MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

Summer-13 EXAMINATION

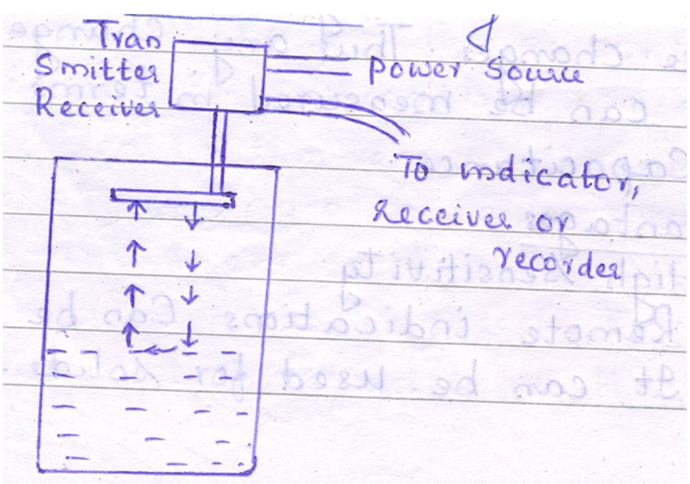
Model Answer

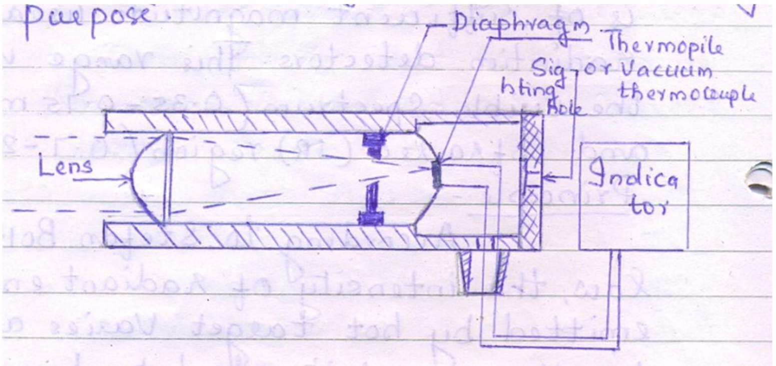
Subject code:CIP(12208)

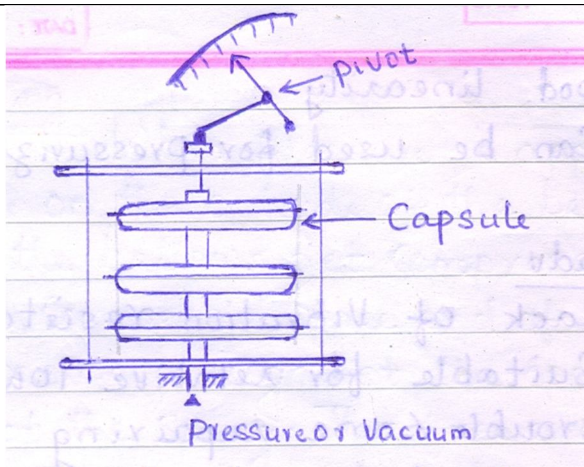
Important instructions to examiners :

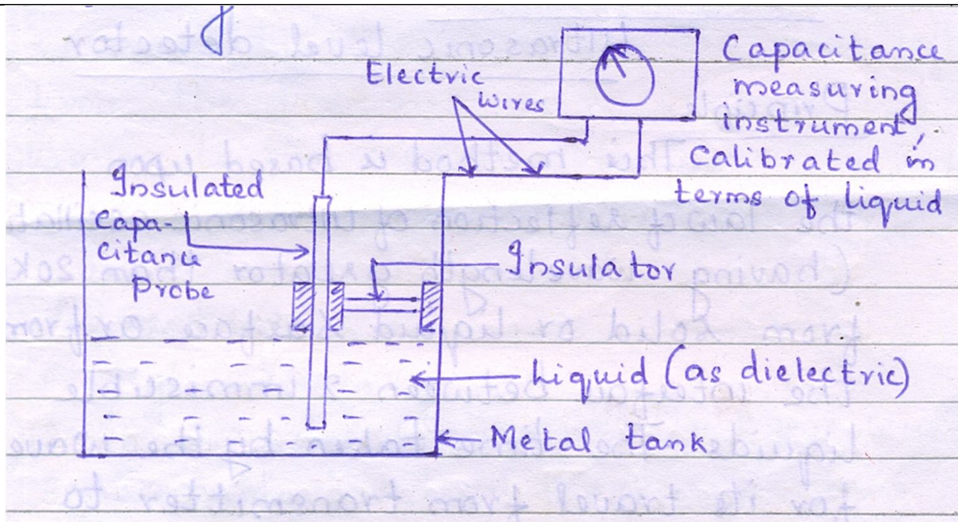
1. The answers should be examined by keywords and not as word to word as given in the model answer scheme.
2. The model answer and the answer written by candidate may vary, but the examiner may try to assess the understanding level of the candidate.
3. The language errors such as grammatical, spelling errors should not given more importance.
4. While assessing figures, examiner may give credit for principal components indicated in a 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 answer and model answer.
6. In case of some questions credit may be given by judgment of relevant answer based on candidates understanding.

