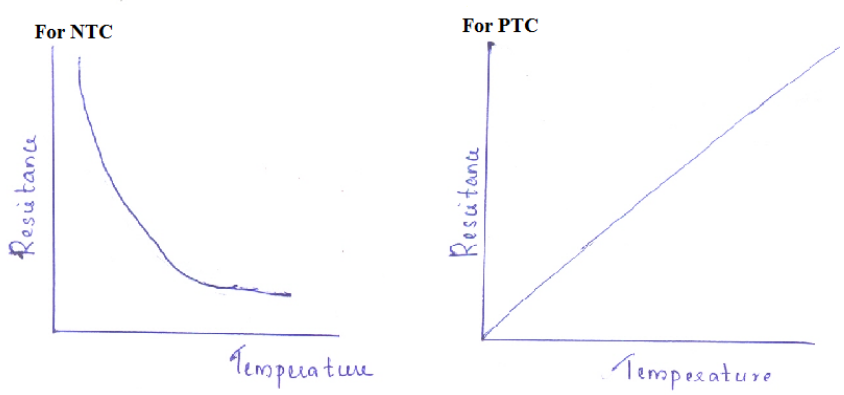
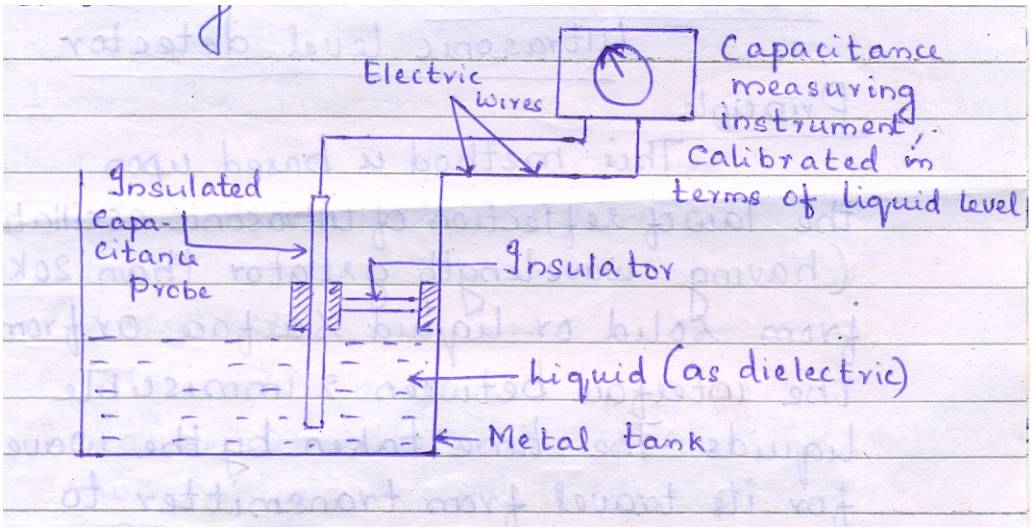
SUMMER-16 EXAMINATION

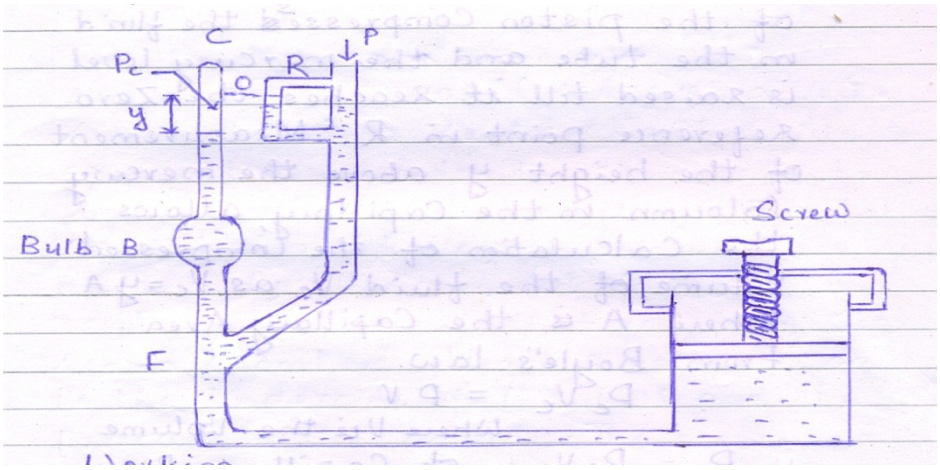
Model Answer

Important Instructions to examiners:

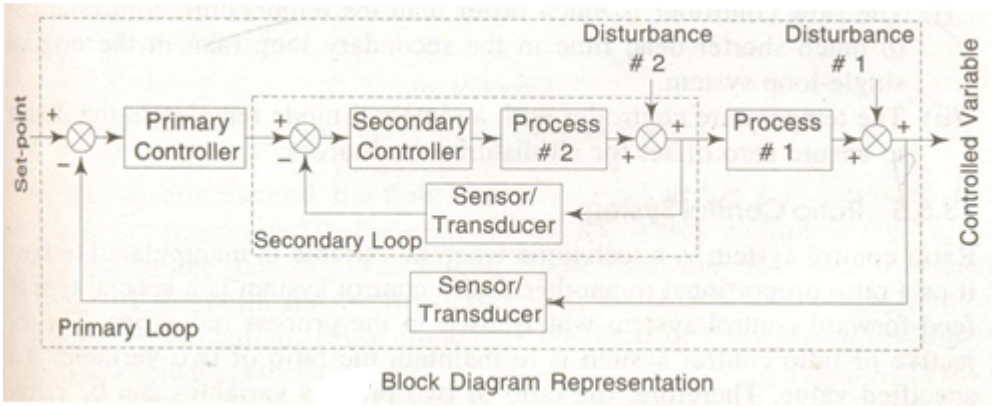
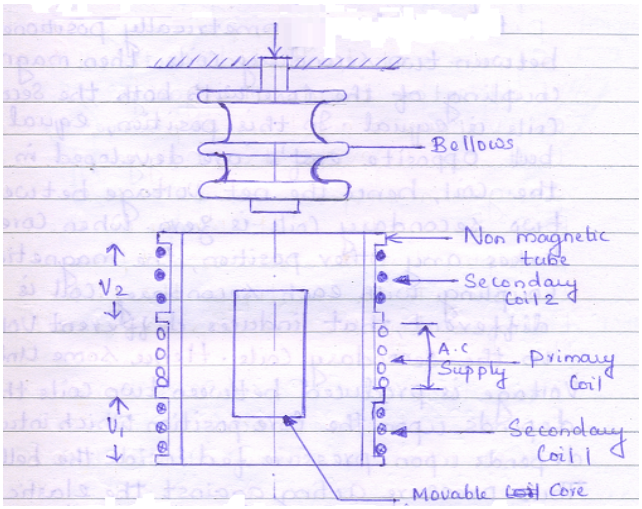
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 No.	Answer	marks	Total marks
1A	**Attempt any three**		**12**
1A-a	**Accuracy:** It is the instruments ability to indicate or record the true value of the variable being measured. **Sensitivity:** It is the smallest change in the value of the measured variable to which an instrument responds.	2 2	4
1A-b	**Thermistor:** 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:** NTC means Negative Temperature Coefficient where as the temperature increases resistance of thermistor decreases. **PTC:** PTC means Positive Temperature Coefficient where as the temperature increases resistance of thermistor increases. **Characteristics:**  	1 1 1 1	4

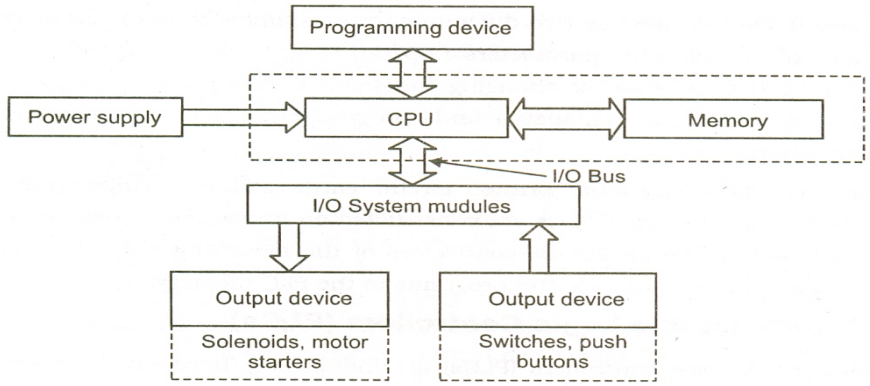
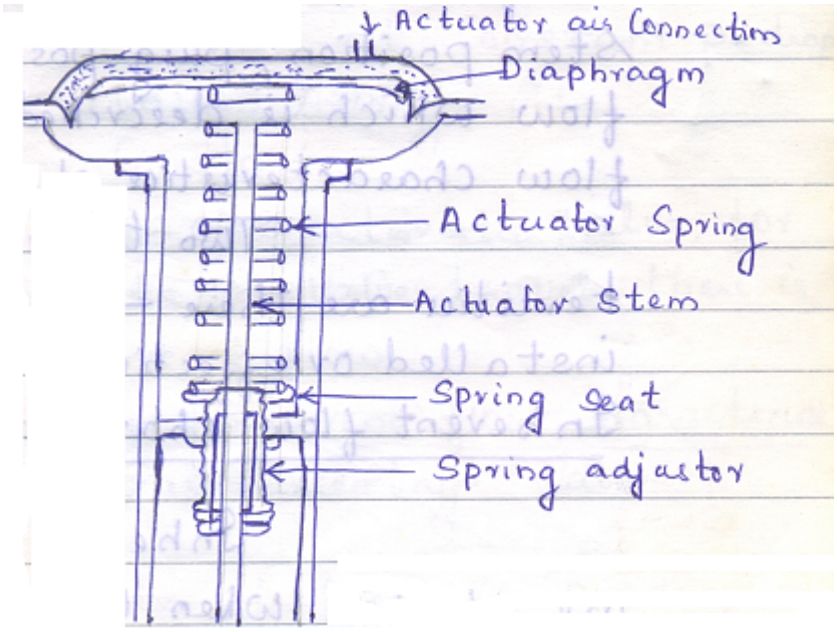
1a-c	**Indirect methods of liquid level measurement:** Pressure gauge, air purge, radioactive, ultrasonic,capacitive **Capacitance level indicator(Diagram)**  	1/2 mark each for any two 3	4
1A-d	**Principle of piston type flowmeter.** Piston flow meter is an eg of variable area meter. In this meter, the size of flow restriction is adjusted by an amount necessary to keep the pressure differential constant when the flow rate changes and the amount of adjustment required is proportional to flow rate.	4	4
1B	**Attempt any one**		**6**
1B-a	**Mcleod gauge:** **Explanation:**The equipment can be visualized as a U tube manometer, sealed at one end. The sealed end contains a capillary and a bulb. The other end contains a piston. 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	3	6

