SUMMER – 13 EXAMINATIONS

Subject Code: **12156** **Model Answer**

Important Instructions to examiners:

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

Q.1 A) Attempt any four

a) **Measurement**: It is an act or result of a quantitative comparison between a predetermined standard and an unknown quantity. (1)

Requirements: i) The standard which is used for comparison must be accurately known and commonly accepted ii) the procedure and apparatus employed for obtaining the comparison must be provable. (1)

Significance: i) Little progress is possible in any field of investigation without ability to measure. ii) Present day mass production, communication; scientific and technological progress could not exist without adequate measurement techniques. iii) Measuring instruments have provided the man to gather the information about the world he lives in.

iv) Whole area of automatic control is measurements. (2)

b) **Definition:** (1 each)

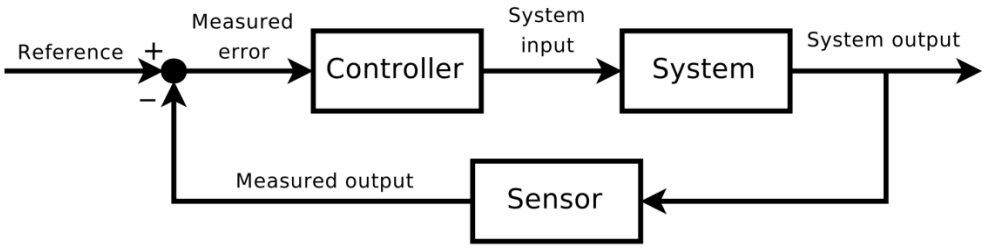
I. Accuracy: It is the degree of closeness of measured value with the true value. It is the ability of the instrument to indicate the true value.

II. Precision: it is the quantitative or numerical indication of the closeness with which a repeated set of measurements of the same variable agree with the average set of measurements.

III. Threshold: The smallest measurable input to start or stop indicating as a sensed parameter increases from or decreases to zero.

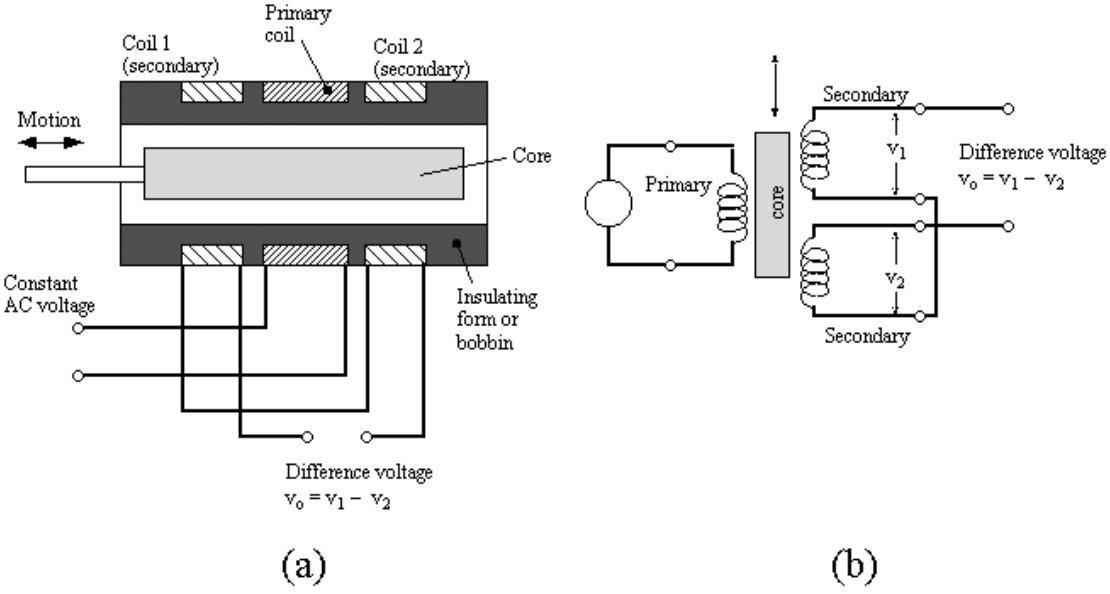
IV. **Resolution:** The smallest change in a measured value that the instrument can detect. Resolution is also known as sensitivity.

c) Block Diagram of **Closed Loop control system** (2)



Explanation: In this case output is measured with the help of sensor and is compared with the input reference signal. Deviation or error between the two is used by the controller which will send the output so that the error of system becomes zero. Usually negative feedback is used. In closed loop control action depends on the output. The system is more accurate, reliable but expensive. It has tendency for oscillations. It has steady state error due to friction, inertia and backlash. (2)

d) **Sketch of LVDT**: (1)



Working: It is a linear variable differential transformer. It is passive transducer. LVDT works under the principle of mutual induction, and the displacement which is a non-electrical energy is converted into an electrical energy.

It consists of a hollow concentric non-magnetic form on which three windings i.e. one primary and two secondary are mounted. The core is normally nickel iro alloy.

