SUMMER-14 EXAMINATION

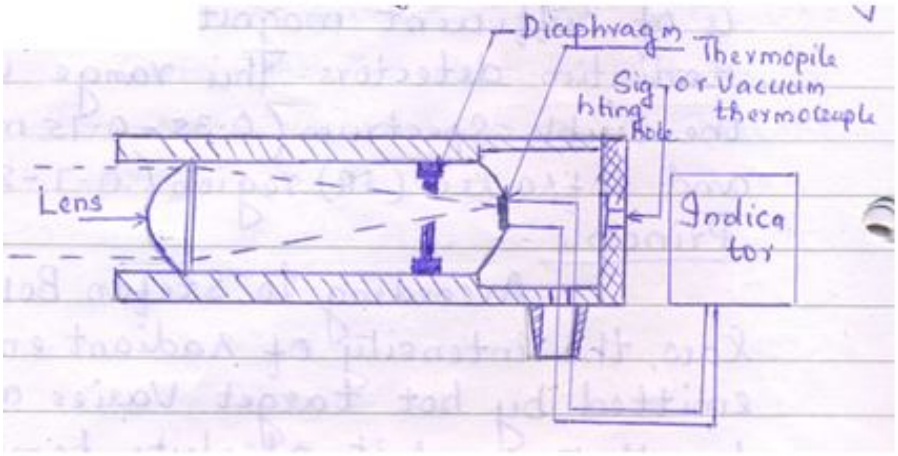
Model Answer

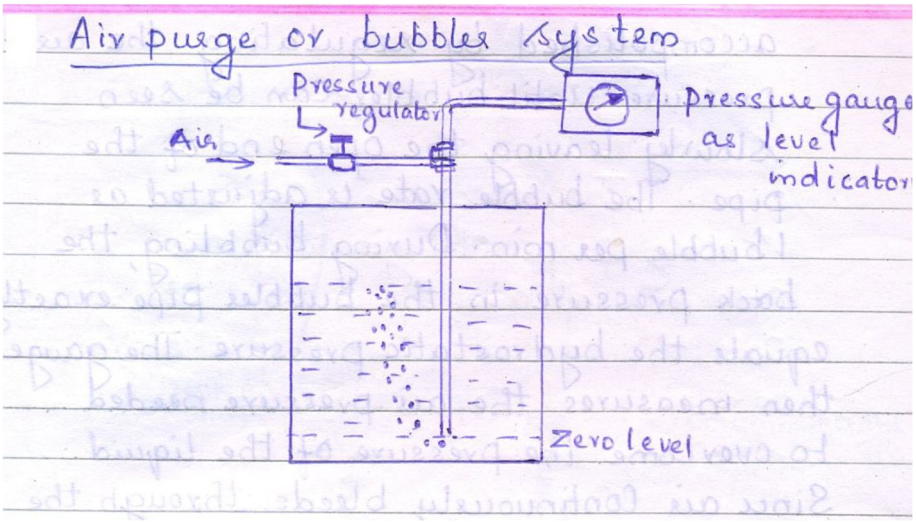
Subject code : (12208)

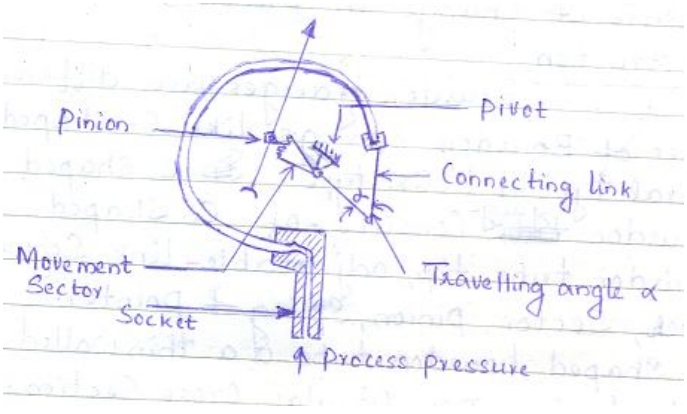
Important Instructions to examiners:

