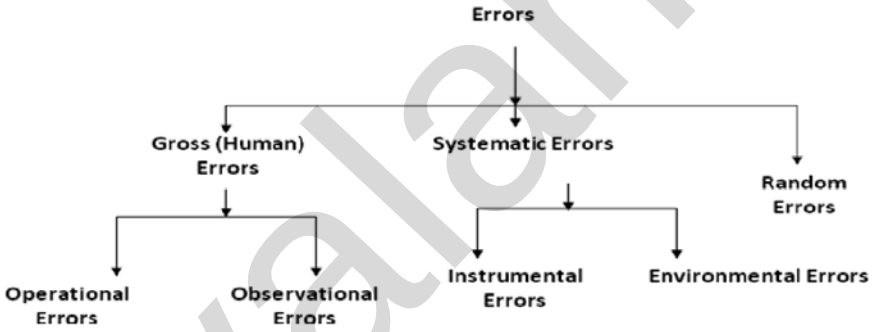
Following are the examples of control system :

(i) Electric switch
(ii) Air conditioner
(iii) Boiler control

Q.2 Attempt any FOUR the following : **[16]**

Q.2(a) What are different types of errors in measurement system? Give classification. **[4]**

(A) In spite of taking all types of care and precautions it is not possible to eliminate all types of error completely. [2 marks]
Error can be minimize not it never zero.



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

Observation errors : Example, the pointer of a voltmeter rests slightly above the surface of the scale. Thus an error on account of parallax will be occurred unless the line of the observer is exactly above the pointer. To minimize parallax error, highly accurate meters are provided with mirrored scale.
Error may cause due to Wrong Reading Taken, Tendency to Read High or to Read Low, Lack of Experience, Parallax Errors, Individual Limitations Operational Errors :
Misalignment error, Excessive Pressure,
Systematic error

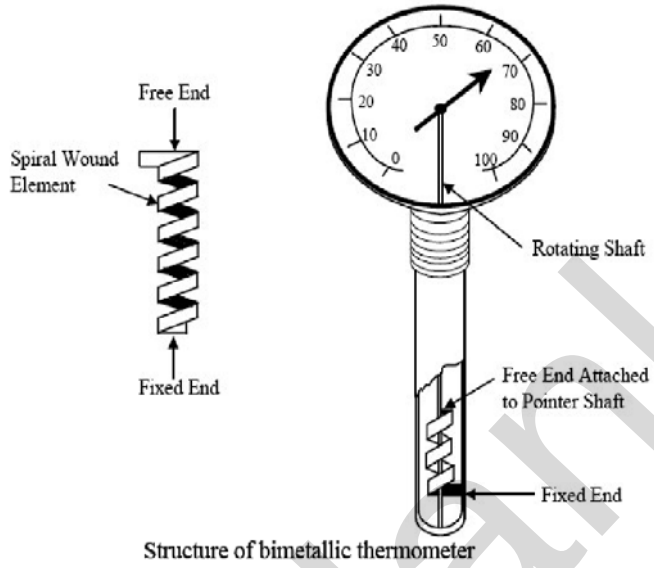
Instrumental errors: These errors arise due to the following reasons:
Due to inherent shortcoming in the instrument
Zero error
Calibration error
Environmental errors

Random Error: 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". [2 marks]

Q.2(b) Explain the working of bimetallic thermometer with the help of a neat sketch. [4]

(A) [Sketch 02 marks, Explanation 02 marks]

Two different materials having different coefficient of thermal expansion rigidly joint together, one on other from a bimetallic strip. When bimetallic strip is fixed at one end and heated from free ends then it bends in the direction of material having low thermal coefficient of expansion. The bending movement of free end is connected to pointer which moves over calibrated scale. Usually bimetallic strip is wound in the form of helix or in spiral form. Its one end is fastened permanently to outer casing to form stopper and other end is connected to pointer. A pointer moves over a circular dial as helix coils and uncoils with temperature variation. A typical bimetallic thermometer is shown in fig.



Structure of bimetallic thermometer

Q.2(c) Differentiate between accuracy and precision with suitable example. [4]

(A) **Accuracy :** Accuracy of measuring system is defined as the closeness of the instrument output to the true value of the measured quantity. However, in usual practice, it is specified as the percentage of deviation or inaccuracy of the measurement from the true value.

[4 marks]

Precision is defined as the ability of the instrument to reproduce a certain set of readings within a given accuracy.

For example, if a particular transducer is subjected to an accurately known input and if the repeated read outs of the instrument lie within say ±1%, then the precision or alternatively the precision error of the instrument would be sated as ±1%. Thus the highly precise instrument is one that gives the same output information when the reading is repeated a large number of times.

Precision of the instrument is in fact, dependent on the repeatability.

1) In accuracy measurements are dependent on the systematic errors, In presion it depends on random errors
2) Accuracy is determined by proper calibration, presion is determined by statistical analysis

Q.2(d) Explain the components of an automatic domestic air conditioning system, with the help of a block diagram. [4]

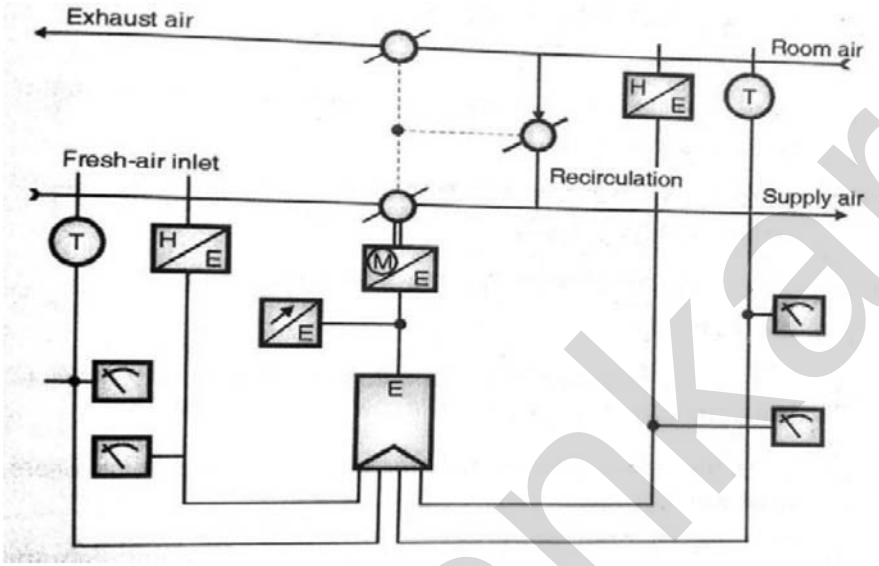
(A) [Sketch 02 marks, Explanation 02 marks]

Domestic Air conditioner control system:

Fig shows the automatic control schematic diagram for the variation of outdoor air during the air when the specific enthalpy of the outdoor airii0 , exceeds that of the extracted room air, in summer, it is recorded in volume flow. This is to avoid overheating the room or

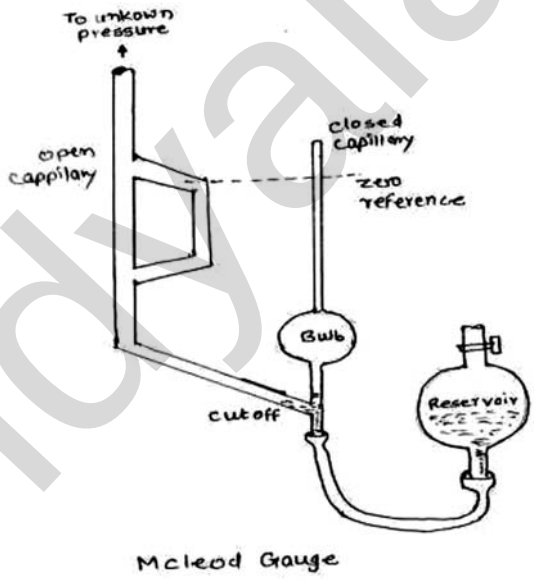
to minimize the cooling plant load. Air temperature and humidity detector are located in the return air duct from the room and in the fresh air inlet duct. Display devices allow manual reading of the data. The enthalpy controller compares the two sets of data. The output signals from the controller is 0-10V.

- A 5 V signal corresponds to equal specific enthalpy of the two air streams h_0/h_r of 1.
- In winter when h_0 is much less than h_r and h_0/h_r is 0.25, the controller output signal is 10 V. in summer, when h_0 is much greater than h_r and h_0/h_r of 2, the controller output signal is 0 V



Q.2(e) Explain with neat sketch working of McLeod gauge. **[4]**

(A)



[2 marks]

The gas enters the gauge through the open capillary tube and fills the tubes down to the level of mercury in the reservoir. The pressure is equal through the tubes and the bulb. Mercury is pumped up from the reservoir. As the mercury raises the cut-off, it traps the gas inside the bulb. The mercury is then pumped higher in the open end capillary tube until all the gas in the bulb is compressed into the bulb. Operator allows the mercury to rise until it reaches zero reference line on the closed capillary tube. The mercury rises faster in the open capillary tube. The compression of gas in closed capillary tube makes the pressure of trapped gas higher than the measured pressure. This pressure difference causes difference in the mercury level in the two tubes. [2 marks]

Mathematically pressure is calculated as P = KHHo(1 - KH)

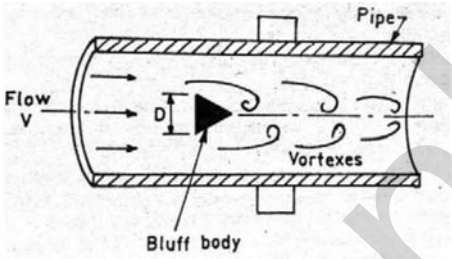
Q.2(f) Explain the working of vortex-type flow meter with a net sketch and state its advantages. **[4]**

(A) [Sketch 01 marks, Explanation 01 marks, advantages 02 marks (any two) 01 mark each)]

The principal of working of a vortex shedding flow meter is based on the fact that when a bluff is placed in a flow stream, vortices are alternately formed, first on one side of the obstruction and then on the other as shown in fig. the vortices are formed downstream when the flow impinges on the bluff body upstream. When the pipe Reynolds number R_e exceeds about 10^4 , vortex shedding and the shedding frequency is given by f = (N * V) /D where, v= fluid velocity , D= characteristics dimension of bluff body, N= strouhal number.

Advantages

1) the flow meter is of portable type
2) Very low pressure loss.
3) the instrument is very accurate and precise, the accuracy and the precision is in the range of ±5% and ±1% respectively.
4) the calibration constant is same for all fluids which include hazardous or corrosive liquid/ gases



Note: - other type of vortex flow meter (i.e swirlmeter) can be accepted

3. Attempt any **FOUR** of the following : **[16]**

Q.3(a) Write the specification for displacement transducer. **[4]**

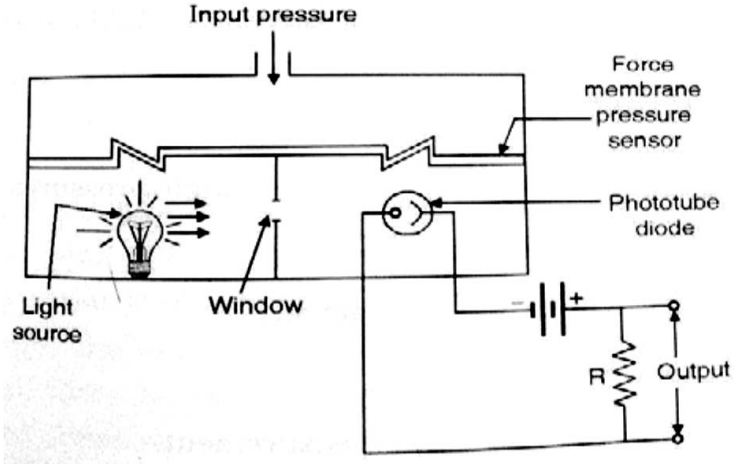
(A) Specification for displacement Transducer: [Any 4 Specifications: 1 mark each]

The technical specification of LVDT is as follows :

Range: 0 to 50 mm
Accuracy: 0.1% range
Power: +/ V dc
Ambient Temperature: −40 to +50°C
Input: 0 to 1.0 V ac
Output: 0 to 50 Mv dc
Enclose: General purpose type 4/Nema 4.
Cable: Belden 8408/4 conducting shielded 20 AWG or Equivalent.

Q.3(b) Explain with neat sketch photoelectric pressure transducer. **[4]**

(A) Photoelectric Pressure Transducer: [Sketch with labeling : 2 M, Explanation : 2 M]



It consist of port for input pressure ,Pressure sensing member like diaphragm ,light source ,a small window, a photo tube with output circuit. The function of pressure sensing element is to control the aperature of small window. The amount of output is entirely depends upon the amount of incident light falling on phototube.

When the pressure to be measured is applied through port to the pressure sensing member, it changes the position of window. As the light source and phototube are separated by a window it changes the amount of light falling on phototube, causing change in the current. This change in current is approximately linear with displacement of window i.e applied pressure. The current in phototube is amplified by a suitable output circuit. A meter connected across output terminal can directly calibrate in terms of pressure measurement. An A.C Modulated light or stable source of light can be used for incident light.

Advantages:
1. It can measure both static & dynamic pressure.
2. It is highly efficient
3. Easy portability
4. Compact size.

Limitation:
1. Less stable for long term measurement
2. Considerably displacement in force membrane is necessary.