When a primary winding is excited by suitable a.c. source, it produces a magnetic flux. This magnetic flux links with the secondary windings and changes the voltage induced in it. When the core is centrally located, it induces equal voltage in the secondary windings. But when the core is displaced flux linkages change. Hence more voltage is induced in one secondary than the other. The net voltage increases linearly with the displacement of core. It is calibrated as a measure of displacement. (2)

Characteristics: i) No physical contact between core and coils, thus no friction or wear. ii) it provides precise, repeatable and comparatively high electrical output. No need of amplification. iii) Infinite resolution with high sensitivity. iv) Very low power consumption of the order of one watt. (1)

Q.1 B) Attempt any one

a) **Classifications of errors**: (3)

i) Gross error: ii) systematic error iii) Random error

Also classified as

i. Controllable Errors

– Environmental Conditions

– Elastic Deformation Due to Loading

– Alignment Errors

– Parallax Errors

ii. Non-Controllable Errors

– Scale Errors

– Reading Errors

– Linearity

– Hysteresis

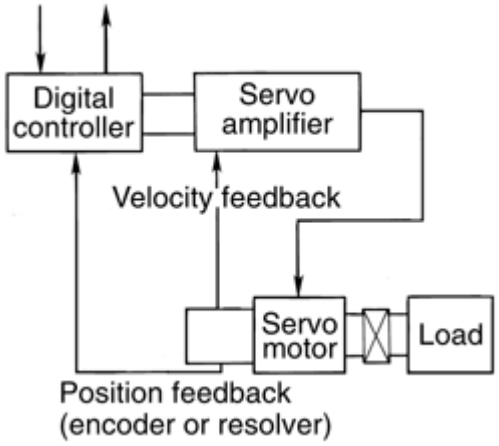
– Repeatability & Random Errors

Explanation: (3)

i) **Environmental errors**: instrument readings are largely affected due to changes in the surrounding such as temperature change, pressure change, change in humidity. Neighboring electromagnetic fields, vibrations create error in instrument reading. To reduce these errors provide air conditioning, shielding and proper earthing.

ii) **Hysteresis error**: it is a serious source of error in moving iron instruments. Owing to the hysteresis in the iron of operating system, readings are higher when descending values of current or voltages are measured when ascending values are measured. To reduce this error, irons are made small so that effect of hysteresis is small.

b) Sketch of **DC servomechanism:** (2)



Working: Servomechanism, automatic device for the control of a large power output by means of a small power input or for maintaining correct operating conditions in a mechanism. It is a type of feedback control system. The constant speed control system of a DC motor is a servomechanism that monitors any variations in the motor's speed so that it can quickly and automatically return the speed to its correct value.

In this type of block diagram, Typical dc servo motor system with either encoder or resolver feedback. Some older servo motor systems use a tachometer and encoder for feedback. There are two feedbacks i) velocity feedback and ii) position feedback. (2)

Applications: Any Two

1.Automatic machine tools 2.Satellite-tracking antennas

3.Celestial-tracking systems on telescopes 4.Automatic navigation systems

5.Antiaircraft-gun control systems 6.Roll stabilization of ships (2)

Q.2 Attempt any four

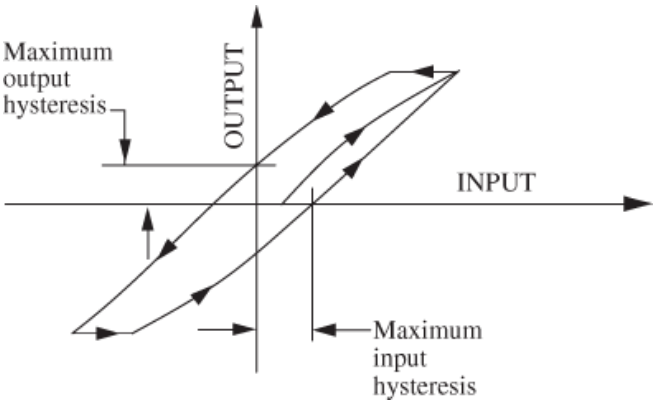
a) **Undesirable characteristics of instruments:** (1)

Static: drift, dead zone, static error, hysteresis

Dynamic: Lag and dynamic error

Hysteresis: It is also the delay between the action and reaction of a measuring instrument. Hysteresis is the amount of error that results when this action occurs. It is non-coincidence loading and unloading curves in input and output relationship. It is serious source of error in moving iron instruments. Owing to the hysteresis in the iron of operating system, readings are higher when descending values of current or voltages are measured when ascending values are measured. To reduce this error, irons are made small so that effect of hysteresis is small. i.e. internal friction of stressed parts such as springs and external sliding friction i.e. play or looseness in mechanism of instrument (2)

Curve:

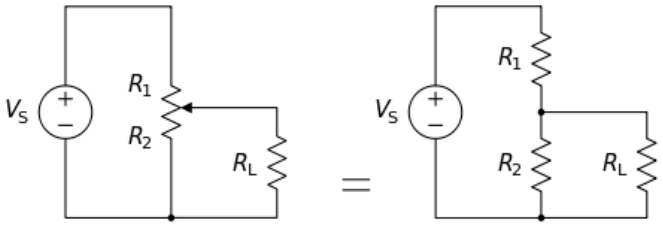


(1)

b) Comparison of Pneumatic control system and Hydraulic control system (4)

Sr. No.	Pneumatic control system	Hydraulic control system
1.	It deals with the transmission and control of power using pressurized air.	It deals with generation, transmission and control of power using pressurized fluid (by virtue of Pascal's law).
2.	Difficult to control with high forces, medium forces can be controllable.	High degree of control and precision with high forces.
3.	Possibility of explosive failure, Noisy.	Oil may leak: fire hazard, Chemical / environmental problems possible.
4.	Energy storage is good and cost is highest	Energy storage is limited and cost is medium.

c) Sketch of **Linear potentiometer for displacement measurement**: (1)



Working: The potentiometer can be used as a voltage divider to obtain a manually adjustable output voltage at the slider (wiper) from a fixed input voltage applied across the two ends of the potentiometer. This is their most common use.