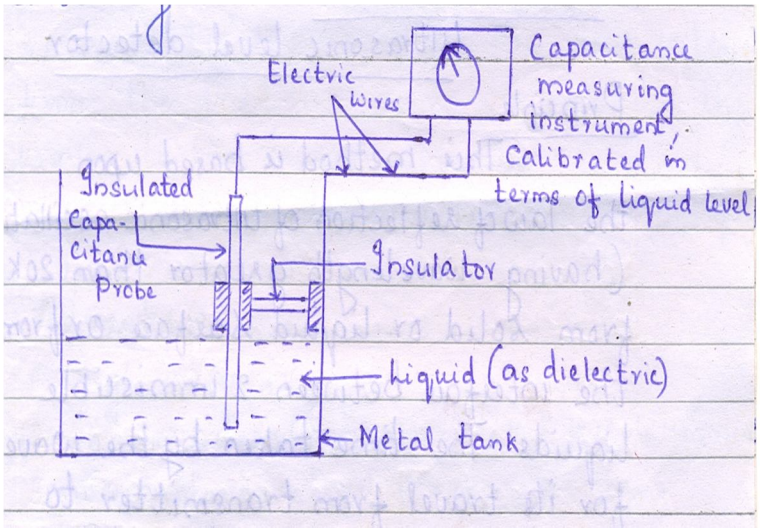
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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-a	**Dynamic characteristics of measurements:** 1) Speed of response 2) Fidelity 3) Lag 4) Dynamic error **Definition:** 1) Speed of response: it is the rapidity with which an instrument response to changes in the measured quantity. 2) Fidelity: it is the degree of closeness with which the instrument indicates or records a change in value of the variable. 3) Lag: it is the retardation or delay in the response of an instrument to changes in the measured quantity. 4) Dynamic error: it is the difference between the true value of a quantity changing with time and the value indicated by the instrument if no static error is assumed.	2 1 mark each for any two definitions	4

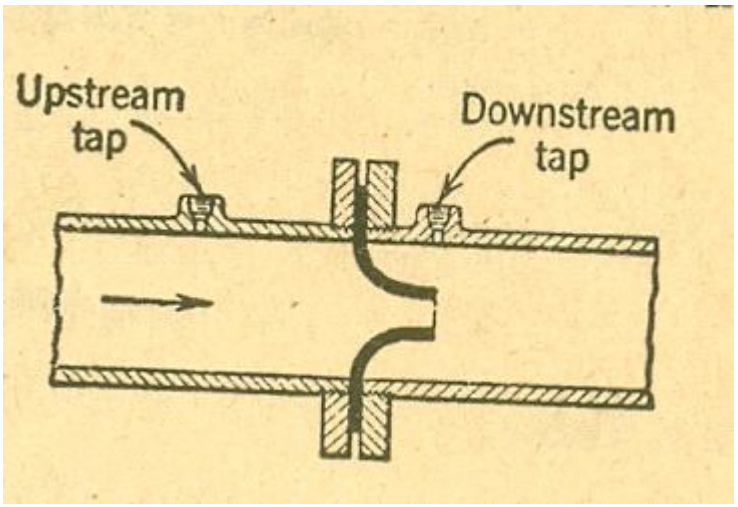
1A-b	Diagram of radiation pyrometer: 	2 marks for diagram and 2 marks for labelig.	4
1A-c	**Advantages of Bourdon Tube:** 1) Low cost 2) Simple construction 3) Wide pressure range 4) High accuracy in relation with low cost **Disadvantages of Bourdon Tube:** 1) Low spring gradient 2) Susceptible to shock and vibration 3) Susceptible to hysteresis	2 2	4