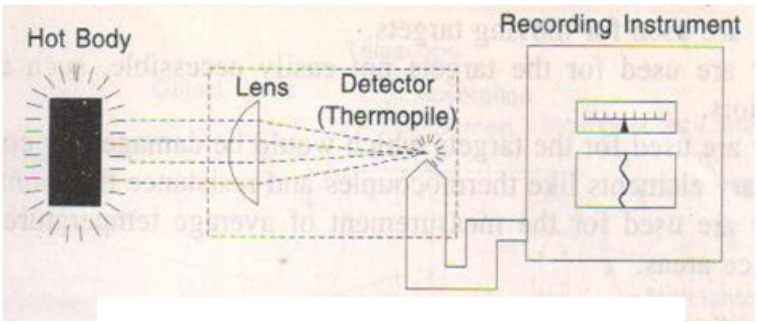
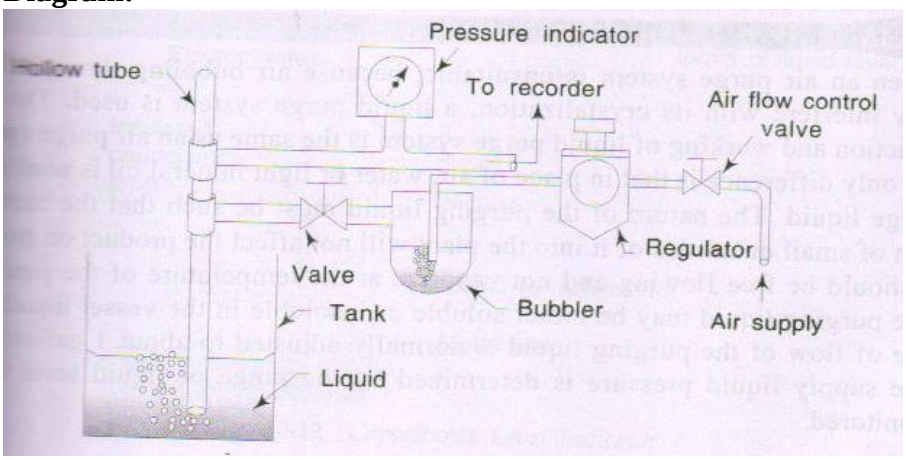
	it also flows and fills the bulb and capillary. Next, the piston is pushed in, moving the mercury level up to block the junction. At this stage,, the fluid in the capillary and the bulb is at pressure P. Further movement of the piston compresses the fluid in the tube and the mercury level is raised till 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 **Diagram:** 	3	
1B-b	**Difference between open loop and closed loop control system.** Sr No. / **Open loop control system** / **Closed loop control system** 1 / Feedback doesn't exists / Feedback exists	1 mark each for any 6 points	6

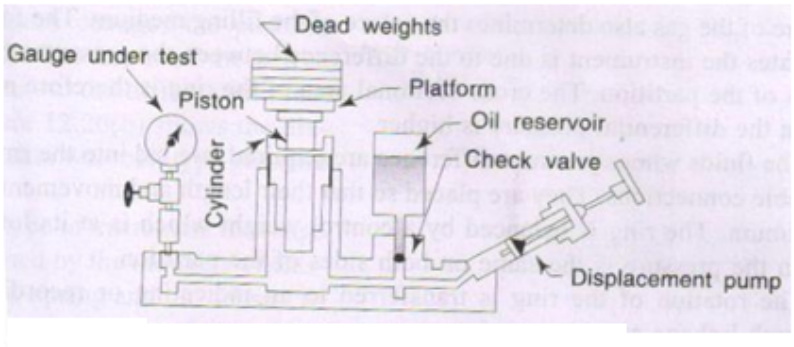
	2	Output measurement is not necessary	Output measurement is necessary		
	3	Any change in output has no effect on input	Changes in output affects the input		
	4	Error detector is absent	Error detector is present		
	5	Inaccurate and unreliable	Highly accurate and reliable		
	6	Highly sensitive to disturbance	Less sensitive to disturbance		
	7	Highly sensitive to environmental changes	Less sensitive to environmental changes		
	8	Simple in construction and cheap	Complicated in construction and hence costly		
	9	Highly affected by non-linearities	Reduced effect of non-linearity		
2	**Attempt any four**				**16**
2-a	**Cascade control system:** **Explanation:** In a cascade control system, there is one manipulated variable and more than one measurement. It employs 2 feedback controllers, with the output of the master (primary) controller changing the set point of the slave (or secondary) controller. It eliminates the effect of disturbances and improves the dynamic response of control loop. The feedback controller attempts to maintain the process variable at its set point in response to all the disturbances and ensures zero steady state offset for step like disturbances. Cascade control system considers the likely disturbances and tune the control system to the disturbances that strongly degrades the performance. It uses an additional secondary			2	4