The voltage across R_L can be calculated by:

$$V_L = \frac{R_2 R_L}{R_1 R_L + R_2 R_L + R_1 R_2} \cdot V_s.$$

If R_L is large compared to the other resistances, the output voltage can be approximated by the simpler equation:

$$V_L = \frac{R_2}{R_1 + R_2} \cdot V_s.$$

(2)

Applications: (1)

i) **Audio control:** Low-power potentiometers, both linear and rotary, are used to control audio equipment, changing loudness, frequency attenuation and other characteristics of audio signals.

ii) **Motion control:** Potentiometers can be used as position feedback devices in order to create "closed loop" control, such as in a servomechanism.

iii) **Television**: Potentiometers were formerly used to control picture brightness, contrast, and color response.

d) Classification of transducers: (4)

i) Input / output transducer

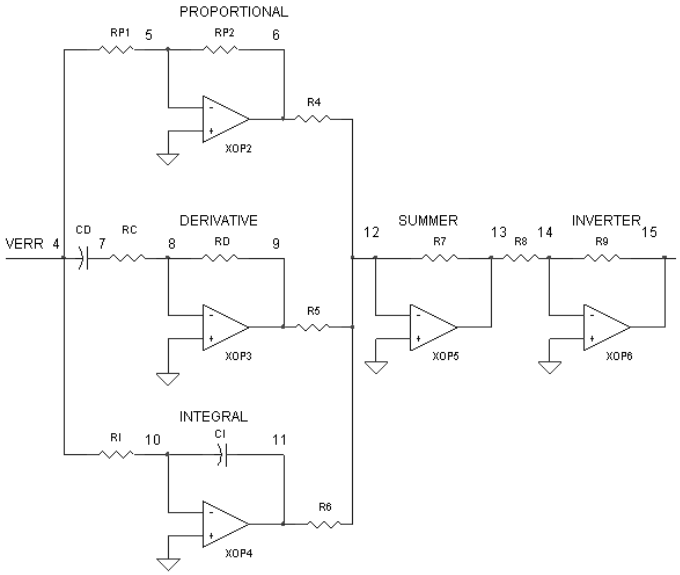
ii) Analog transducer / digital transducer:

iii) Active / passive transducer

a) Active transducer: thermoelectric, photoelectric, piezoelectric, electromagnetic

b) Passive transducer: resistive, inductive, capacitive

e) **Sketch of PID controller (Electronic)** (2)



Explanation: Heart of electronic controllers is a high gain operational amplifier connected between input and feedback networks. PID algorithm is widely used in process control. This method of control is also used in electronic solutions in analogue as well as digital components.

There are two types of controls

- **PID Position Algorithm:** The control output is calculated so it responds to the displacement (position) of the process variable from the set point value (error term).
- **PID Velocity Algorithm**: The control output is calculated to represent the rate of change (velocity) for the process variable to become equal to the set point value.

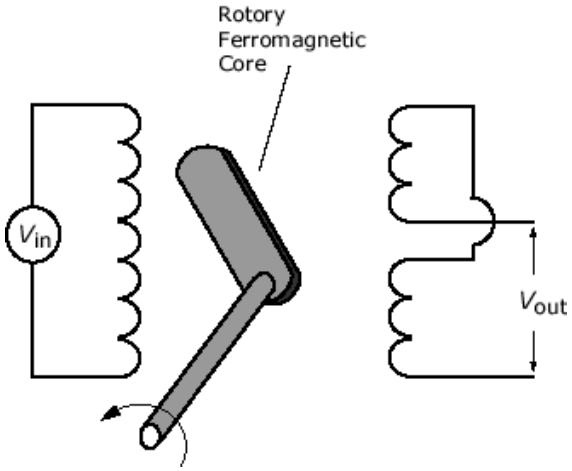
As shown in figure there are three parallel paths of PID controller calculation block.

1. **Proportional**: The proportional term simply responds proportionally to the current size of the error. This loop controller calculates a proportional term value for each PID calculation. When the error is zero, the proportional term is also zero.

2. **Integral**: The integrator (or reset) term integrates (sums) the error values. Starting from the first PID calculation (after the controller was released), the integrator keeps a running total of the error values.

3. **Derivative**: The derivative (or rate) term responds to change in the current error value from the error used in the previous PID calculation. Its job is to anticipate the probable growth of the error and generate a contribution to the output in advance. (2)

f) Sketch of RVDT (1)



Working: The **Rotational Variable Differential Transformer** (**RVDT**) is used to measure rotational angles and operates under the same principles as the LVDT sensor. It converts angular displacements into electric signals. Whereas the LVDT uses a cylindrical iron core, the RVDT

uses a rotary ferromagnetic core. Construction of RVDT is same as that of the LVDT; it has a primary winding and two secondary windings.

Core is rotated in clockwise and anticlockwise direction with respect to the null position. When the core is at null position, output voltage is zero as voltage induced in both secondary windings is and in opposite directions. If any angular measurement to be measured is applied to the shaft, differential voltage is applied at the secondary output which increases with the increase in the angle. The output voltage is calibrated to measure the angle. (2)

Application: It is ideal for measuring angular displacements in the most demanding industrial, automotive and defense applications; where minimum mechanical friction is required. i.e. flight control, engine control, steering control, braking control and surface controls. (1)

Q.3 Attempt any four:

a) Define: (1 each)

i) Overshoot:- It is the maximum amount by which the pointer moves beyond the steady state. Because of mass of inertia the pointer does not come to rest immediately and it goes beyond the steady state.

ii)Linearity:- It is defines as the ability to reproduce the input characteristics symmetrically, and linearly. The working range of most of the instrument provides a linear relationship between the output and input.

iii) Speed of Response:- In measuring instrument the speed of response is defined as the value of the rapidity with which an instrument responds to a change in the value of the quantity being measured.