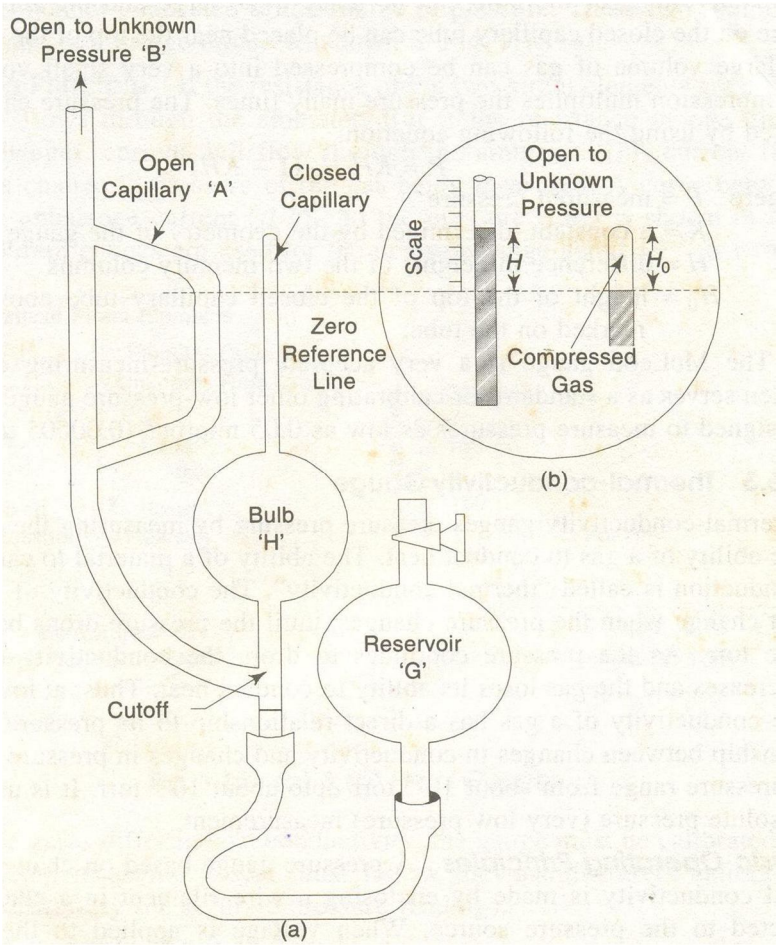
1A-d	**Labeled diagram of air purge level measurement:**  **Disadvantages:** 1) Clogging of the bubbler pipe may occur with some chemical slurries 2) Feed must be available at a pressure slightly greater than the maximum head to be measured.	3 1 mark for any one	4
1B-a	**Radiation Pyrometer:** **i) Principle:** According to Stefan Boltzmann's law, the intensity of radiant energy emitted by a hot target varies as the fourth power of its absolute temperature. **ii)Construction:** It consists of a lens, diaphragm, radiation receiving element, sighting hole and recorder or indicator. Lens is used to concentrate the radiant energy from the hot source on the diaphragm and on the thermopile. Sighting glasses enable the proper line of sight and proper focus to be established. **iii) 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	 1.5 1.5 1.5	6