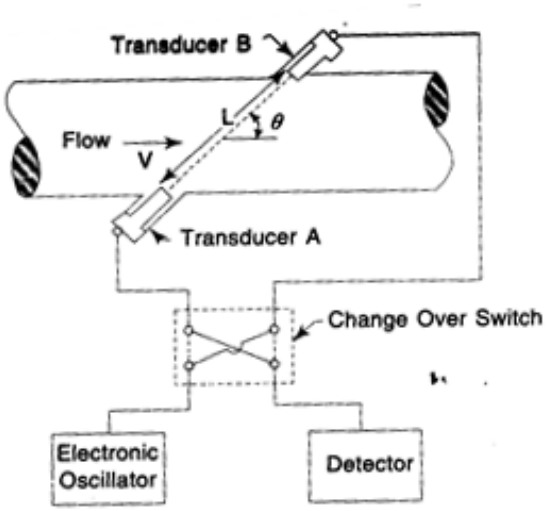
	measured process input variable that has the important characteristics of indicating occurrence of the key disturbances. **Block Diagram:**  Block Diagram Representation	2	
2-b	**LVDT:**  When the pressure insidethe bellows changes, its free end gets deflected along with the movable core.When the core is symmetrically positioned between the two secondary coils, themagnetic coupling of the core with both the secondary coils is equal. In thisposition, equal but opposite emfs are developed in the coil, and hence the netvoltage between two secondary coils is zero. When core takes any other position,the magnetic coupling with each secondary coil is different,	4	4

	that induces differentvoltages in the secondary coils. Hence some unbalance voltage is producedbetween the coils that depend upon the position of the core which in turndepends upon the pressure fed inside the bellows. Thus it converts the displacement due to the pressure applied into an electrical signal.		
2-c	**Valve positioner:**It is that part of the control valve whichis used along with the actuator to correctly position the stem when static frictional forces are large **Function:** 1. To correctly position the valve stem in response to the control signal. 2. Improves the speed of response and reduces the hysteresis effect.	2 1 mark each	4
2-d	**Features of distributed control system.** The DCS architecture provides a single window to the process & control systems so that it can perform the following function : i. Monitor & manipulate the process ii. Retrieve historical data (batch history is required to facilitate display & analysis of key characteristics within a batch between batches of similar types) iii. Configure the system iv. Develop control programs **v.** Diagnose system failures.	1 mark each for any four	4
2-e	**Diagram of Programmable logic controller**	4	4

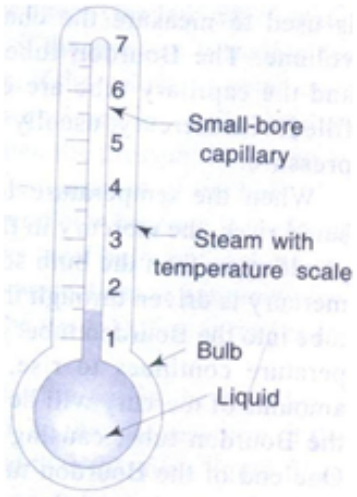
			
2-f	**Working of spring diaphragm actuator**  Actuator is the portion of the valve that responds to the applied signal and results in the movement of the stem due to which the flow rate of fluid changes. It consists of a pressure tight housing sealed by a flexible diaphragm, stem and diaphragm returning spring. Signal air pressure from the controller is applied to upper diaphragm case, that exerts force on the diaphragm and the actuator assrmbly.by selecting proper spring rate or stiffness, desired stem displacement	4	4