Q.3(c) Explain construction and working of bimetallic thermometer. [4]

(A) Construction & working of Bimetallic Thermometer:

[Construction with fig. 2 M & working 2 M]

Construction :

"Bimetallic Thermometer is a device which utilizes the principal of thermal expansion of metals at different temperatures."

It consists of two different materials having different coeff. of thermal expansions rigidly joint together, one on other form a bimetallic strip. Various metallic strips of Nickel-steel alloy & brass can be used.

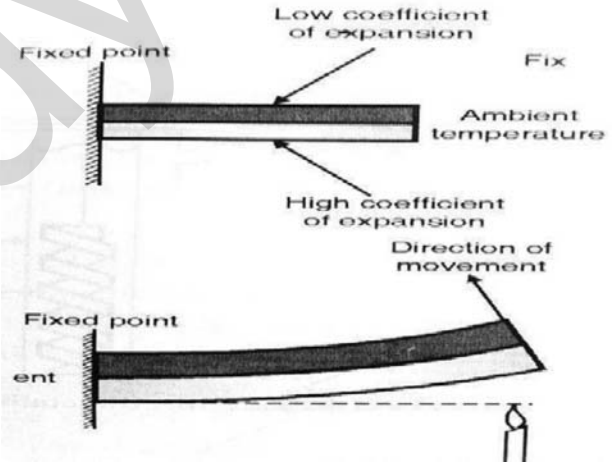


Fig.: A himetallic strip

Working : When two metallic strips of different coeff. Of thermal expansions are brazed together and if a temperature change is applied then a free deflection of assembly takes place, since one strip expands more as compared to another strip.

Such bimetallic strips can be used in the thermometers for temperature measurement or can be used in thermostats for controlling the temperature of furnacs, cooling systems, and refrigeration sans A.C. system.

This type of thermometers are having
- better ruggedness,
- better ease of reading,
- Low cost better accuracy.

Q.3(d) List two advantages and two limitations of resistance thermometer. [4]

(A) Advantages : [any two, 1 mark each]

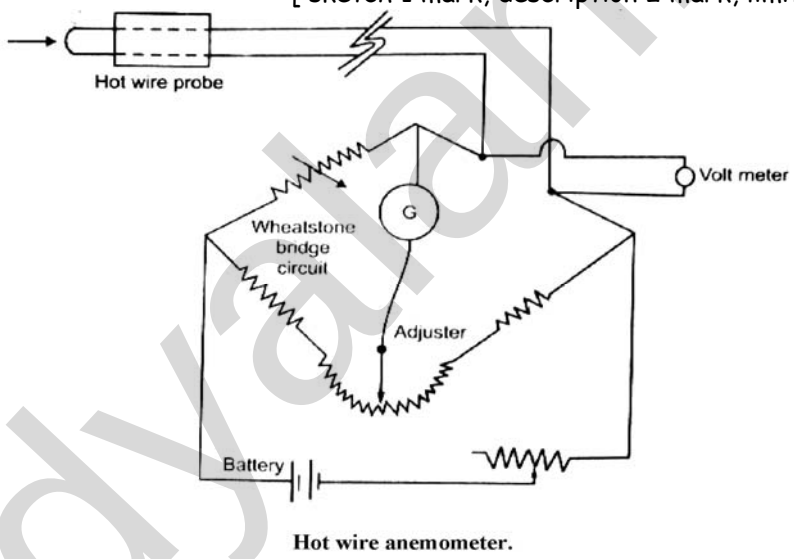
1. it can be used for wide range of temperature from -2000 C to 10000 C.
2. it has linear characteristics.
3. It has + and - 0.15 % accuracy.
4. Installation is easy.

Limitations : [any two, 1 mark each]

1. Response is slow
2. Balancing of bridge takes time
3. Possibility of current leakage between resistance element and ground.
4. Affected by shock and vibrations.
5. It does not give temp. of a point but gives temp. of small area.

Q.3(e) Explain the working of Hot-wire Anemometer for the measurement of rate of fluid flow also mention its limitations. [4]

(A) [sketch 1 mark, description 2 mark, limitations 1 mark]



Hot wire anemometer.

Resistance of platinum or tungsten wire changes as per change in temp. of wire. It forms one of the arm of wheatstone's bridge.

The hot-wire anemometer measures a fluid velocity by nothing the heat convected away by the fluid.

The core of the anemometer is an exposed hot wire either heated up by a constant current or maintained at a constant temperature in either case, the heat lost to fluid convection is a function of the fluid velocity.

By measuring the change in wire temperature under constant current or the current required to maintain a constant wire temperature, the heat lost can be obtained the heat lost can then be converted into a fluid velocity.

Methods of measuring fluid flow :
1. Constant current type
2. Constant temp. type.

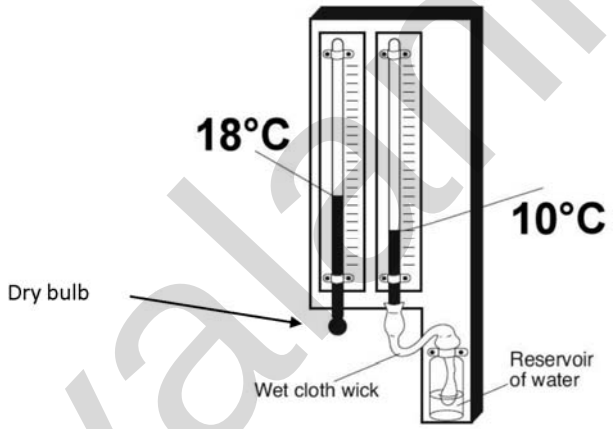
Constant current type :
In constant current type, the heating current i.e. voltage across the bridge maintained constant, initially circuit is adjusted such that the galvanometer reads zero when probe wire lies on stationary air. When air flows, the hot wire cools and changes its resistance, hence deflects galvanometer. Which is already calibrated to get flow velocity.

Constant temp. type :
In this operating resistance of wire hence the temp. of the wire is maintained constant. The hot wire will be cooled when it comes in contact with moving air, the external voltage is applied to keep temp. constant.

The bridge voltage is varied to bring the galvanometer reading to zero; the reading of volt meter is recorded and correlated with fluid velocity.

Limitations :
1. Fine wire has limited physical strength.
2. Due to dirt accumulation calibration of instrument changes.

Q.3(f) What is psychrometer? Explain its use for measuring humidity with a neat sketch. [4]
(A) [sketch 1 mark, description 3 mark]



PSYCHROMETER.

A psychrometer is simple type of hygrometer, an instrument that is used to measure the amount of humidity that is present in the atmosphere.