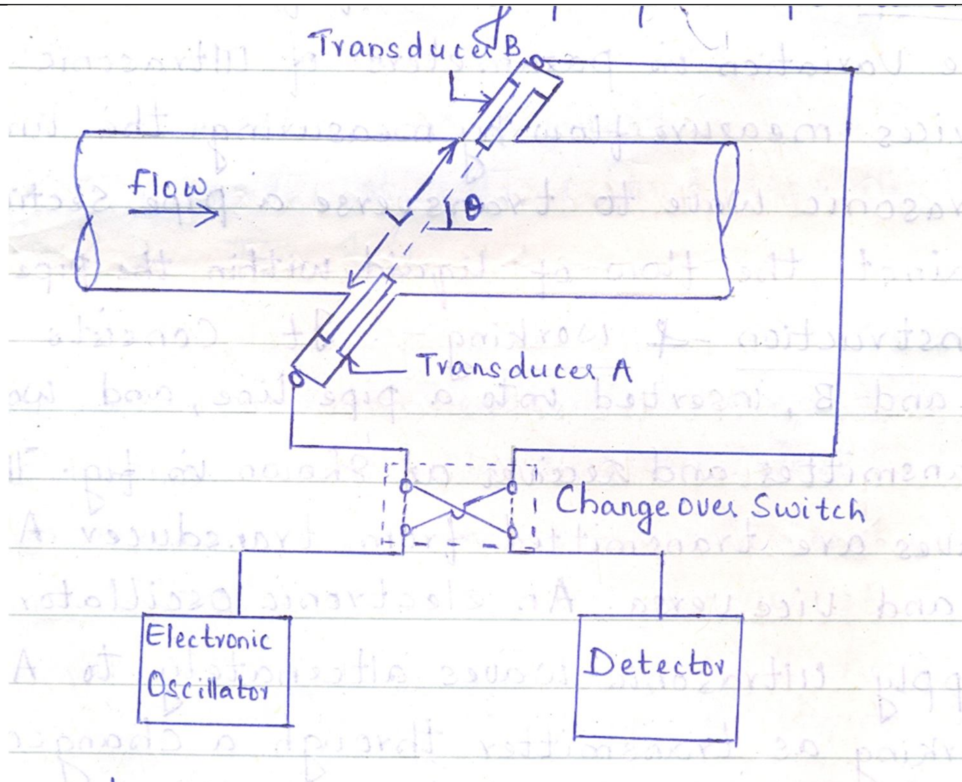
Q no:	Answer	mark	Total marks
1A a	**Four static characteristics** Accuracy: It is the instruments ability to indicate or record the true value of the variable being measured Reproducibility: It is the degree of closeness with which a given value may be repeatedly measured ,over a period of time approaching from both directions Sensitivity: It denotes the smallest change in the value of measured variable to which an instrument responds : that is the instrument has a dead zone Precision : It is the degree of exactness for which an instrument is	1 mark each for any four points	4

	designed to perform Resolution: It is the least incremental value of input or output that can be detected , caused or discriminated by the measuring device. Calibration: it is defined as the process for the determination, by measurement or comparison with a standard of the correct value of each scale reading Repeatability: It is_defined as the closeness of_ agreement among a number of consecutive measurements of the output for the same value of input under same operating conditions		
b.	**Material of construction for RTD** Platinum, nickel or nickel alloys are the commonly used. Gold, copper, silver , tungsten are rarely used **Principle of RTD :** Electrical resistance of the substance(conductor) changes with temperature	2 2	4
c.	**Advantages of inclined leg manometer :** 1. To measure very small pressure differences. 2. High sensitivity 3. Easy to read 4. Large reading in the inclined leg can be obtained even for very small pressure difference.	1 mark each	4
d.	**Ultrasonic level detector** **Diagram:** 	2	4

	Advantages: 1. High accuracy 2. It provides continuous level measurement 3. Suitable for level measurement in liquid and solid	2	
1 B a	**<u>Radiation pyrometer</u>**		6
	Diagram: 	2	
	Construction: It consists of a lens, diaphragm, radiation receiving element, sighting hole and recorder or indicator.	1	
	Working: Radiation of all possible wave lengths from a hot body is focused by the lens on the radiation receiving element.When thermopile or vacuum thermocouple is used as radiation receiving element, the radiant energy from the target is focused in blackened measuring junction. Due to absorption of radiant energy, the measuring junction temperature rises. According to Seebeck effect, emf is developed between output leads which is proportional to temperature difference between measuring and reference junction. The emf developed is calibrated in terms of target temperature by using either a voltmeter or Wheatstone bridge circuit	3	
1.B b.	**<u>Pressure measurement below atmosphere:</u>**		6
	Devices used are McLeod gauge or capsule gauge.	1	
	Capsule Gauge:		
	Diagram:	2	

	 **Description:** A capsule is formed by welding or soldering of two diaphragms at their periphery. Number of such capsules are arranged in the stack. Pointer mechanism is connected to topmost capsule that represents pressure on calibrated scale. When pressure inside the first capsule changes, the free end of the last capsule in the stack gets deflected. This deflection depends on the diameter of the capsule, thickness of the material, elasticity of the diaphragm material, shape and number of corrugations on the diaphragm. ***(Marks may be given for diagram and explanation for McLeord gauge in the same distribution format)***	3	
2a	<u>**Measurement of solid level :**</u> **Capacitance level detector** **Diagram**	2	8