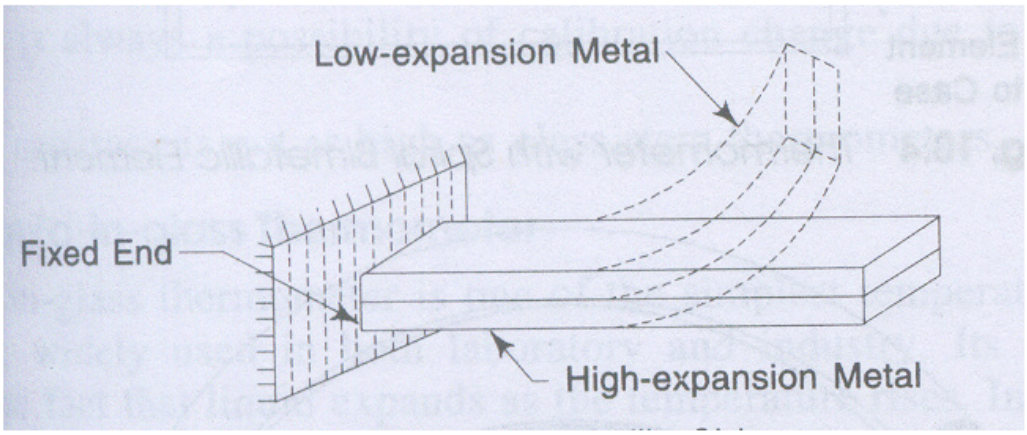
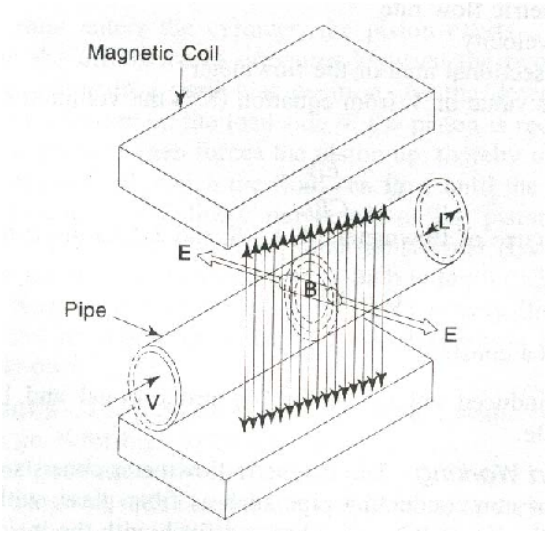
	can be obtained for any given input signal. The diaphragm is made of neoprene or any other synthetic elastic element.		
3	**Attempt any four**		16
3-a	**Diagram of radiation pyrometer:** 	4	4
3-b	**Air purge method:** **Diagram:**  **Working:** When there is no liquid in the tank or the liquid level in the tank is below the bottom end of the bubble tube, the air flows out of the bottom of the bubble tube and the pressure gauge indicates zero. In other words, there is no back pressure because the air escapes to the atmosphere. As the liquid level in the tank increases, the air flow is restricted by the depth of liquid and the air	2 2	4

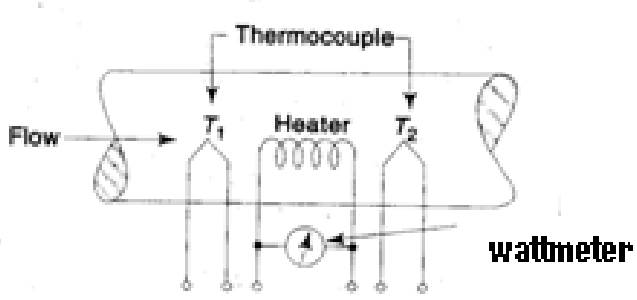
	pressure acting against liquid head appears as back pressure to the pressure gauge. This back pressure causes the pointer to move on a scale, calibrated in terms of liquid level. The full range of head pressure can be registered as level by keeping the air pressure fed to the tube, slightly above the maximum head pressure in the tank. The range of the device is determined by the length of the tube. Because air is continuously bubbling from the bottom of the tube, the tank liquid does not enter the bubbler tube and hence, the tube is said to be purged. The common purging fluid is air, but, if air reacts with the tank fluid or is absorbed, different gases (like carbon or nitrogen) are chosen depending on liquid properties.		
3-c	**Dead weight tester:** **Diagram:**  **Working:** It consists of a very accurately machined, bored and finished piston which is inserted into a close-fitting cylinder. The cross sectional areas of both the piston and the cylinder are known. At the top of the piston is provided a platform on which the standard weight, of known accuracy, can be placed. An oil reservoir with a check valve at its bottom is also provided. The oil from the reservoir can be sucked by a displacement pump on its upward stroke.	2 2	4

	For calibration purpose, first a known (calculated) weight is placed on the platform and the fluid pressure is applied on the other end of the piston until enough force is developed to lift the piston-weight combination and the piston floats freely within the cylinder, whenthe fluid gauge pressure equals the dead weight divided by piston area.		
3-d	**Ultrasonic flow meter:** **Construction and working: (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 tosupply 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	4	4

<table>
<tr><td></td><td>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:
$$T_{AB} = \frac{L}{(C + V\cos\theta)}$$
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,
$$\Delta T = T_{AB} - T_{BA} = \frac{2LV\cos\theta}{C}$$
Note: Any other type of ultra sonic flow meter should be given due consideration.</td><td></td><td></td></tr>
<tr><td>3-e</td><td>Difference between P, I and D action in controller
<table><tr><th>Controller</th><th>Response time</th><th>Overshoot</th></tr><tr><td>Proportional</td><td>Small</td><td>Large</td></tr><tr><td>Integral</td><td>Decreases</td><td>Increases</td></tr><tr><td>Derivative</td><td>Increases</td><td>Decreases</td></tr></table></td><td>2 marks each</td><td>4</td></tr>
<tr><td>4</td><td>Attempt any three</td><td></td><td>12</td></tr>
<tr><td>4A-a</td><td>Liquid filled thermometer:
Explanation:
Its operation is based on the fact that liquid expands as the temperature rises.
Glass Thermometer consists of a small bore tube with a thin wall glass bulb at its lower end. The liquid that fills the bulb and part of the tube is mercury. As heat is transferred through the well and metal stem and into the mercury, the mercury expands, pushing the column of mercury higher in the capillary above</td><td>2</td><td>4</td></tr>
</table>