A psychrometer measures the relative humidity in the atmosphere through the use of two thermometers. The first, a dry bulb thermometer, is used to measure the temperature by being exposed to the air. The seconds, a web bulb thermometer, measures temperature by having the bulb dipped in a liquid. Through the comparison of both temperatures, individuals determine the relative humidity of the surrounding area by calculating the difference between the temperatures.

A psychrometer chart makes it easy to find the relative humidity once a reading has been taken. This reduces the need for on-the-fly calculations which may be difficult to perform.

Ventilated and aspirated psychrometers, which are designed to work with fans that ventilate the wet bulb thermometer. The process also increase evaporation rates evenly, which produces a more accurate reading.

Used in greenhouses and industrial spaces, hygrometers are also used in some incubators (egg), humidors and museums.

4. Attempt any **FOUR** of the following : **[16]**

Q.4(a) Draw neat sketch of Rotameter and explain its working. **[4]**

(A) Working of Rotameter : [Explanation: 2 marks and Figures: 2 marks]

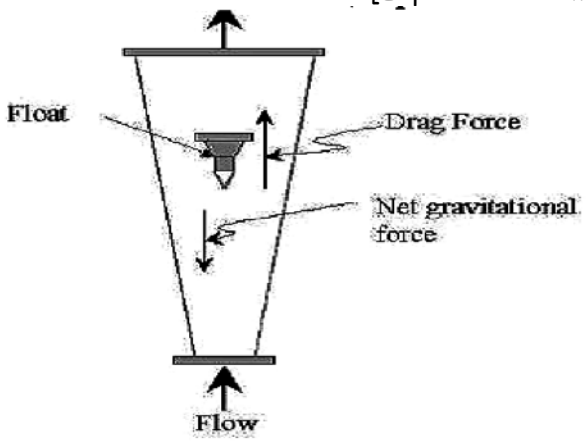


Fig. : Rotameter

The rotameter consists of three basic elements :

1) A uniformly tapered flow tube, 2) a float, and 3) a measurement scale.

A control value may be added if flow control is also desired. In operation, the rotameter is positioned vertically in the fluid system with the smallest diameter end of the tapered flow tube at the bottom. This is the fluid inlet. The float, typically spherical, is located inside the flow tube, and is engineered so that its diameter is nearly identical to the flow tube's inlet diameter.

When fluid like gas or liquid is introduced into the tube, the float is lifted from its initial position at the inlet, allowing the fluid to pass between it an the tube wall. As the float rises, more and more fluid flows by the float because the tapered tube's diameter is increasing. Ultimately, a point is reached where the drag force exerted by the fluid is balance by weight of float and gravitational force. The float is now stationary at that level within the tube as its weight is being supported by the fluid forces which caused it to rise. This position corresponds to a point on the tube's measurement scale and provides an indication of the fluid's flow rate.

Q.4(b) A resistance wire strain gauge with a gauge factor F = 2.1 is bonded to a steel member subjected to a stress of 100 mN/m^2. Calculate the percentage change in the value of gauge resistance due to applied stress. For steel E = 2006 N/m^2. **[4]**

(A) Given : gauge factor, F = 2.1, stress = 100 mN/sq.m, E = 2006 N/sq.m

calculate % change in gauge resistance,

E = stress/strain, and strain is $\Delta L/L$,

$2006 = 100 \times 10^{-3} / (\Delta L/L)$

$(\Delta L/L) = 4.985 \times 10^{-3}$ [2 marks]

gauge factor, $F = (\Delta R/R) / (\Delta L/L)$

$2.1 = (\Delta R/R) / 4.985 \times 10^{-3}$

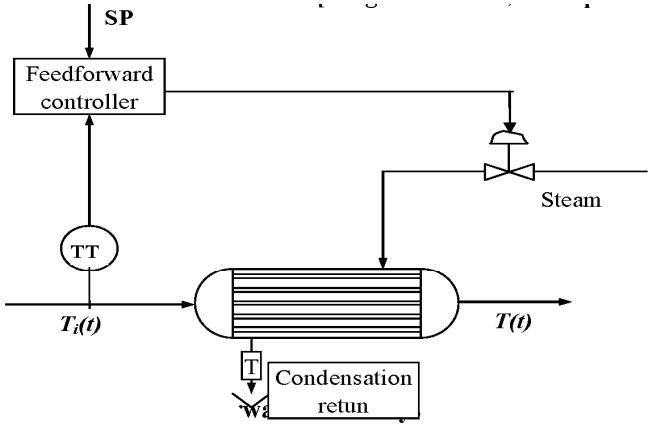
$(\Delta R/R) = 1.046 \times 10^{-4}$

Percentage change in gauge resistance $= 1.046 \times 10^{-4} \times 100$

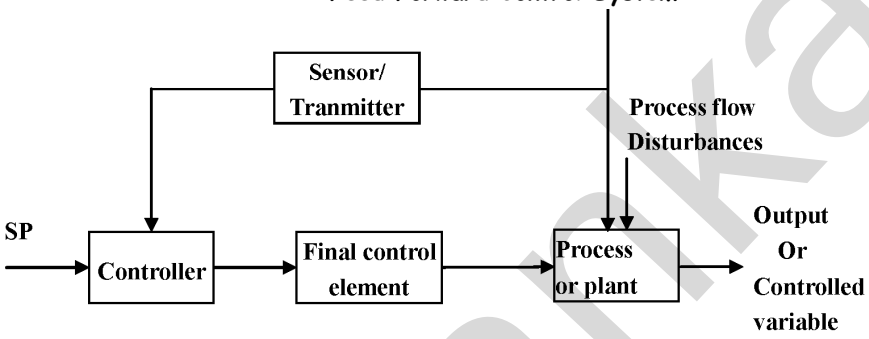
$= 0.01046\ \Omega$ [2 marks]

Q.4(c) Explain the feed forward control system with the help of a neat sketch. [4]

(A) [diagram 2 mark, description 2 mark]



Feed Forward Control System



Block diagram of feed forward control system

In feed forward control system, disturbances are measured and compensated for them before the controlled variable eviates fron set point.

In control system, it is considered that the disturbance affect the o/p adv.

Rsly and considerably. If these disturbances are measurable, then this signal can be added to the controller output to modify the actuating signal. Thus a corrective action s initiated without waiting for the effect of the disturbance affect the output is called feed forward control system.

Feed forward controller makes the decision about how to manipulate the actuating element steam valve to maintain the controlled variable at set point.

Q.4(d) Explain sound measurement using electro–dynamic microphone. [4]

(A) Sound measurement using electrodynamic microphone:

[Sketch 1 ½ M & explanation: 2 ½ M]

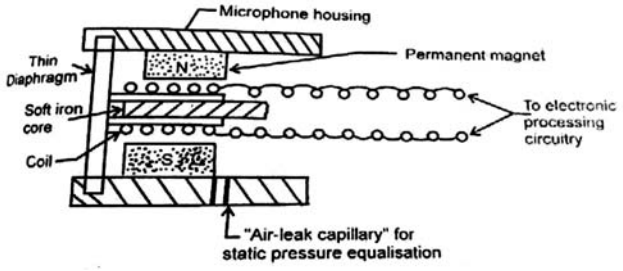


Fig.: Electrodynamic microphone

The working of this microphone is based on the principle of generation of e.m.f. when a moving conductor is placed in a magnetic field.