Or it is the quickness of an instrument to read the measured variable.

iv) Measuring lag:- It is refers as delay in the response of an instrument to change in the input signal. The lag is caused by conditions such as capacitance, inertia or resistance.

b) Define transducer and state selection criteria for selection of Transducer. (1+3)

Ans. A transducer is a device to convert position displacement, thermal and optical signals into electrical quantities that may be amplified, recorded and otherwise processed in the instrumentation system. Transducers are also known as prime sensors, pickups and signal generators. Transducers use almost all mechanical-electrical principles to convert all measured quantities into their analogs.

Following are criteria for selection:

Size and weight, exceptional reliability, low cost, accurate transducers for the measurement of fast transient pressures, high sensitivity, ability to withstand wider extremes of environmental conditions, linear relationship between input and output.

c) Draw neat sketch of Bubbler or purge system for liquid level measurement.

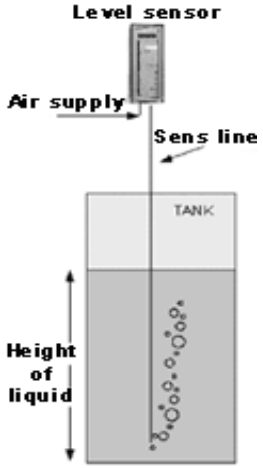


Fig. Bubbler or purge system for liquid level measurement (sketch-2m + Label-2m)

d) What is automatic control system? Write two advantages and two applications of the same. (2+1+1)

Ans. An automatic control system is a preset closed loop control system that requires no operator action. This assumes the process remains in the normal range for the control system. An automatic control system has two process variables associated with it, a control variable and a manipulated variable. A control variable is the process variable that is maintained at a specified value or within a specified range. A manipulated variable is the process variable that is acted on by the control system to maintain the controlled variable at the specified value or within the specified range.

The storage tank level is the controlled variable and the flow rate of the water supplied to the tank is the manipulated variable. In Automatic control system four basic functions occurs- measurement, comparison, computation & correction.

Advantages:-1) Uniformity of products improves.

2) Production rate increases.

3) Wear & tear decreases so plant life increases.

Applications:-1) In transportation systems such as railways, airplanes etc.

2) Power machines, compressors etc.

3) In refrigeration systems.

e) Write four differences between open loop and closed loop system. (1 each - 4m)

Sr. No.	**Open loop system**	**Closed loop system**
1	Feedback is absent.	Feedback is present.
2	Construction is easy.	Construction is difficult.
3	Disturbances occurring in the process are not controllable.	Disturbances do not affect the process, they get control automatically.
4	It is more stable and accurate system.	It is less stable and not so accurate.
5	Response is slow and cost is less.	Response is fast and cost is more.

4. A) Attempt any three:

a) Draw neat constructional details of resistance thermometer and explain its working.

Ans. Resistance thermometer or Resistance temperature detector works on the principle of positive temperature coefficient of resistance. i.e. as temperature increases resistance by the thermometer also increases. Various methods are employed for construction of Resistance thermometer depending on the application.

The Resistance thermometers are available in a variety of sizes, shapes, materials, insulations and winding types. The resistance of wire is given at t^0c is given by

$R_t=R_0*(1+\alpha_0 t)$ where R_t = Resistance at t^0c, R_0 = Resistance at 0^0c, α_0 = Resistance temperature coefficient, t = change in temperature.

In Resistance thermometer the temperature sensitive material is fabricated in a suitable form. The changes in resistance caused by the changes in temperature are detected by the wheatstone bridge. Thus the temperature sensing element which may be of nickel, copper or platinum contained in a bulb or well along with the balancing bridge form essential components of the temperature measuring system based upon this principle.

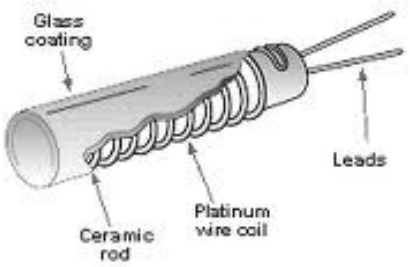


Fig. Platinum resistance thermometer (2+2)

b) Write construction and working of eddy current dynamometer with neat sketch. (2+2)

Ans. Eddy current dynamometer it is the type of absorption type dynamometer. It consists of non magnetic rotor, which moves in the magnetic field of stator. The stator winding is excited by a D.C. supply. When the solid rotor moves in the field produced by stator windings an emf is produced in it resulting in a large loss of power due to eddy current. This power is dissipated as heat in the rotor and therefore water is circulated through air gap between stator and rotor. Torque on the stator casing may be measured in the usual manner.

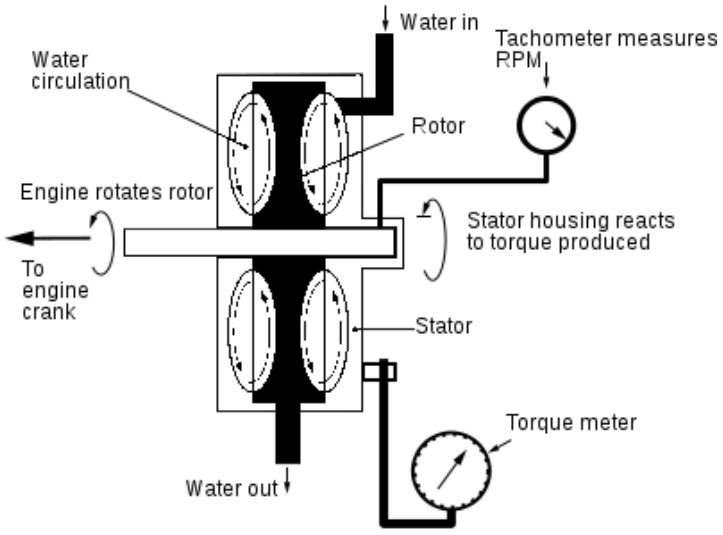


Fig. Eddy current dynamometer

c) Explain with neat sketch liquid in glass thermometer. (2+2)