	 **Principle :** The electrical capacitance of sensing probe changes with level of material and hence level changes can be recorded in terms of changes in electrical capacitance of the sensing probe . **Construction :** It consists of two conductors separated from each other by dielectric material between them. There is an insulated capacitance probe fixed near and parallel to tank wall such that the probe and metal tank wall acts as conductors with conducting liquidas the dielectric medium. These two conductors are connected to capacitance detecting element **Working** As the solid level changes, the dielectric constant changes due to which capacitance changes. Thus any change in solid level can be measured in terms of change in capacitance. . ***(Marks may be given for ultrasonic method or radiation method in the same distribution format)***	2 2 2	
2.b	**Ultrasonic flow meter** : **Diagram** :	2	8



2

Principle :

Measurement of flow rate is determine by the variation in parameters of ultrasonic oscillations. These devices measure flow by measuring the time taken for ultrasonic wave to transverse a pipe section , both with and against the flow of liquid within the pipe.

4

Working :

It consist of two transducers , A and B , inserted into a pipe line, and working both as transmitter and receiver. The ultrasonic waves are transmitted from transducer A to transducer B and vice versa. An electronic oscillator is connected to supply ultrasonic waves alternately to A or B which is working as transmitter through a change over switch , when the detector is connected simultaneously to B or A which is working as receiver. The detector measure the transit time from upstream to downstream transducer and vice versa.

The time T_{AB} for ultrasonic wave to travel from transducer A to transducer B is given by $T_{AB} = L/(C+V\cos\theta)$

The time T_{BA} for ultrasonic wave to travel from transducer B to transducer A is given by $T_{BA} = L/(C-V\cos\theta)$ Where

L – Acoustic path length between A & B

C – Velocity of sound in fluid.

θ – Angle of path with respect to pipe axis.

V – Velocity of fluid in pipe.

$V = \Delta TC/2LCos\theta$ where $\Delta T = T_{BA} - T_{AB}$

Since this type of flow meter relies upon an ultrasonic signal traversing across the pipe, the liquid must be relatively free of solids and air bubbles.

2.c **Differentiation between electronic controllers and pneumatic controllers**. — 1 mark for each point — 8

Property	Pneumatic Controller	Electronic Controller
Initial Cost	Low	High
Design	Simple	Complex
Start up period	Short	Long

<table>
<tr><td></td><td><table>
<tr><td>Accuracy</td><td>Low</td><td>High</td></tr>
<tr><td>Speed of response</td><td>Fast</td><td>Slow</td></tr>
<tr><td>Maintenance</td><td>Less</td><td>More</td></tr>
<tr><td>Environment</td><td>Can be installed in Hazardous environment</td><td>Installation in Hazardous area require proper housing</td></tr>
<tr><td>Compatibility</td><td>Air signal is more compatible with control valves.</td><td>Electronics signal is less compatible and requires additional hardware .</td></tr>
</table></td><td></td><td></td></tr>
<tr><td>3.a</td><td>a) Thermistors are also called thermal resistor. They are semiconductors made from mixture of pure specific mixture of pure oxides of nickel, manganese, copper etc
NTC means Negative Temperature Coefficient where as the temperature increases resistance of thermistor decreases
PTC means Positive Temperature Coefficient where as the temperature increases resistance of thermistor increases)

Diagram</td><td>1 mark

1

1

1</td><td>4</td></tr>
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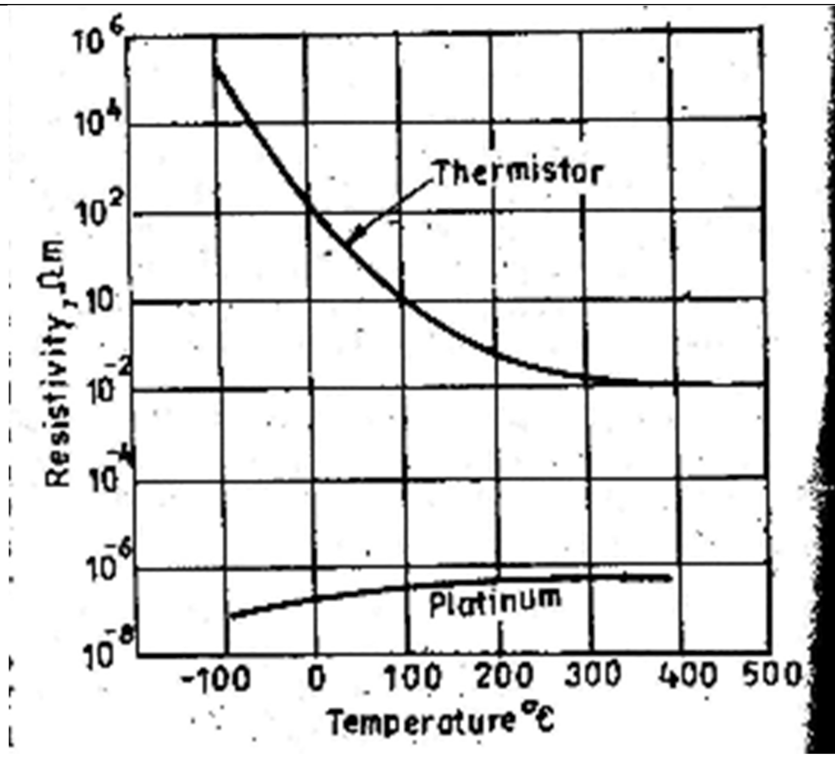
			