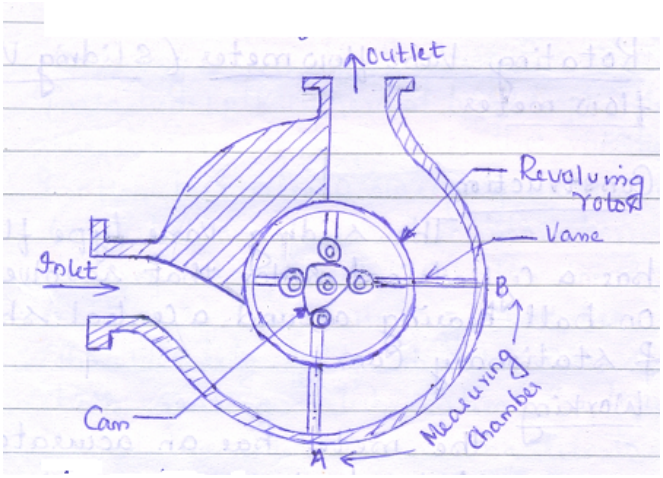
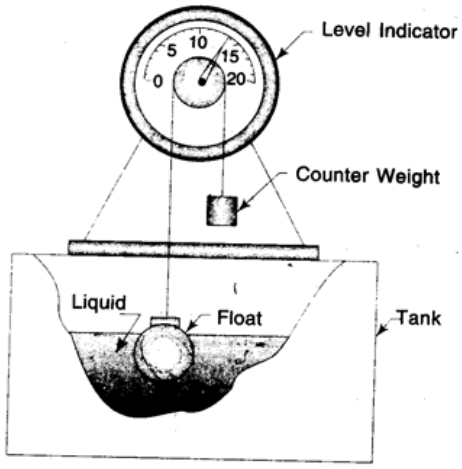
	which indicates the temperature.The liquid in glass thermometer is commonly used for the temperature range of – 18.4 to 608 °F (-120 to 320° c) **Diagram**:  	2	
4A-b	**Bimetallic thermometer:** **Principle:** When heated, different solids expand differently depending on their coefficient of thermal expansion. **Diagram**:	2	4

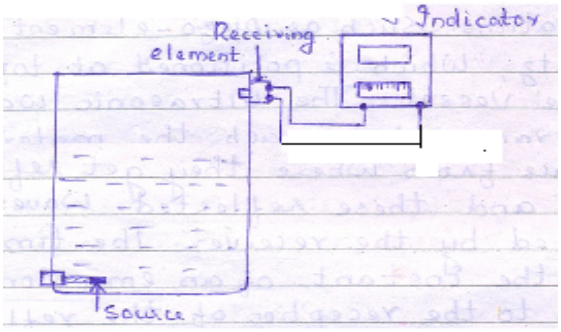
		2	
4A-c	**Electromagnetic flow meter:** **Diagram:**  **Working:** As the conducting fluid flows through the pipe, due to the magnetic field around the pipe, an emf is induced between the electrodes. This emf induced is proportional to the velocity of the conductor. As the flow rate varies, velocity of fluid changes and hence the induced emf changes.	2 2	4

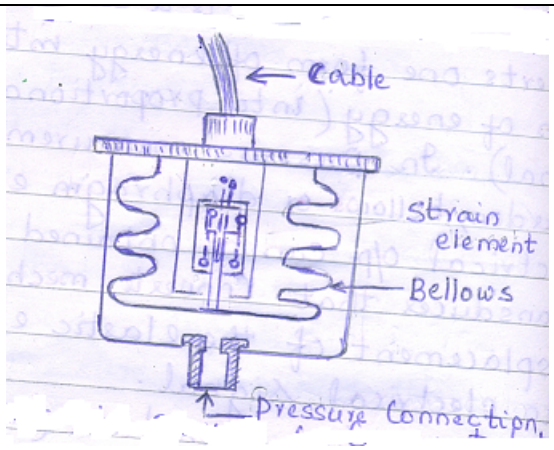
	E = CBLV Where, E = induced voltage in volts C = dimensional constant B = Magnetic field in weber/m^2 L = Length in conductor (fluid) m V = velocity of the conductor in m/sec		
4A-d	**Thermal flow meter:** **Principle:** It works on the principle $Q = \dot{m} C_P \Delta T$ Q=heat transfer $\dot{m}$= mass flow rate of fluid Cp= specific heat of fluid $\Delta T = T_2 - T_1$where T_1=initial temperature of the fluid . T_2=final temperature after heating the fluid **Diagram:**  	2 2	4
4B	**Attempt any one**		**6**
4B-a	**Factors to be considered for valve selection:** 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	1 mark each	6