Here, a thin sensing diaphragm is attached to a coil placed within the poles of a permanent magnet and the movement of the diaphragm due to sould pressure generates the analogous induced voltages in the coil. This induced voltage is given to the "Electronic processing circuitry" to obtain the measurement of "sound pressure level."

Such microphone has the advantages that it is self-generating but their frequency response is poor due to high inertia of the moving coil.

The output voltage of the electrodynamic microphone is given by

$V = [B.l.u \times 10^{-8}]$ volts

Where,

B = Magnetic flux density (Gauss)

l = Length of Conductor

u = Velocity of coid (m/s)

Q.4(e) What is stroboscope? Explain its working principle. [4]

(A) **Stroboscope :** The stroboscope is simple manually operated portable device which is used for measurement of speed. Stroboscope has variable frequency flashing light. An oscillator is Provided to control flashing frequency. The speed is measured by adjusting frequency so that the Moving object is visible at specific intervals.

Working Principal : The flashing light is directed on rotating member, which usually has some spoke, gear teeth or some other feature. If rotating member do not have any of such features, a paper having black and white stripes is attached to it or some marking is done as a target. 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.

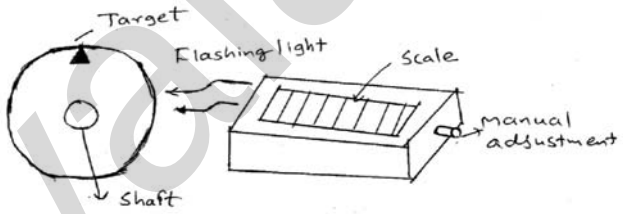
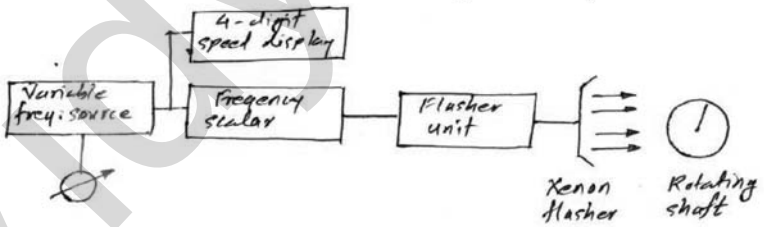


Fig: Stroboscope



Measurement of the speed of a rotating shaft is a common requirement in many industrial and laboratory applications. Such measurements have usually been carried out in the past with the help of contact type tachometers with friction drive.

In this a high intensity light flash of a variable frequency is directed towards rotating shaft. Any marking on the shaft appears stationary, if the time of one shaft revolution is a multiple of the flash period. Earlier stroboscopes used neon tubes of low intensity which forced their use close to the rotating shaft. A highly stable function generator IC based circuit provides the basic variable frequency timing pulses. These are read on an IC based 4-digit speed display in rpm. The flasher unit generates the high intensity flashes at a suitable scaled rate directed towards the rotating shaft. A 10 turn potentiometer makes the task of speed setting very precise. [Working principal & sketch : 3 marks]

Q.4(f) List various advantages of electromagnetic flowmeter. **[4]**

(A) [any four points, 1 mark each]

1. It can handle slurries and greasy materials.
2. It can handle corrosive fluids.
3. It has very low pressure drop.
4. It is totally obstruction less.
5. Available in several construction materials.
6. Available in large pipe size and capacities.
7. Measurement unaffected by change in density, pressure, temperature etc.
8. Capable of handling extremely low flow rates or very high flow rates.
9. Voltage o/p is proportional to average velocity and does not depend on whether flow is laminar or turbulent.

Q.5 Attempt any **FOUR** of the following: **[16]**

Q.5(a) Explain working and application of bonded strain gauge. **[4]**

(A) **Bonded Strain Gauge :** [Working - 2 marks, any 4 applications - 2 marks]

Working :

Bonded strain gauges are metallic or semiconductor filaments cemented on a paper backing or epoxy resin backing.

These gauges (metallic or semi-conductor) are bonded or cemented directly onto the surface of structural member which is being examined.

Strain gauge filaments forms the four resistance of wheatstone bridge circuit.

Any deflection/deformation of structural member on which the strain gauges are mounted, will result the change in length of any one or all the four resistances of wheatstone bridge circuit.

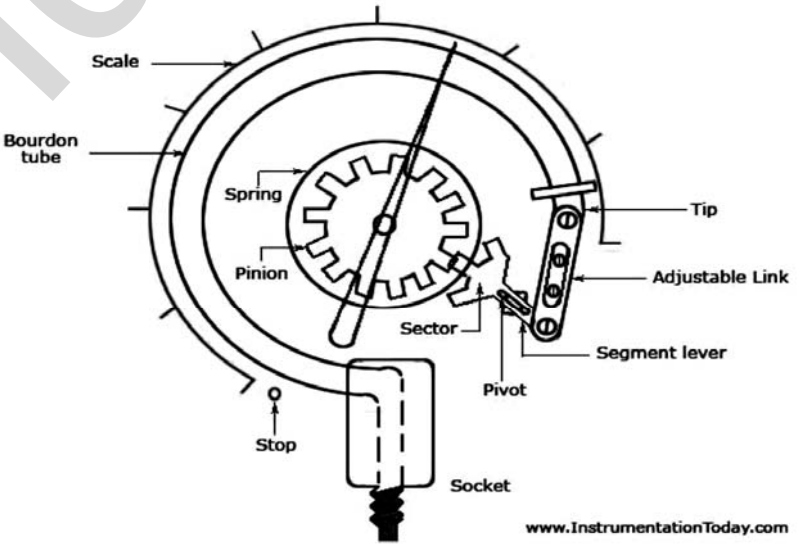
This change in resistance can be caliberated to measure the strain or the measurand.

Applications :

i) Determination of maximum stress values.
ii) Force/Thrust measurement, e.g. Load cells
iii) Pressure Measurement
iv) Torque measurement e.g. strain gauge torsion meter.
v) For experimental verification of strain in complex physical systems (say in human legs and skills)

Q.5(b) Explain with a neat sketch, working of Bourdon-Tube pressure gauge. **[4]**

(A) [Sketch-2 Marks]



Bourdon Tube Pressure Gauge

An elastic transducer that is bourdon tube which is fixed and open at one end to received the pressure which is to be measured. The other end of the bourdon tube is free and closed. To the free end of the bourdon tube is attached an adjustable link which in turn connected to a sector and pinion. To the shaft of a pinion is connected a pointer which sweeps over a pressure calibrated scale.