Ans. These are suitable only at those places where readings can be taken on the equipment or pipe itself, and usually used up to 100^0c. It consist of a glass bulb joined to a length of round glass tubing having a capillary bore of oval-shaped section. Generally a high grade glass properly aged and annealed is used. The bulb is filled with mercury, and with rise of temperature both mercury and glass expand the former expanding eight times than glass and thus the length

of mercury column in the glass tube is related to the temperature applied. For construction of of tube, the glass mixed with white enamel at the manufacturing stage is used. The range of the thermometer depends on the capacity of the bulb and the bore of the tube. A large bulb has a smaller range. It is possible to vary the range to cover a particular zone of temperature by means of a cavity located just above the bulb so that the expanding liquid first fills this cavity, and then commences to rise in the calibrated stem.

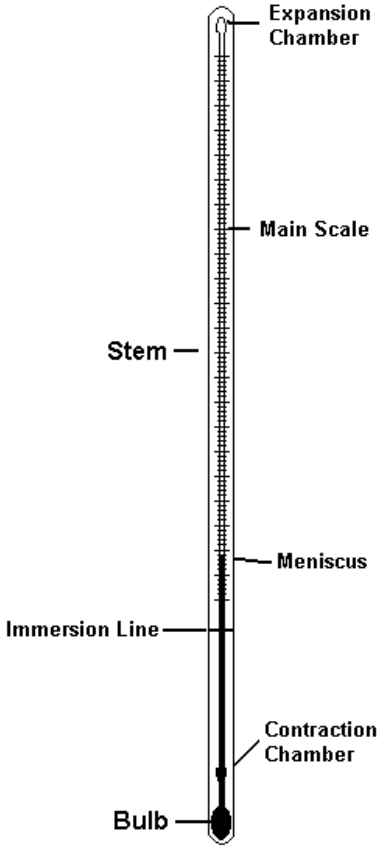


Fig. **liquid in glass thermometer**

d) Draw neat sketch of 'Rotameter' and state its advantages and disadvantages. (2+1+1)

Ans.

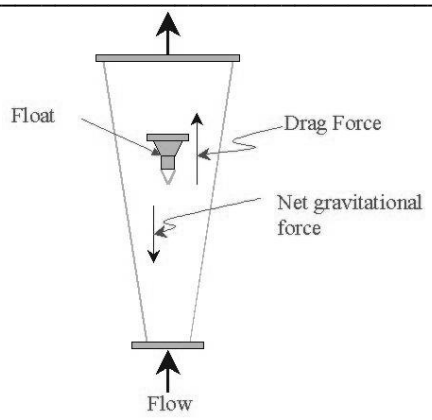


Fig. Rotameter

Advantages: 1) Pressure loss is nearly constant and small.

2) It can handle any corrosive fluid.

3) Good accuracy.

Disadvantages: 1) It must be installed in vertical position only.

2) For high pressure & temperature it is expensive.

3) It cannot be used for large amount of solid contents.

B) Attempt any one:

a) Write construction, working, advantages and disadvantages of slipping clutch tachometer. (2+2+2)

Ans. Construction & working: In this type Clutch is used to connect the driving shaft with indicating shaft. Pointer attached to indicator shaft moves over calibrated scale.

Advantages:- i) Simple to operate, ii) simple in construction, iii) used to measure shaft speed.

Disadvantages: i) it is limited to low speed, ii) more chances of error occurrence; iii) it gives average speed, instead of instantaneous speed.

b) Draw neat sketch of 'Radiation pyrometer' and explain how it is used for measurement of temperature. (3+3)

Ans.

The radiation pyrometer is designed to collect the radiations from the radiating object and focus it by means of mirrors or lens on to a detector. The emf output of which is fed to a millivolt-meter or potentiometer for measurement purposes. The pyrometer consists of a blackened tube T open at one end to receive radiations from the temperature is desired. The other end of the tube

carries the sighting hole E which is essentially an adjustable eye piece. The mirror is centrally fixed to allow light to reach the eyepiece. There are two small semicircular flat mirrors provided which are inclined at a slight angle from the vertical plane. The resulting hole is smaller than the target.

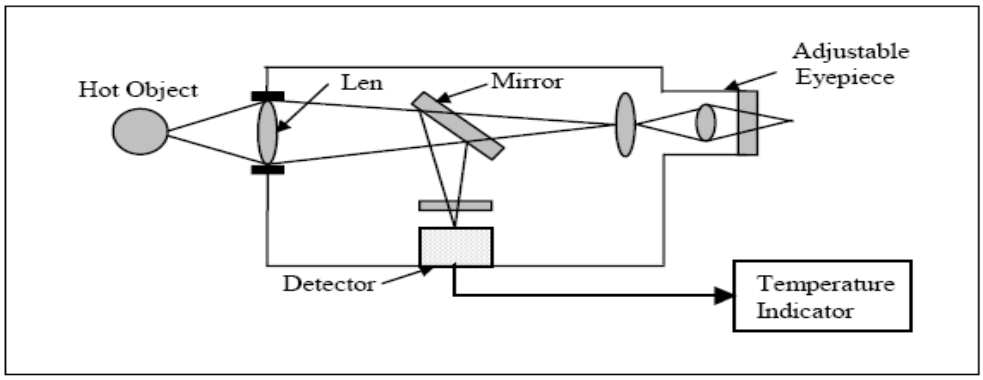
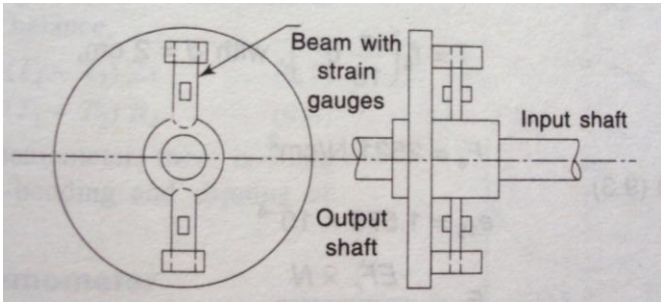