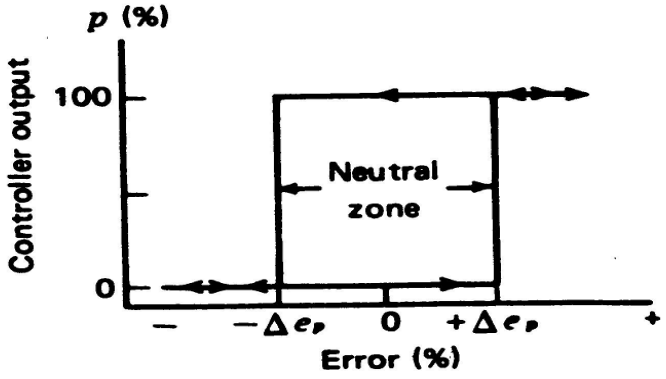
	prior to valve sizing, and determining the supply pressure may require specifying a pump 2. The size of the valve is required; select the smallest valve $C_v$that satisfies the maximum $C_v$requirement at 90% opening. While performing these calculations, checks should be made regarding flashing, cavitation, 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 manual operation of the valve is expected.		
4B-b	**Advantages of distributed control system:** a) Overall cost of the installation is lower because	1 mark each	6

	i. Less wiring is required when information is transmitted serially across the two wires of a dat highway ,rather than in parallel over many paires if wires. ii. Panel space is reduced & so is the control room size required to house it. b) The interface with the process is improved for the benefit of the operators overview of the plant,as The group display provides a means of viewing a combination of control loops that has meaning in terms of process association. Configuartion from the keyboard allows rearranging or adding to the display without the purchase & installation of new equipment. c) They are more reliable,i.e.,even if central station facilities break down,the remote control operation will continue without interruption. d) It is flexible & relatively easy to expand. e) The programming required to tailor the system to the needs of the individual process to which it is aplied can be done without knowing a high-level programming language. **f)** It can handle compex and contineous process.		
5	**Attempt any four**		**16**
5-a	**Rotating vanemeter:** **Principle:** These meters have chambers of known volumetric capacity and they are arranged so that when one chamber is being filled, the other is being emptied. For measuring the total flowover a certain period, the fluid is continuously filled and emptied from the chamber and then the number of times the chamber is being filled and emptied in that period is counted which when multiplied by the volumetric capacity of the chamber gives the total flow.	2	4

	Diagram: 	2	
5-b	**Float type liquid level measurement:** **Diagram**  **Explanation:** 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 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	2 2	4

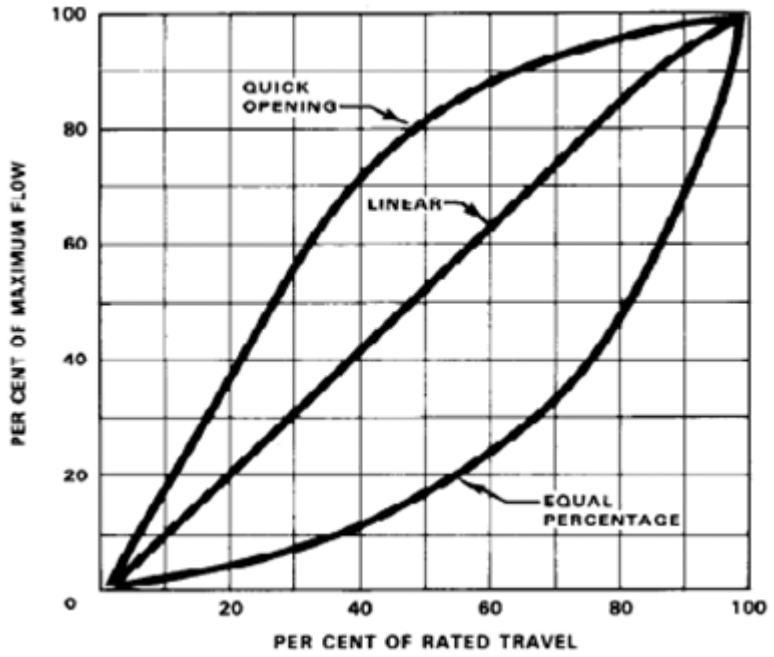
	The movement of the float is transmitted to a pointer through a suitable mechanism which indicates the level on a calibrated scale		
5-c	**Liquid level measurement with no physical contact:**Nuclear radiation method (or) radiation method **Diagram:**  **Explanation:** It consists of a radioactive source such as minute quantity of capsulated radioactive isotope like cobalt60 fixed either inside or outside the vessel, radiation receiving element fixed to the side of the vessel directly across the source along with the indicator. As the liquid level inside the vessel changes, the amount and intensity of radioactive radiations received by the receiver changes. Larger the level of liquid inside the vessel, smaller is the intensity of radiation and vice versa.	1 1.5 1.5	4
5-d	**Strain gauge:** **Diagram:**		4