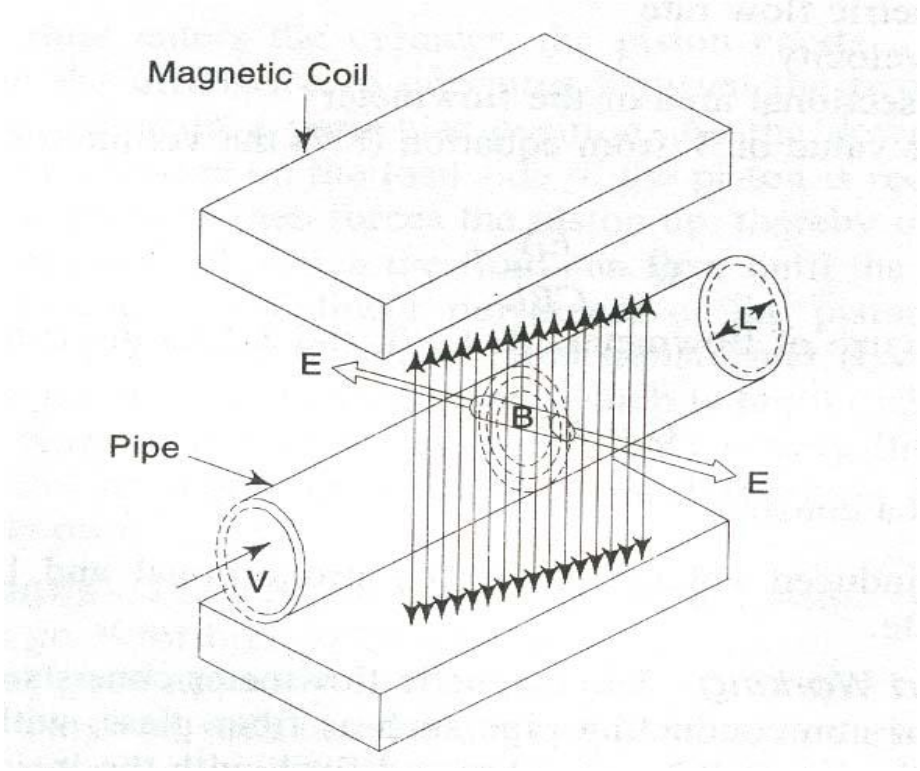
	thermocouple is used as radiation receiving element, the radiant energy from the target is focused in blackened measuring junction. Due to absorption of radiant energy, the measuring junction temperature rises. According to Seebeck effect, emf is developed between output leads which are proportional 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. **Application (Any one):** 1) Used in corrosive environments 2) Used for measuring temperature of moving objects 3) Measuring temperature of targets which are not easily accessible	1.5	
1B-b	**Measurement of vacuum:** 1) Capsule Gauge 2) McLeod Gauge **Diagram of C-shaped Bourdon tube:** 	2 2 marks for diagram and 2 marks for labeling	6

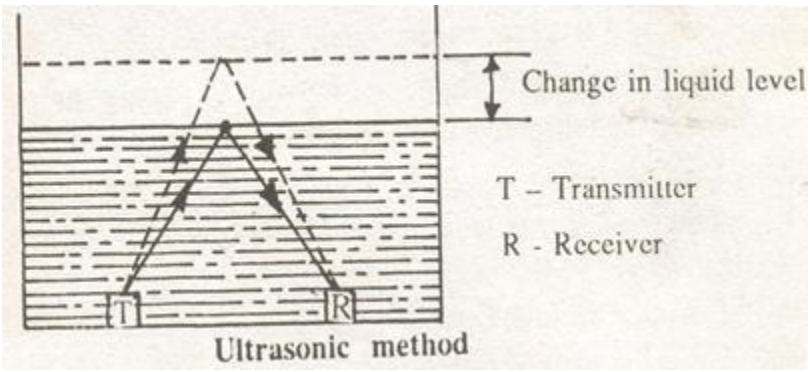
2-a	**Capacitive level measurement:**		8
	i) Principle:	2	
	The electrical capacitance of sensing probe changes with level of material and hence level changes can be recorded in terms of changes in electrical capacitance of the sensing probe.		
	ii) Construction and working	2	
	It consists of two conductors 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 liquid as the dielectric medium. These two conductors are connected to capacitance detecting element As the liquid level changes, the dielectric constant changes due to which capacitance changes. Thus any change in liquid level can be measured in terms of change in capacitance.		
	iii) Labeled diagram	2	
			