The pressure to be measured is connected to the fixed open end of the bourdon tube. the applied pressure act on the inner walls of the bourdon tube. Due to the applied pressure the bourdon tube tends to change in cross section from elliptical to circular. This tends to straighten the bourdon tube causing a displacemnt of the free end of the bounrdon tube.

This displacement of the free closed end of the bourdon tube is proportional to applied pressure. As the free end of the bourdon tube is connected to a link section pinion arrangement, the displacement is amplified and converted to a rotary motion of the pinion. As the pinion rotates; it makes the pointer to assure a new position on a pressure calibrated scale to indicate the applied pressure directly.

[Description of working-2 Marks]

Q.5(c) In a lathe cutting test, the following data has been obtained : [4]

(i) Tangential force = 795 N (ii) Axial force = 88 N
(iii) Speed of spindle = 300 rpm (iv) Feed Rate = 0.8 mm per resolution
(v) Mean diameter of cut = 0.1 m and
(vi) Power input to 3 phase motor = 875 watt/phase
Calculate : (1) Power absorbed in rotating the work piece
(2) Power absorbed in feeding the tool along the work piece
(3) Calculate over all efficiency.

(A) Given data [1 mark]

i) Tangential force = 795N
ii) Axial force = 88N
iii) Speed of spindle = 300 rpm
iv) Feed rate = 0.8 mm per resolution
v) Mean diameter of cut = 0.1 m and
vi) Power input to 3 phase motor = 875 watt/ phase

Power absorbed in rotating the work piece is given by

$= 2\pi nT$

$= F \times r \times 2\pi n$ [1 mark]

Where F = Tangential force = 795 N

r = mean diameter of cut / 2 = 100/2 = 50 mm

n = spindle speed = 300 rpm

Power absorbed in rotating work piece

$= 795 \times 2 \times \pi \times (300/60) \times 50$

$= 1248.150$ W

Power absorbed in feeding the tool along the work piece [1 mark]

$= F \times v$ (v = feed mm/rev)

$= 88 \times 0.8 \times 10^{-3} \times (300 / 60)$

$= 0.352$ W

Total power consumed = 1248.150 + 0.352 = 1248.502

Input to the motor = $3 \times 875 = 2625$ Watt

Overall efficiency = 1249.13 / 2625 = 0.4758 = 47.58 % [1 mark]

Q.5(d) Explain proportional and derivative type (PD) control action. [4]

(A) Proportional and derivative type (PD) control action

[2 Diagrams – 2 marks, correct Explanation; mathematical expressions are optional – 2 marks]

The magnitude of the controller output is proportional to the rate of change of the actuating error signal.

The PD controller refers to the control action where derivative control action is added to the proportional control action.

The equation of PD controller is

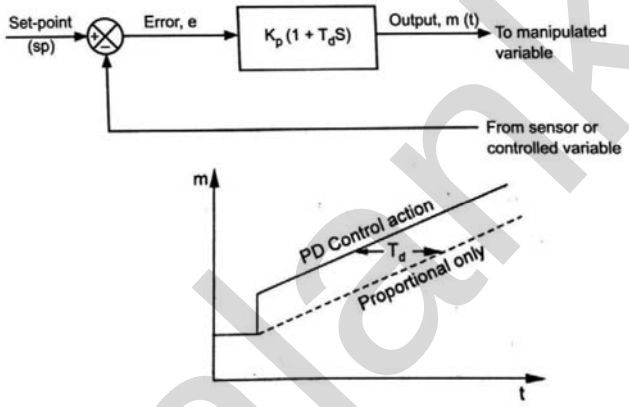
$$m(t) = k_p \left\{ e(t) + T_d \frac{d_e(t)}{d_t} \right\}$$

where T_d = derivative time = time interval by which the rate action advances the offset of proportional control action.

Its Laplace transform is,

$M(s) = k_p(1 + T_d S) E(s)$

Block diagram of PD control action and its response to a unit ramp function is as in shown figure below.



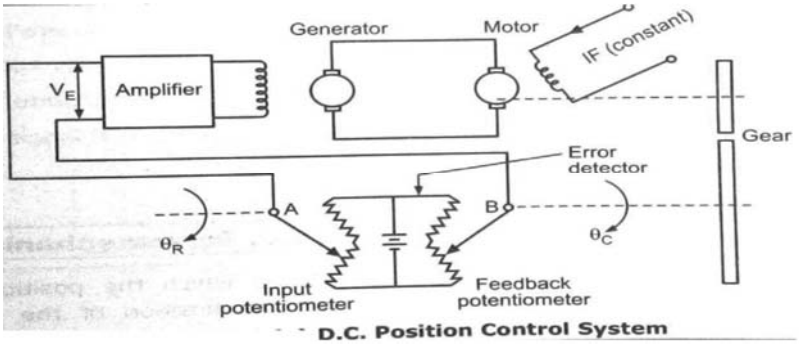
Q.5(e) With a suitable example, explain servo motor mechanism. [4]

(A) Servo motor mechanism [Diagram – 2 marks, Correct Explanation – 2 marks]

- A servomechanism is an automatic control system in which the controlled variable is 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 (demand signal).
- Servomechanism are inheranlty fast acting and usually employ electric or hydraulic actuation.
- essentially used to control position or speed of mechanism which is either heavy or too remote to be controlled manually.
  e.g. : Power assisted steering and control in large cars, aircrafts, ships etc. Complete automation of machine tools together with programmed instructions.

D.C. motor position control with servomechanism :

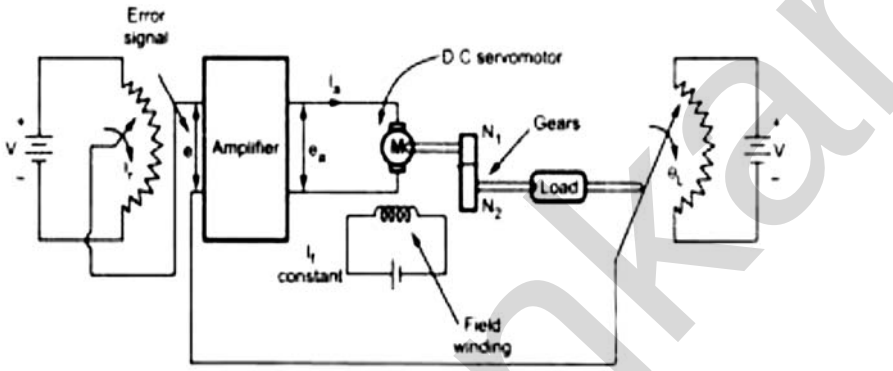
- Assume k_P = 100 volts/rad, and output shaft position be 0.5 rad, corresponding to this condition the slider arm B has voltage of +50 volts.
- Let slider arm A also set at +50 volts. Then error signal will be zero (i.e. V_E = 0). Hence the motor has zero output torque, so the load stays stationary at 0.5 rad.
- Now assume that, the new desired position of the load is 0.6 rad. To achieve this, the arm A is placed at +60 volts position, while arm B at the +50 volts position. This makes an error signal of + 10 volts. This error signal is amplified and fed to servomotor which generates an output torque that repositions the load. The system comes to a steady position only when error signal becomes zero that the arm B reaches the position corresponding to 0.6 rad (i.e. +60 volts)