	 **Explanation:** As the pressure acting against the bellows changes, bellows get compressed or expanded that causes straining of the strain elements. Strain element being a resistance element, its electrical resistance changes with strain produced. This change in resistance causes deflection of galvanometer in the bridge circuit. The galvanometer can be calibrated in terms of pressure. It can be used for absolute, gauge and differential pressure measurement. ***Due consideration should be given for any other type of strain gauge transducer***	2 2	
5-e	**Relation between absolute, gauge and atmospheric gauge:** Absolute pressure = atmospheric pressure + Gauge pressure **(or)** Absolute pressure = atmospheric pressure – Vacuum pressure Gauge pressure =101.325 KPag Atmospheric pressure = 101.325 KPa Absolute pressure = atmospheric pressure + Gauge pressure = 101.325 + 101.325 = 202.650KPa	2 2	4
6	**Attempt any Two**		**16**

6-a	**ON-OFF control:** In ON/OFF control action,the output has only two states -fully ON or fully OFF. It operates on the manipulated variable only when the measured variable crosses the set point. Analytical equation for the control action is, M = 0% ,for e>0 M = 100%,for e<0 m – output , e – error  **Differential gap:**It is the range through which the error signal moves before switching occurs. **Application:**ON/OFF controller is adapted to large-scale systems with relatively slow process rates. 1) Room heating system 2) Air conditioner system 3) Liquid-bath temperature control 4) Level control in large volume tanks	2 2 2 1 mark each for any two points	8
6-b	**Control valve:**It is a device(final control element) capable of modulating flow at different rates between minimal flow and full capacity in response to a signal from the controller.	2	8

Control valve characteristics with their equation:

The relation between stem position, plug position and rate of flow is described in terms of flow characteristics of valve. Two types of valve characteristics are there –Inherent and Installed or effective.



2

Inherent flow characteristics are plotted when constant pressure drop is maintained across the valve. There are two different inherent flow characteristics- linear and equal percent.

Linear Opening characteristics: Linear characteristics valve has linear relation between valve opening and flow rate at constant pressure drop

Q = by

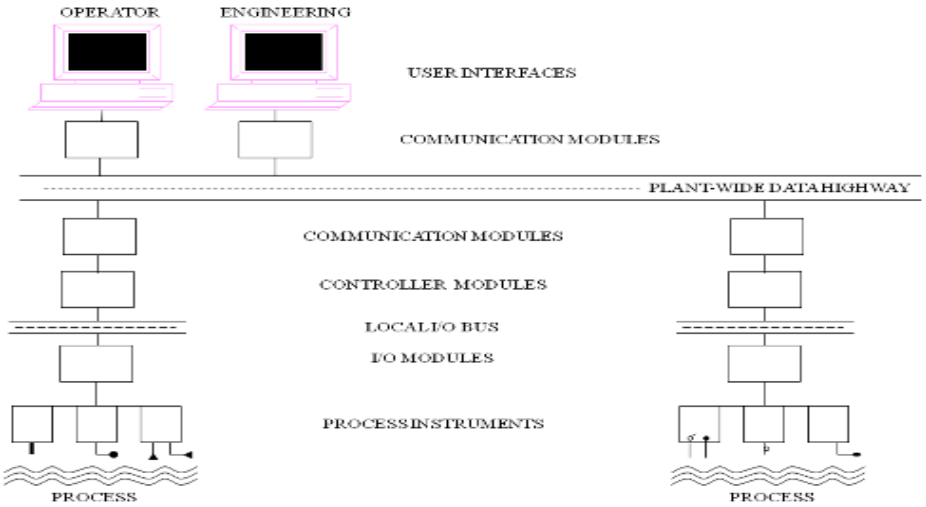
Q- Flow rate at constant pressure drop

b - constant

y - valve opening / valve stem travel

Generally used

	• For slow process • When more than 40% of the system pressure drop occurs across the valve. **Equal Percentage characteristics**: In equal percentage valve equal increment of the stem travels give equal % change of the existing flow $Q = be^{ay}$ Q= Flow rate at constant pressure drop a& b = constant e = base of natural logarithms y = valve opening / valve stem travel Generally used • For fast processes • When high rangeability is required At heat exchangers where an increase in product rate requires much greater increase in heatingand cooling medium. **Installed flow characteristics**are plottedwhen the differential pressure across the valve changes. **Quick opening** – In this there is maximum flow for minimum travel It is approximately linear when the flow rate is less but beyond 30% the flow increases rapidly with valve opening It gives approximately 90% flow at 30% travel Generally used • For on – off control • When maximum valve capacity must be obtained quickly.	2 2	
6-c	**Distributed control system:** **Block diagram:**		8



4

Explanation:

In DCS equipment is separated in functional area and is installed in different work areas of a process plant. The plant operator monitors and manipulates the set-points of the process parameter from central control room.

Controlling portion of the DCS, distributed at various location performs following two function at each location.

1. Measurement of analog variable and discrete inputs
2. Generation of output signals to actuators that can change process condition

In Figure above the operator console in the conrol room is connected through a data highway to several distributed system components.

A DCS consist of the following modules:

1 Operator stations that use microprocessor based CRT display and keyboard communication with control device and displays

2 Remote multifunction microprocessor based controllers (PLCs)

3 A digital data link (data highway) that connects the multifunction controllers with the central operator stations.

4

	The first priority of DCS is to provide operator interfacing and real time process control. DCS has flexibility of implementation of sequential control and integration among the various types of control.		