3.b	**List of Various gauges used for differential pressure measurement are** 1.Manometer 2.Micromanometers 3.Bellows 4.Diaphragm **List of Various gauges used for vacuum measurement are** 1.Mcleod gauge 2. Pirani gauge 3. Thermocouple gauge 4.Capsule gauges	½ mark each ½ mark each	4
3.c			4

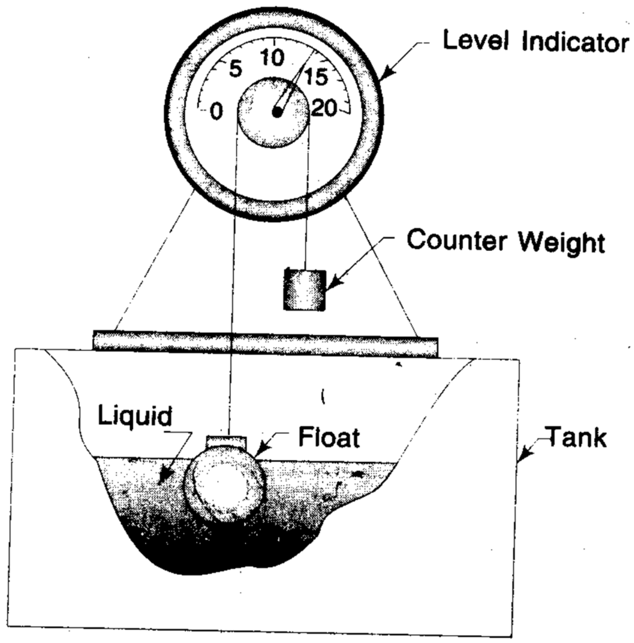
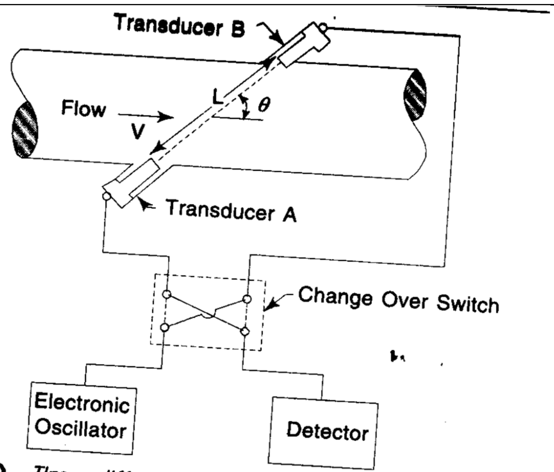


Fig. 7.5 *Float-operated Liquid Level Indicator.* 2

Float operated level indicator is used to measure liquid levels in a tank in which a float rests on the surface of liquid and follows the changing level of liquid. The movement of the float is transmitted to a pointer through a suitable mechanism which indicates the level on a calibrated scale. Various types of floats are used such as hollow metal spheres, cylindrical-shaped floats and disc-shaped floats. 2

Construction and Working Figure shows the simplest form of float operated mechanism for the continuous liquid level measurement. In this case, the movement of the float is transmitted to the pointer by stainless steel or phosphor-bronze flexible cable wound around a pulley, and the pointer indicates liquid level in the tank. The float is made of corrosion resisting material (such as stainless steel) and rests on liquid level surface between two grids to avoid error due to turbulence. With this type' of instrument, liquid level from 4 ft. (152 mm) to 60, ft. (1.52 m) can be easily measured.

3.d	 **Fig. 8.20(a)** *Time-difference Type Ultrasonic Flowmeter.* In ultrasonic flowmeters, the measurement of flow rate is determined by the variation in parameters of ultrasonic oscillations. **Time Difference Type** These devices measure flow by measuring the time taken for ultrasonic wave to transverse a pipe section, both with and against the flow of liquid within the pipe. It consists of two transducers, A and B, inserted into a pipe line, and working both as transmitter and receiver, as shown in Fig.. The ultrasonic waves are transmitted from transducer A to transducer B and vice versa. An electronic oscillator is connected to supply ultrasonic waves alternately to A or B which is working as transmitter through a changeover switch, when the detector is connected simultaneously to B or A which is working as receiver. The detector measures the transit time from upstream to downstream transducers and vice versa. The time TAB for ultrasonic wave to travel from transducer A to transducer B is given by the expression:	2 2	4

	$$T_{AB} = \frac{L}{(C + V\cos\theta)}$$ and, the time (T_{BA}) to travel from B to A is given as, $$T_{BA} = \frac{L}{(C - V\cos\theta)}$$ where, L = the acoustic path length between A and B C = velocity of sound in the fluid θ = angle of path with respect to the pipe axis V = velocity of fluid in pipe The time difference between T_{AB} and T_{BA} can be calculated as, $$\Delta T = T_{AB} - T_{BA} = \frac{2LV\cos\theta}{C}$$ $V = \Delta TC/2L\cos\theta$		
3.e	In P mode there is a continuous linear relation between the value of the controlled variable or deviation and the position of the final control element. $m = K_c e$ In proportional controller even if the set point is equal to the process variable there is some output known as offset. Offset can be removed by adding integral controller to P controller. As the integral control mode will continuously increment or decrement the controller's output to make the process variable equal to set point.	2 2	4