	iv) **Advantages (Any one)** 1) High sensitivity	1	

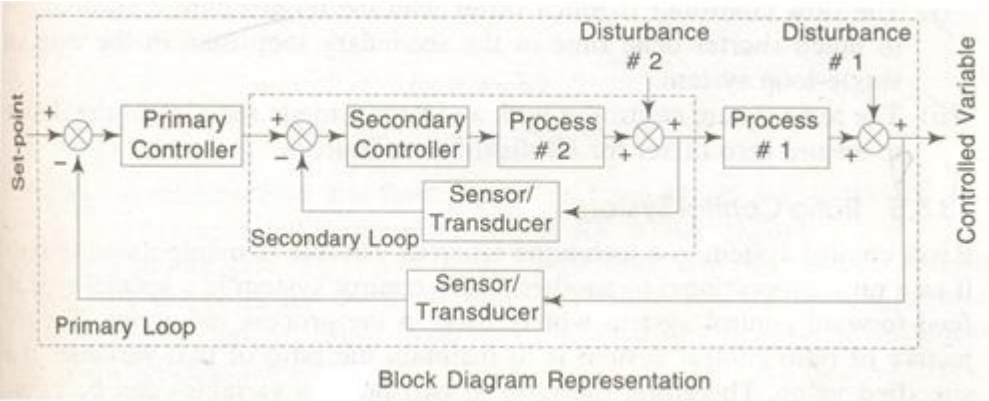
<table>
<tr><td></td><td>2) Remote indications can be obtained
3) Can be used to measure the level of solids and liquids
Disadvantages (Any one)
1) Liquid should be pure, because presence of contaminants affects the capacitance
2) Any change in the liquid composition requires recalibration of the indicator</td><td>1</td><td></td></tr>
<tr><td>2-b</td><td>Differentiation of Open loop and closed loop:
<table>
<tr><th>Sr No.</th><th>Open loop</th><th>Closed loop</th></tr>
<tr><td>1</td><td>Feedback doesn’t exists</td><td>Feedback exists</td></tr>
<tr><td>2</td><td>Output measurement is not necessary</td><td>Output measurement is necessary</td></tr>
<tr><td>3</td><td>Any change in output has no effect on input</td><td>Changes in output affects the input</td></tr>
<tr><td>4</td><td>Error detector is absent</td><td>Error detector is present</td></tr>
<tr><td>5</td><td>Inaccurate and unreliable</td><td>Highly accurate and reliable</td></tr>
<tr><td>6</td><td>Highly sensitive to disturbance</td><td>Less sensitive to disturbance</td></tr>
<tr><td>7</td><td>Highly sensitive to environmental changes</td><td>Less sensitive to environmental changes</td></tr>
<tr><td>8</td><td>Simple in construction and cheap</td><td>Complicated in construction and hence costly</td></tr>
<tr><td>9</td><td>Highly affected by non-linearities</td><td>Reduced effect of non-linearity</td></tr>
</table></td><td>1 mark each for any 8 points</td><td>8</td></tr>
</table>

2-c	**Flow nozzle:** **Diagram:**  **Construction & working:** It consists of a convergent inlet whose shape is a quarter eclipses and a cylindrical throat. Differential pressure measurement taps are normally located one pipe diameter upstream and one-half diameter down-stream from the inlet faces of the nozzle. Flow nozzles are manufactured commonly from material such as stainless steel. They are made in various configurations:- flange type, holding ring type, weld-in type, throat type etc. Flow nozzles have high coefficient of discharge.	4 4	8
3-a	$R_t = R_0\left[1 + \alpha\left(t - t_0\right)\right]$ where: R_t = resistance at temperature t R_0 = resistance at a standard temperature t_0	4	4