D.C. Position Control System

Q.5(f) Explain working of D.C. position control system. **[4]**

(A)



[Neat sketch – 2 marks]

The remote position system is shown in figure wherein the output shaft rotation is required to follow the input shaft rotation. Two toroidal type potentiometers are coupled to each shaft for measuring the angular position of the two shafts respectively. The wiper arm of potentiometer decides the input position of the input shaft. But the potentiometers are driven through a common power supply. If the output shaft position is same as that of the input shaft, there will be no potential difference between the output voltages of two potentiometers. If there is any misalignment then there will be a potential difference between voltage of two potentiometers. This error signal is amplified by the amplifier and the resultant voltage is fed to the field controlled d.c. motor. Here the armature current Ia is maintained constant. This error signal is applied to field winding of motor. Now the motor will develop a torque of the magnitude and the sign so as to rotate output shaft in the direction as to reduce the error signal to zero.

[Explanation-3Marks]

6. Attempt any **FOUR** of the following: **[16]**

Q.6(a) Explain the working of optical Encoder with its neat sketch of construction. **[4]**

(A)

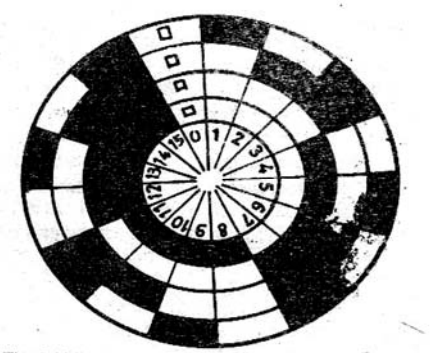
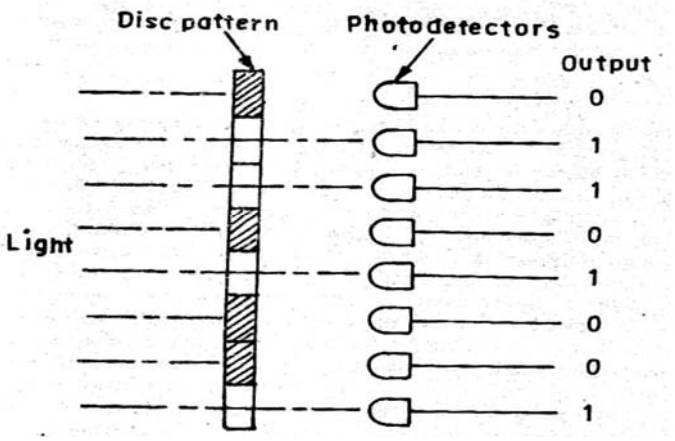
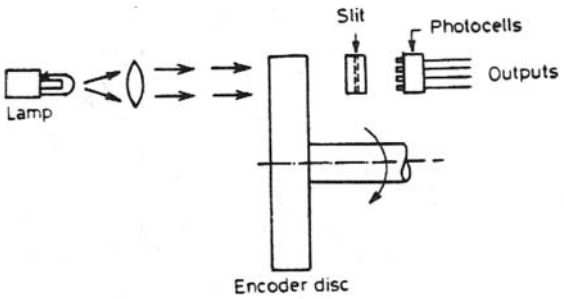


Fig. 5.121. A rotary shaft encoder using four track.





Optical encoder

[Any one diagram – 2 marks]

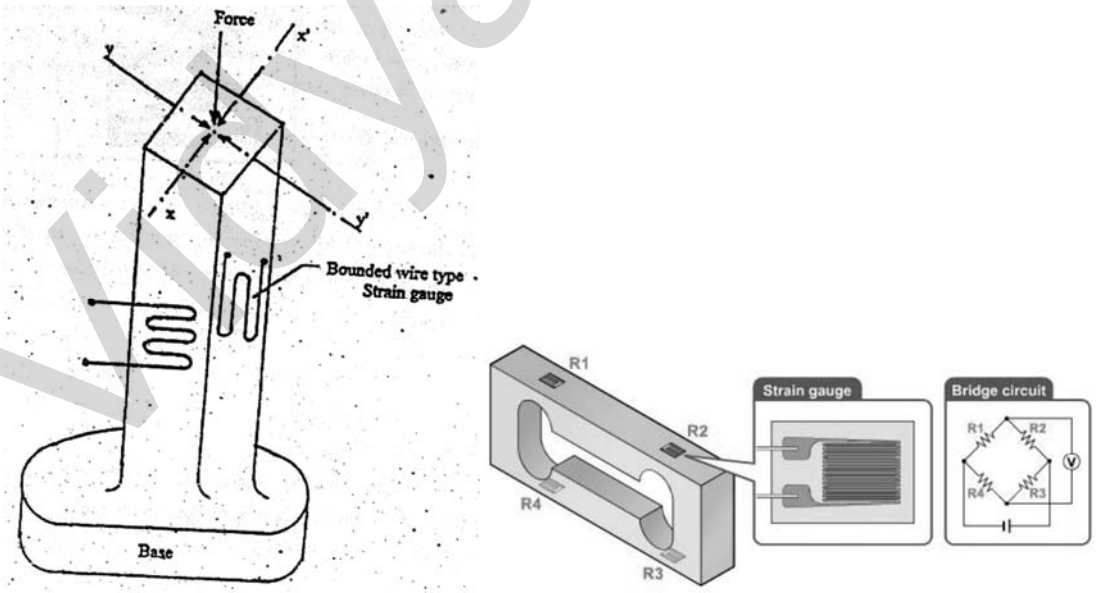
Shaft encoder is a digital device used for measurement of angular position. There is a necessity of measuring devices that form a basic part whose output is compatible with digital nature of the computer. The disc is divided into concentric circular tracks & each tack is then divided into segments. For pure binary code the inner track is halfed, 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.