<table>
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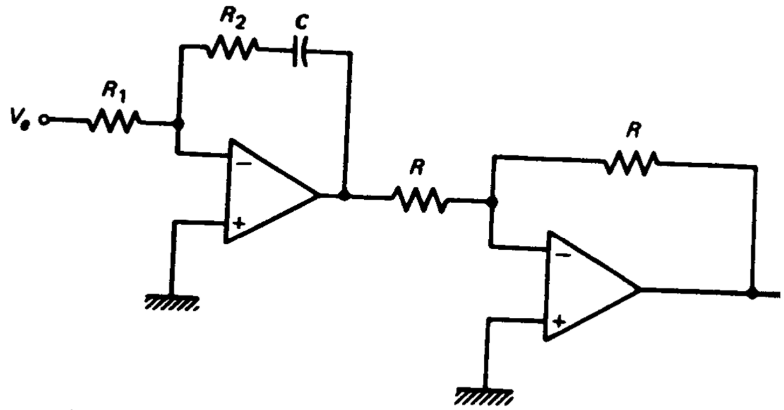
<td>4.A
-a</td>
<td>


FIGURE 10.16
An op amp proportional-integral (PI) mode controller.

$$V_{out} = \left(\frac{R_2}{R_1}\right) V_e + \frac{1}{R_1 C}\int_0^t V_e \, dt$$

PI controller, its controller output is made up of the sum of the proportional and integral control actions using Opamp
Proportional controller output is the proportional control mode, plus a bias. The bias is needed so that the controller can maintain an output (say at 50%) while there is no error (set point = process variable). The use of proportional control alone has a large drawback – offset. Offset is a sustained error that cannot be eliminated by proportional control alone.

The integral control mode will continuously increment or decrement the controller’s output to reduce the error. Given enough time, integral action will drive the controller output far enough to reduce the error to zero.

If the error is large, the integral mode will increment/decrement the
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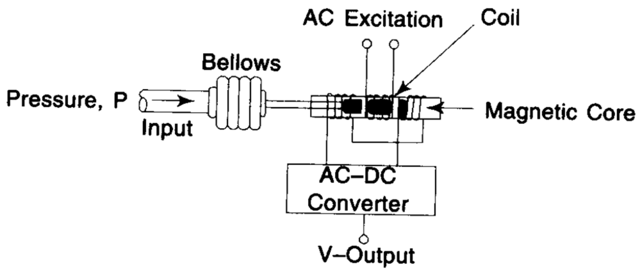
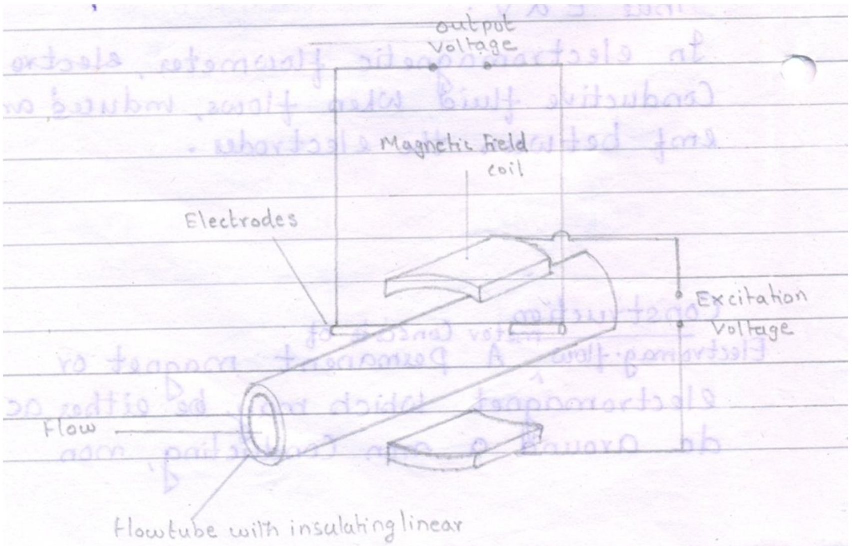
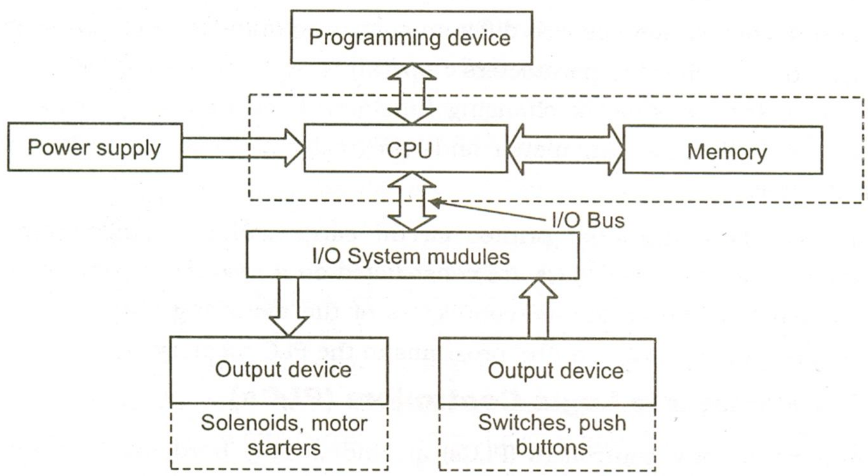
	controller output fast, if the error is small, the changes will be slower. For a given error, the speed of the integral action is set by the controller's integral time setting (T_i). A large value of T_i (long integral time) results in a slow integral action, and a small value of T_i (short integral time) results in a fast integral action.I If the integral time is set too long, the controller will be sluggish, if it is set too short, the control lop will oscillate and become unstable.		
4.A -b	**Control Valve Coefficient**. It is defined as the U.S gallons per minute of water at 60^0 F that a control valve will pass with 1 psi pressure drop across the valve **Actuator**Pneumatically operated control valve actuators are the most popular type in use, but electric, hydraulic, and manual actuators are also widely used. The spring-and-diaphragm pneumatic actuator is most commonly type also called as linear actuator. It consist of a diaphragm with the input pressure from the controller on one side and atmospheric pressure on the other side. The diaphragm is usually made of rubber which is sandwiched in its center between two circular steel disc. Spring is used for providing the restoring force **Valve Positioner** The function of valve positioner is to sense both the instrument signal and the valve position and from these measurement ensure that the valve position is directly proportional to its controller output signal Positioner is mounted on the control valve to be able to measure the stem position.	1 1.5 1.5	4