Fig. Radiation Pyrometer

Q. 5. Attempt any FOUR

a) Strain gauge transmission dynamometer (Fig. 2m & Explanation 2m)



The principle involved in transmission dynamometer is that the power being transmitted either to or from the dynamometer is not absorbed or dissipated. The power after measurement is available in useful mechanical or electrical means. However, a small power is dissipated on account of friction.

Strain gauge transmission dynamometer is used to measure bending strains rather than strains due to torque at 45^0 and so an arrangement using beams (as shown in fig.) may be employed, in which the transmitted torque results in bending the beams.

b) Types of thermistor – (Fig. 2m & Explanation 2m)

i) NTC (Negative Temperature Coefficient)

ii) PTC (Positive Temperature Coefficient)

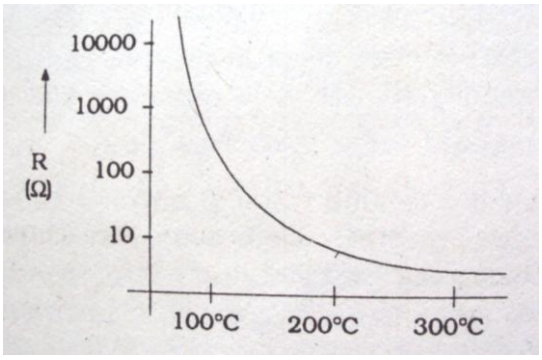


Fig. NTC Type

In NTC type, as the temperature increases their resistance decreases. They are made of oxides of manganese, nickel, cobalt, uranium which are milled in proper proportions with binders, pressed into the desired shape and sintered. Resistance variation with temperature is shown in fig. The change is non linear. They are available in values ranging from few ohms to mega ohms.

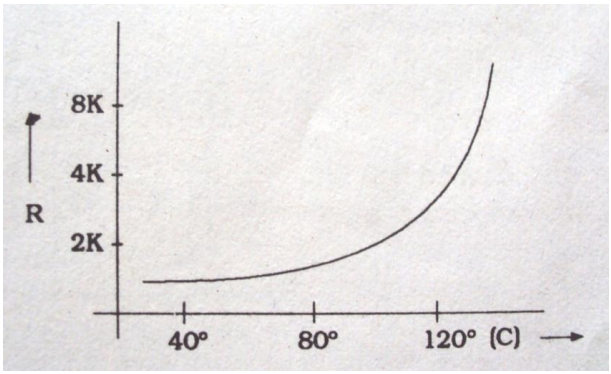


Fig. PTC type

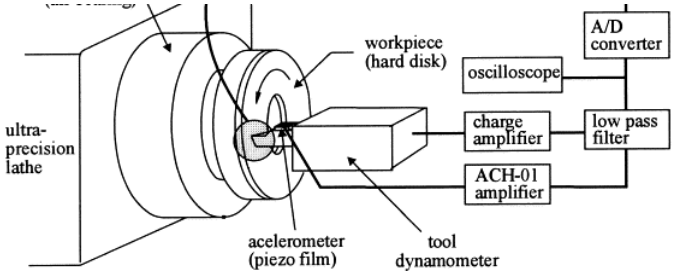
In PTC type, they are positive i.e. their resistance increases with temperature as shown in below fig. They are manufactured by sintering barium and strontium titanate mixtures. They are used as a device to protect all kinds of electrical apparatus against overheating.

c) Difference between Orifice plate and venturimeter (Any four points)

Sr. No.	Orifice Plate	Venturimeter
1	It is a thin plate of metal circular in shape used to measure flow.	It is the tube used along with convergent and divergent pipe used to measure flow.

2	It is made up of steel. Monel, phosphor bronze.	It is made up of cast iron or steel.
3	It is inexpensive compared to venturimeter	It is not so inexpensive
4	Pressure recovery is poor	Pressure recovery is good
5	It requires less space	It required more space
6	It can be utilized for measurement of extremely large water flow rates	It can be utilized for measurement of extremely small water flow rates

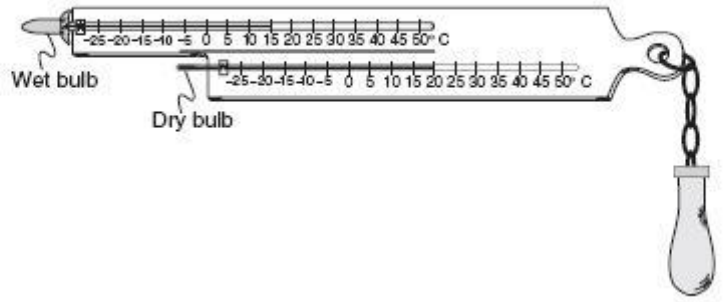
d) Tool Dynamometer **(Fig. 2m & Explanation 2m)**



A tool dynamometer is a multi-component dynamometer that is used to measure forces during the use of the machine tool. Empirical calculations of these forces can be cross-checked and verified experimentally using these machine tool dynamometers.