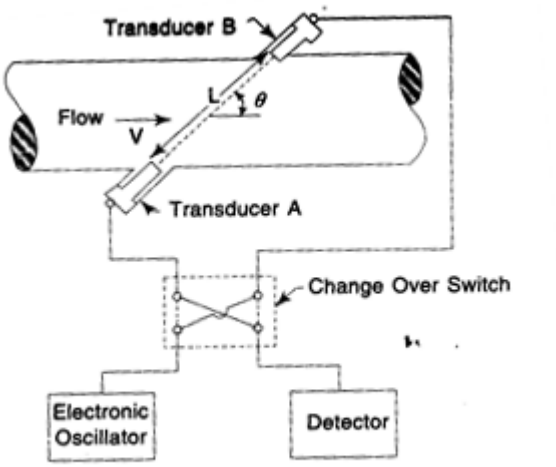
	α= temperature coefficient of resistance ($^{\circ}C^{-1}$) **Rt =100(1+.0042(-160-0))** **Rt = 32.8 Ω at -160^{0}C**		
3-b	**McLeod Gauge**  	4	4

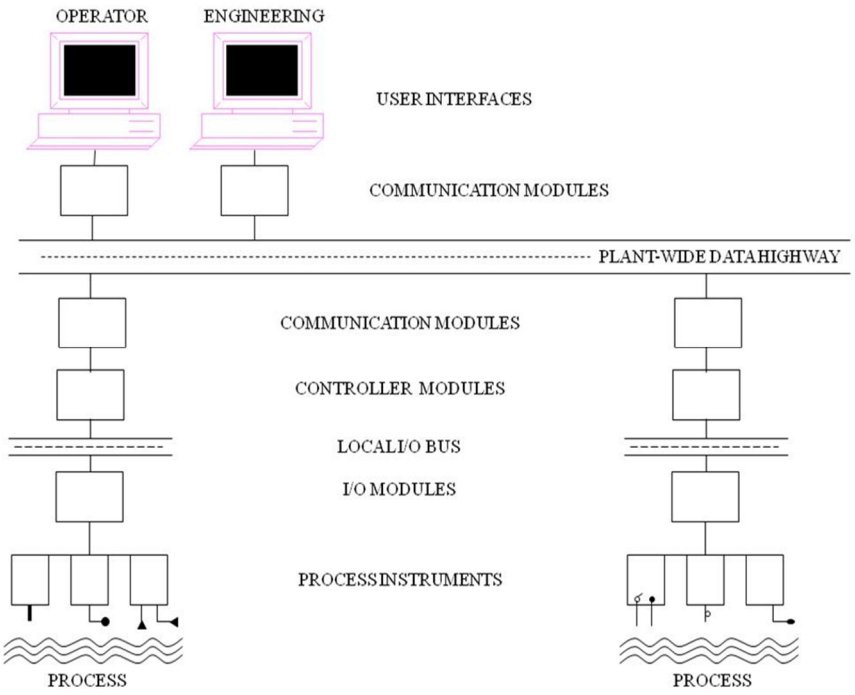
3-c	 **Magnetic Flow meter** E = CBLV V = E / CBL Where, E = induced voltage in volts C = dimensional constant B = Magnetic field in weber/m^2 L = Length in conductor (fluid) m V = velocity of the conductor in m/sec Q = VA Q = Volumetric flow rate V = fluid velocity A = Cross sectional area of flowmeter	4	4

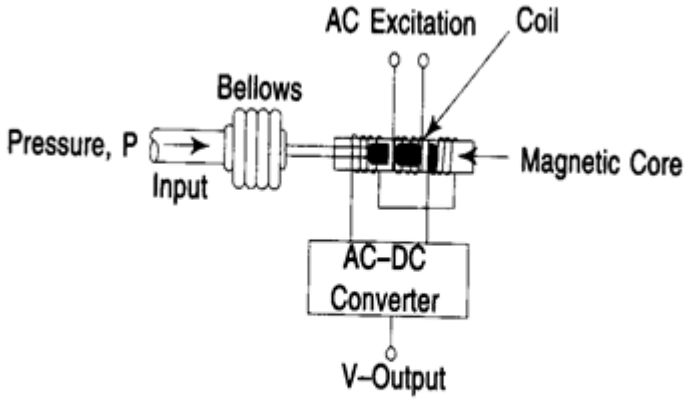
	If K = A / CBL Where A , C, B and L becomes constants Thus Q = KE **VOLTAGE is directly proportional and linear with VOLUMETRIC FLOW RATE**		
3-d	**Solid measurement** Capacitance method, radioactive method and ultrasonic methods are used for level measurement Ultrasonic Level measurement  Ultrasonic method **Principle**: This method is based upon utilization of law of reflection of ultrasonic oscillations (having wavelength greater than 20 KHz) from solid surface. The time taken by the wave for its travel from transmitter to the liquid surface and back to the receiver can be taken as the measure of liquid level. **Construction and working:** Transmitter is the source of ultrasonic oscillations such as piezo-element like Quartz, which is positioned at the top or bottom of the vessel. The ultrasonic waves from the transmitter reach the material surface from where they get reflected back and these reflected waves are received by the receiver. The time	2 1 1	4