4.A -c	 **Fig. 9.24** *Linear Variable Differential Transformer (LVDT).* Construction and Working: It consists of a primary winding (or coil) and two secondary windings (or coils). The windings are arranged concentrically next to each other. They are wound over a hollow bobbin which is usually of a non-magnetic and insulating material. A ferromagnetic core (armature) is attached to the transducer sensing, shaft (such as bellows). The core is generally made of a high permeability ferromagnetic alloy and has the shape of a rod or cylinder. A.C. excitation is applied across the primary winding and the movable core varies the coupling between it and the two secondary windings. When the core is in the centre position, the coupling to the secondary coils is equal. As the core moves away from the centre position, the coupling to one secondary, and hence its output voltage, increases while the coupling and the output voltage of the other secondary decreases. Any change in pressure makes the bellows expand or contract. This motion moves the magnetic core inside the hollow portion of the bobbin. It causes the voltage of one secondary winding to increase, while simultaneously reducing the voltage in the other secondary winding. The difference of the two voltages appears across the output terminals of the transducers and gives a measure of the physical position of the core and hence the pressure.	2 2	4

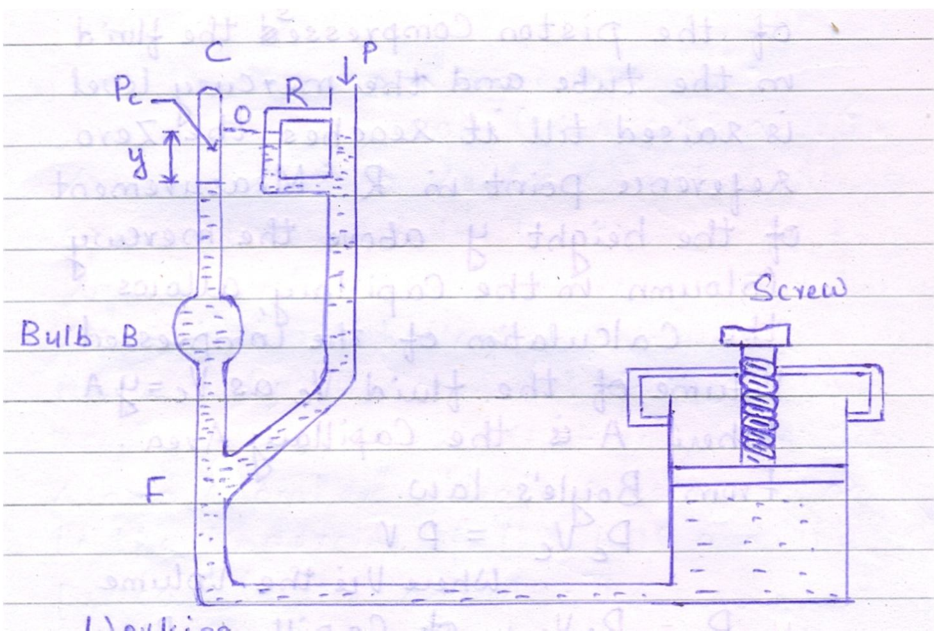
4.A -d	An optical pyrometer consists of an incandescent lamp filament which is used as the reference source of radiation. The filament is heated by a 2 volts battery in series with a rheostat by which the temperature of the filament is adjusted. This filaments is connected in one arm of a wheat-stone bridge circuit across which is connected a moving coil galvanometer. On rotating the Rheostat the temperature of the filament is progressively increased until the visible radiation matches that of the hot object. At this stage the tip of the filament becomes invisible and the temperature is read from the galvanometer. Optical Tungsten Ribbon Filament Strip Lamps are used to calibrate Optical pyrometers.	3 1	4
4.B -a	The basic 4 control action are 1. On-Off or Two position control action $M=M_1$ for $e>0$ $M=M_2$ for $e<0$ 2. Proportional (P)controller $m=K_P e$ 3.Integral (I)or reset action $m = \frac{1}{T_i}\int_0^t e\,dt$ 4. Derivative (D)or Rate controller $m=T_d\ de/dt$ The derivative mode cannot, by itself, control a process. One reason for this is that a constant deviation from the set point makes the above expression equal to zero. As well, if a sudden change in the process variable occurs, an infinite signal is sent to the controller, which causes the relevant mechanical apparatus to fully open or close. This leads to an unending instability.	1 mark each 2	6