With advancement of technology, machine tool dynamometers are increasingly used for accurate measurement of forces and for optimization of the machining process. These multi-component forces are measured as an individual component force in each co-ordinate, depending on the co-ordinate system used. The forces during machining are dependent on depth of cut, feed rate, cutting speed, tool material and geometry, material of the work piece and other factors such as use of lubrication/cooling during machining.

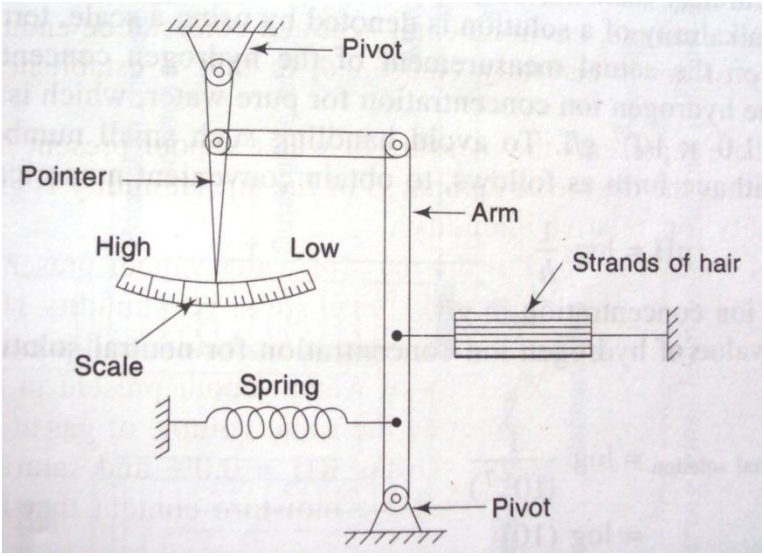
e) Sling Psychrometer **(Fig. 2m & Explanation 2m)**



A Sling psychrometer in which the wet- and dry-bulb thermometers are mounted upon a frame connected to a handle at one end by means of a bearing or a length of chain; the psychrometer may be whirled in the air for the simultaneous measurement of wet- and dry-bulb temperatures.

f) Hair hygrometer (Fig. 2m & Explanation 2m)

Certain materials such as human hair, animal membranes, wood and proper undergo changes in linear dimensions when they absorb moisture from the atmosphere. Human hair becomes longer



as the humidity of the surrounding air increases, and shortens when the air becomes drier. This property of hair can be used to operate a pointer or recording pen through a system of mechanical linkage. The indicator scale can be calibrated to give a direct indication of the humidity. Fig. illustrates the schematic diagram of hair hygrometer. The transducer element consists of strands of hair to give it increased mechanical strength. The air strands are generally

arranged parallel to each other with sufficient space between them for giving free access to the air sample under test. Further, for proper functioning, the element is maintained under light tension by a spring.

Q. 6. Attempt any FOUR

a) Optical pyrometer (Fig. 2m & Explanation 2m)

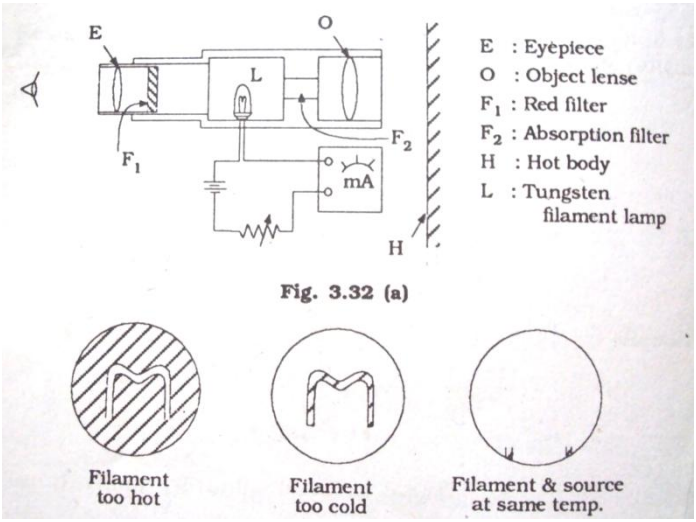
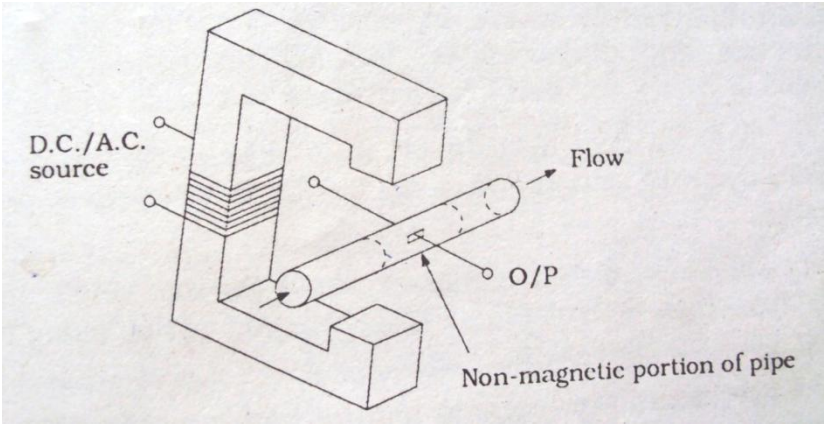


Fig. 3.32 (a)

Radiant energy has wavelengths in the optical part of the spectrum. Optical pyrometer makes use of a single wavelength or very narrow band of wavelengths for measuring the temperature of a hot body. They use a method of matching as the basis for their operation. In general, a reference temperature is provided in the form of an electrically heated lamp filament and a measure of temperature is obtained by optically comparing visual radiation from the filament with that from unknown source. For this purpose two methods are used (1) Variable intensity comparison lamp method as shown in fig. (2) Constant intensity comparison lamp method.