[Explanation-2 Marks]

Q.6(b) Explain strain measurement method using load cell with a neat sketch. [4]

(A)

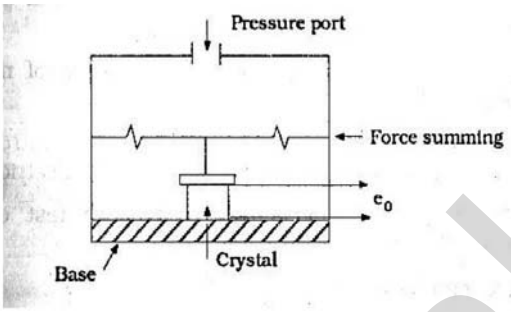


Load cell is application of wire type bonded strain gauge. It works on the principle of the elasticity i.e. when axial force is applied, its column gets compressed and when force is released it regain its original position .Four wire type bonded strain gauges are cemented on the column of load cell as shown in fig such that gauges along x-x are cemented in horizontal position where as along y-y in vertical position. The resistance offered by each gauge is same in magnitude. Gauges are connected to form Wheatstone bridge network. When axial

force applied is zero then the resistance of each gauge is equal in magnitude, which keep bridge in balance condition and deflection shown by detector is zero. When the axial force applied is zero then the resistance of each gauge is equal in magnitude, which keep bridge in balance condition and deflection shown by detector is zero. When the axial force to be measured & resulting strain is applied on load cell then its column gets compressed. The compression of column causes decrease in resistance of strain gauge along y-y and remains unaffected along x-x. This turns the bridge to unbalance condition. The deflection shown by detector can be directly calibrated to read axial force or strain.

Q.6(c) Explain the working of piezoelectric type pressure transducer for pressure transducer with a neat sketch. **[4]**

(A)



[Explanation-2 Marks]

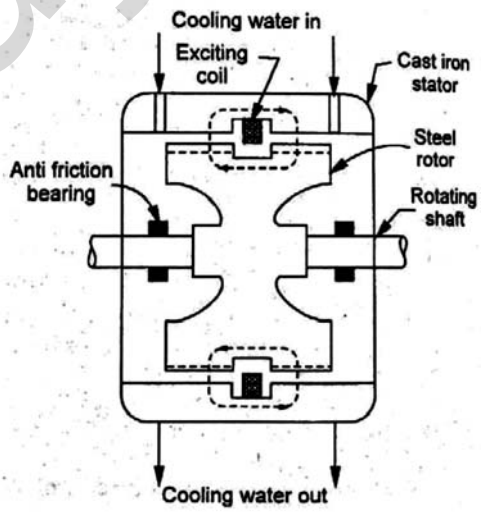
When certain crystalline substances are subjected to pressure or stresses along specific planes, voltage is generated in them. This effect is called as piezoelectric effect. The piezoelectric effect is direction sensitive i.e. if tension is applied definite voltage polarity will be produced while if compression is applied opposite polarity will be produced. Usually a crystal is placed between a solid base and a force summing member. Meter electrodes are plated on to selected faces of piezoelectric material. The electrodes become the plates of a capacitor.

Output v = Q/C

When unknown pressure is applied through the port, voltage is generated across the crystal, which can be directly calibrated in terms of pressure.

Q.6(d) Explain working principle of eddy–current dynamometer. **[4]**

(A) Eddy Current dynamometer [Diagram - 1 marks, Correct Explanation - 3marks]



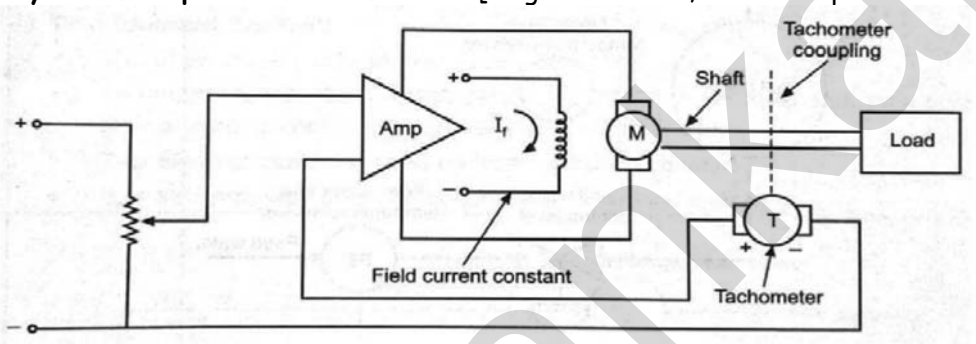
Principle: When an isolated conductor moves through the magnetic flux, voltage is induced and local currents flow in a short circular path (eddy currents) within conductor. These induced eddy currents get dissipated in the form of heat.

Working :

- It consists of toothed non-magnetic solid metallic rotor connected to the shaft whose power is to be measured.
- Nonmagnetic rotor rotates inside cast iron stator.
- Stator consists of D.C. supply excited coil. The stator is mounted such that it permits free swing about its axis and is provided with torque arm, which measures torque.
- To dissipate the generated heat, water is supplied in stator casing.
- During operation, rotor turns and causes constant change in flux density at all points of stator, resulting formation of eddy current, which opposes the motion of rotor. This opposing resistance is measured by brake drum in the form of torque.
- Apprx. Speed limit = 6000 rpm.
- Usual power limit = 250 kW

Q.6(e) Explain control system for speed control of motor. **[4]**

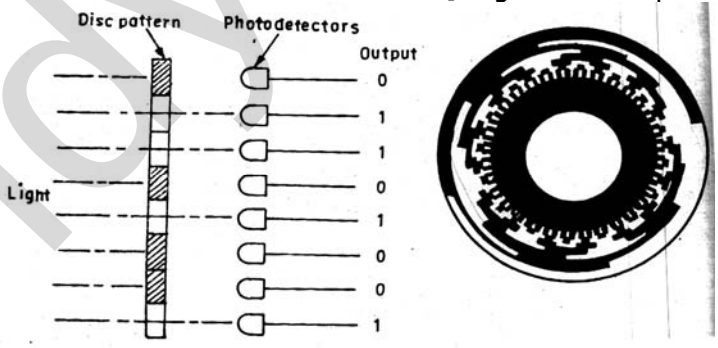
(A) Control system for speed control of motor [Diagram – 1 mark, Correct Explanation – 3 marks]



- The D.C. shunt motor is used where the field current is kept constant and armature voltage is changes to obtain desired speed. The feedback is taken by speed tachnometers.
- This generates voltage proportional to speed which is compared with voltage required to the speed.
- This difference is used to change the input to the controller which cumulatively changes the speed of the motor as required.

Q.6(f) What is optical measurement scale? Explain. **[4]**

(A)Optical Measurement Scale [Diagram-2M, Explanation-2M]



Optical measurement scale is used in optical encoders for rotary displacement measurement.

The disc has transparent and opaque areas corresponding to the conducting and non-conducting areas. A light source is used along with photo cells. The photo cell corresponding to a particular track, would produce an electrical output if the transparent portion is in front of the light source giving state ON (or 1) while no electrical output from a cell would correspond to OFF (or 0).

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