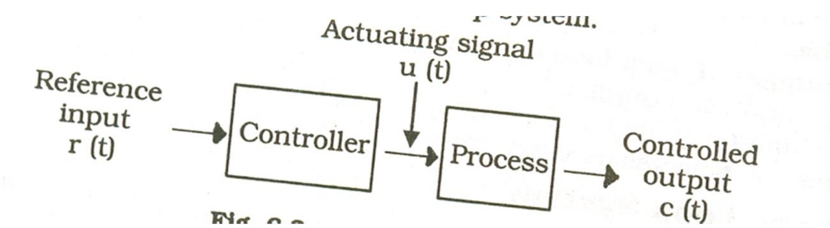
4.B -b	The selection criteria for control valve are presented below. 1. The first step in control valve selection involves collecting all relevant data and completing the ISA Form S20.50. The piping size must be set prior to valve sizing, and determining the supply pressure may require specifying a pump 2. The size of the valve is required; select the smallest valve C_v that satisfies the maximum C_v requirement at 90% opening. While performing these calculations, checks should be made regarding flashing, cavitation, sonic flow and Reynolds number to ensure that the proper equation and correction factors are used. As many difficulties occur due to oversized valves as to undersized valves. Adding lots of "safety factors" will result in a valve that is nearly closed during normal operation and has poor rangeability. 3. The trim characteristic is selected to provide good performance; goals are usually linear control loop behavior along with acceptable rangeability. 4. The valve body can be selected. The valve size is either equal to the pipe size or slightly less, for example, a 3-inch pipe with a 2-inch globe valve body. When the valve size is smaller than the process piping, an inlet reducer and outlet expander are required to make connections to the process piping. 5. The actuator is now selected to provide sufficient force to position the stem and plug. 6. Finally, auxiliaries can be added to enhance performance. A booster can be increase the volume of the pneumatic signal for long pneumatic lines and large actuators. A positioner can be applied for slow feedback loops with large valves or valves with high actuator force or friction. A hand wheel is needed if	**1mark each**	6

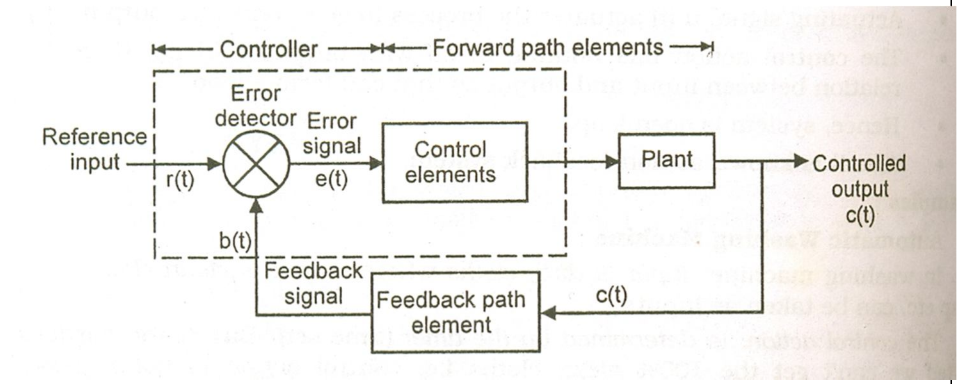
	manual operation of the valve is expected.		
5.a	**<u>Electromagnetic flow meter</u>** **Diagram:** 	2	8
	Principle: Electromagnetic flow meter works on the principle of Faraday's law of electromagnetic induction which states that when a current carrying conductor moves through stationary transverse magnetic field, an emf is induced between the ends of the conductor and this emf. is proportional to relative velocity between the conductor and magnetic field. The induced emf is given by E=Blv where E-emf l-Length of conductor B-Magnetic flux density v-Velocity of conductor	2	
	Construction : It consist of a permanent magnet or electro magnet around a non conducting, non magnetic pipe. It is insulated from flowing fluid. Two electrodes are placed the right angles to the magnetic field. Fluid should flow in the pipe at right angles to the plane of magnetic flux and induced	2	

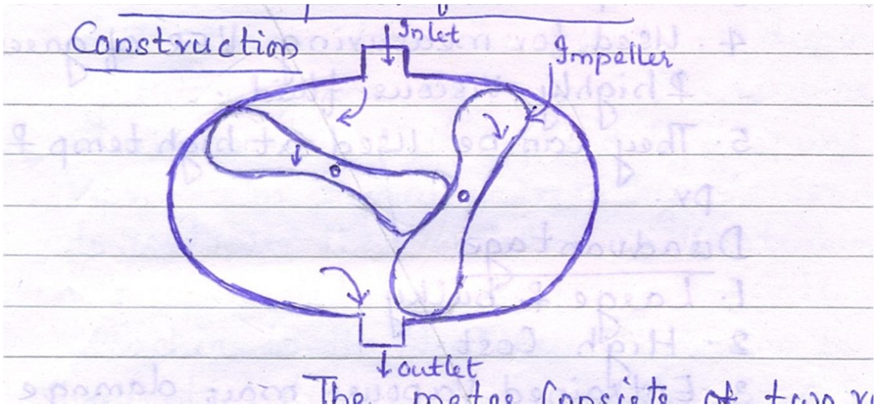
	emf direction along the line joining the electrode. **Working** : As the fluid flows through the pipe, due to magnetic field an emf is induced between the electrodes. The emf induced is proportional to the velocity of fluid. As the flow rate varies , velocity of fluid changes causing the induced emf to change.	2	
5.b	**<u>PLC system</u>** : **Block diagram** :  **Description** : PLCs are industrially hardened micro computers that perform discrete or continuous control functions in a variety of processing plant and factory environments. A PLC architecture consists of the following main units. 1. Power supply : Power supply unit converts power line voltages to those required by the solid state components. 2. Input / Output system : Inputs are real world signals of sensors . These signals can be Analog or Digital , low or high frequency, continuous or momentary Outputs can be of discrete, register and analog. 3. Central Processing Unit (CPU) : It performs the tasks necessary to fulfill the PLC functions such as scanning, I/O bus traffic control , program execution, peripheral and external device	3 5	8