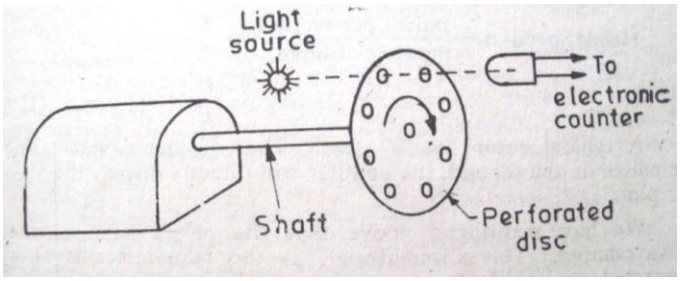
b) Electromagnetic flow meter (Fig. 2m and advantages 2 m)



Advantages:

1. No obstruction is created to flow
2. No drop in fluid pressure
3. Ability to measure reverses flow
4. Provides wide linear range
5. Gives rapid response to flow changes
6. Provides zero output for nonflow condition

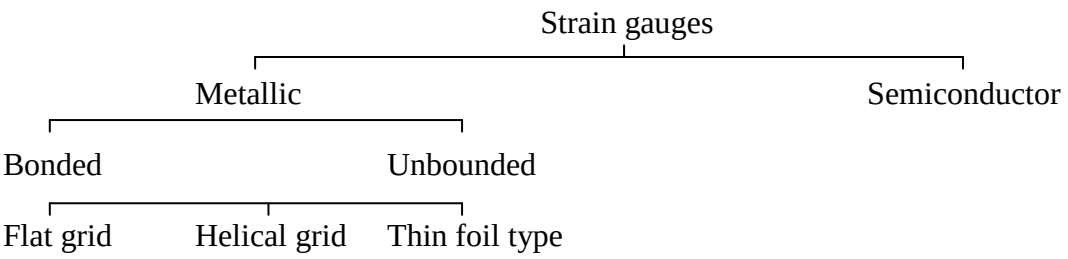
c) Photoelectric tachometer **(Fig. 2m & Explanation 2m)**



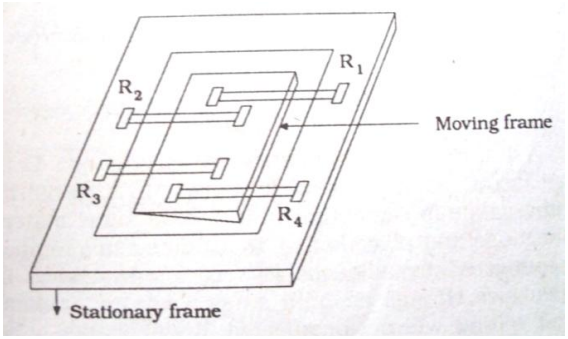
This method of measuring speed of rotation consists of mounting an opaque disc on the rotating shaft as shown in fig. The disc has a number of equidistant holes on its periphery. At one side of the disc a light source is fixed and at the other side of the disc and in line with the light sources, a light sensor such as a photo tube or some photosensitive semi-conducting device is placed. When the opaque portion of the disc is between the light source and the light sensor the latter is illuminated and produces no output. But when a hole appears between the two light falling upon the sensor produces an output pulse.

d) Strain gauges **(Types 1m & Unbounded 3m)**

Types of strain gauges-



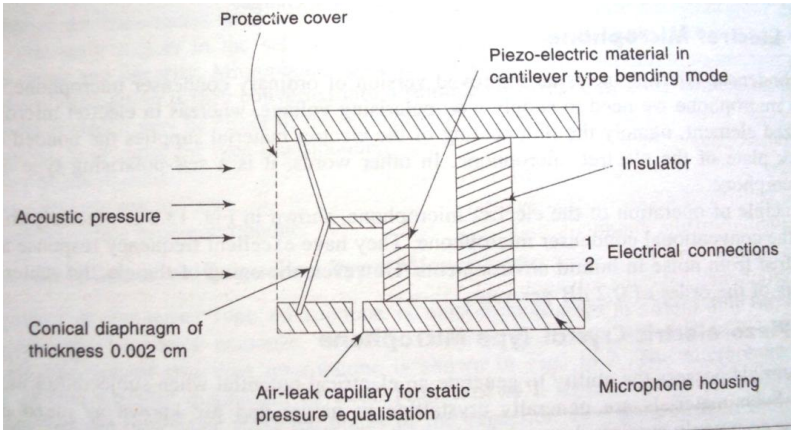
Unbounded strain gauge



It consists of 4 resistance wires wound so that they are in tension. The arrangement consists of two members. One is moving member and the other is a fixed member. The one type of construction is shown in fig. Resistance wires R1, R2, R3 and R4 are connected in bridge form. When load id not applied bridge is balanced and its output voltage is zero. When load is applied, bridge gets unbalanced and output voltage results.

e) Piezo-electric crystal transducer (Fig. 2m and explanation 2 m)

Certain materials possess the ability to generate an electrical potential when subjected to mechanical strain. Such materials are generally crystalline in nature and are known as piezo-electric crystals. For the greatest sensitivity, a cantilever type of crystal element is mechanically



coupled with the sensing diaphragm as shown in fig. Further other constructions employ direct contact between the diaphragm and the crystal element either by cementing or by direct contact. Piezo-electric crystal transducers are very sensitive and can measure accurately sound pressure levels below 24 dB. Further, their response at lower frequencies is also very good. In addition, they require impedance matching and are also sensitive to variations.

------XXX------