	communications, data handling and self diagnostics. 4. Memory Unit : This is the library where the application program, input data, as well as output data are being stored. 5. Programmer Unit : Programmer unit provides an interface between the PLC and user during program development, start-up and trouble shooting. 6. Peripheral Devices : Peripheral devices are grouped in to categories such as programming aids, operational aids, I/O enhancements and computer interface devices.		
5.c	**<u>Factors to be considered for sizing of control valve</u>** The following factors are considered while deciding the size of a control valve. 1. **Flow rate**: For a fixed flow rate the valve size should not be neither too low or too high. Ideal valve will be the one that will function between 40% and 70% of the full operating range so that for maximum flow, it is not wide open and for minimum flow not closing down too near to its seated position. 2. **Liquid flash point**: when in the down stream side, pressure suddenly drops and the liquid with low flash point may vaporize and expand. In such cases over size valves are normally employed. 3. **Pressure drop across the valve**: if the valve is installed in a long piping then pressure drop across the valve should be estimated at maximum flow with reasonable allowance for pressure losses in series with the valve. 4. **Rangebility and turndown**: Rangebility of the control valve is the ratio of maximum controllable flow to minimum controllable flow. Turndown of a control valve is the ratio of a normal maximum flow to minimum controllable flow. For valve sizing the maximum flow considered should be the required maximum flow and not the full capacity of the valve.	2 marks per each point.	8

6.a	**Application of PLC** : A PLC produces ON/OFF voltage output and can actuate elements such as electric motors, solenoids, fans, heaters, and light switches (Any two) **Application of DCS** : DCSs were originally designed for continuous processes. Now a days DCS has become a powerful integrated control system having capabilities such as data acquisition, advanced process control and batch control capabilities for various industrial environments such as cement factories, oil refineries, power plant.	2 2	4
6.b	**McLeod gauge:** **Diagram:**  **Working:** To operate the gauge, the piston is first withdrawn, causing the level of mercury in the lower part of the gauge to fall below the level of the junction between the two tubes. The unknown pressure source is connected to the gauge from where it also flows and fills the bulb and capillary. Next, the piston is pushed in, moving the mercury level up to	2 2	4

	block the junction. At this stage,, the fluid in the capillary and the bulb is at pressure P. Further movement of the piston compresses the fluid in the tube and the mercury level is raised till it reaches the zero reference point in R. Measurement of the height above the mercury column in the capillary allows the calculation of the compressed volume of the fluid. The expression for calculating the unknown pressure is $P = A\rho g y^2 / V$ Where A is capillary area ρ is density of fluid y is height above the mercury column in capillary		
6.c	**Open- loop and Closed-loop control system** : **Open-loop System** : **Block diagram** :  **Definition** : When the input is independent of the output, the system is called open-loop system. The control action is based on only some predetermined settings.	1 1	4

	Closed-loop Control System : **Block diagram** :  **Definition** : When the input is dependent of the output, the system is called closed-loop control system. The output is continuously measured and fed to the input.	 1 1	
6.d	<u>**Sources of static error in pressure spring thermometer**</u> : The various sources of static error in pressure spring thermometer are as follows : (any four can be considered) 1. Ambient-temperature effect : The ambient-temperature changes at the capillary and at the receiving element of a liquid-expansion thermometer is to cause the instrument to be in error. 2. Head effect : The head effect in a pressure thermometer is caused by placing the thermometer bulb at a considerably higher or lower position than the receiving element. 3. Barometric effect : The barometric effect in a pressure spring thermometer is the error due to barometric pressure changes. 4. Immersion effect : The immersion effect result from conduction of heat along the bulb and thermal well, thereby reducing the temperature at the bulb and causing an error. 5. Radiation effect : Radiation error exist in the measurement on gas and air temperatures because the ability of the thermometer bulb to "see" solid bodies whose temperatures are lower or	One mark for each point	4

	higher than that of the gas.		
6.e	**Lobbed impeller type flow-meter** : (Out-of syllabus) **Diagram** :  **Working** : As rotor rotates, the measuring chamber is formed by the wall of the cylinder and the surface of one half of one rotor. When one of the rotor is in a vertical position, the measuring compartment has certain fixed volume of fluid which gets discharged through the bottom of the meter. This action takes place four times for one revolution. The impeller speed drives the counter that registers total flow over certain time period.	2 2	4