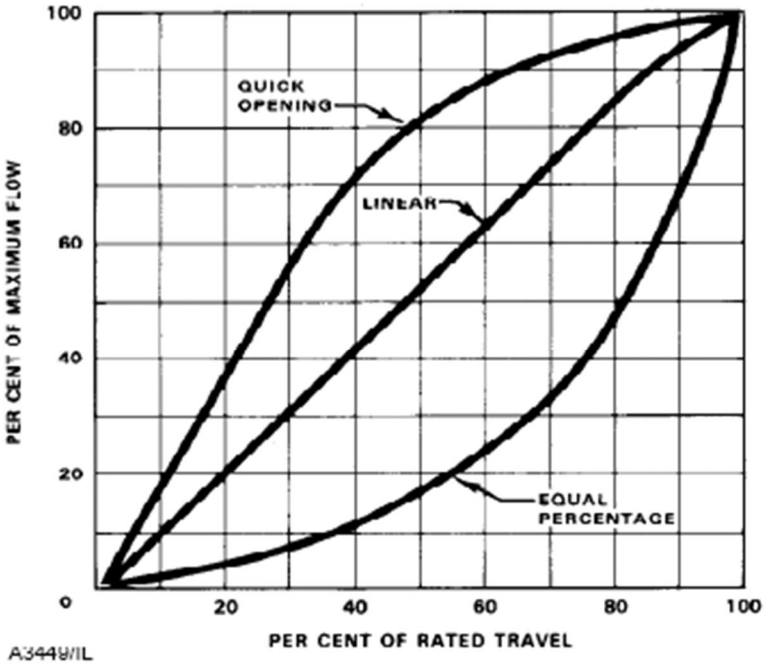
<table>
<tr><td></td><td>interval from the instant of an emission of the waves to the reception of the reflected rays is measured, which varies with liquid level.
(Due consideration should be given for any other type of solid level measurement)</td><td></td><td></td></tr>
<tr><td>3-e</td><td>Cascade control System
 

Block Diagram Representation</td><td>4</td><td>4</td></tr>
<tr><td>4A-a</td><td><table>
<tr><th>Criteria</th><th>RTD: resistance temperature detector</th><th>Thermistor</th></tr>
<tr><td>Temp Range</td><td>-240°C to 649°C</td><td>-100°C to 500°C</td></tr>
<tr><td>Accuracy</td><td>Best</td><td>Good</td></tr>
<tr><td>Linearity</td><td>Best</td><td>Good</td></tr>
<tr><td>Sensitivity</td><td>Better</td><td>Best</td></tr>
<tr><td>Cost</td><td>Good</td><td>Better</td></tr>
<tr><td>temperature coefficient</td><td>Positive temperature coefficient</td><td>Available with negative (NTC) and positive (PTC) temperature coefficients.</td></tr>
<tr><td>Construction</td><td>Wire-wound or thick film metal resistor</td><td>Thermally sensitive resistor
Sintered metal oxide or passive semiconductor materials</td></tr>
</table></td><td>1 mark each for any four</td><td>4</td></tr>
</table>

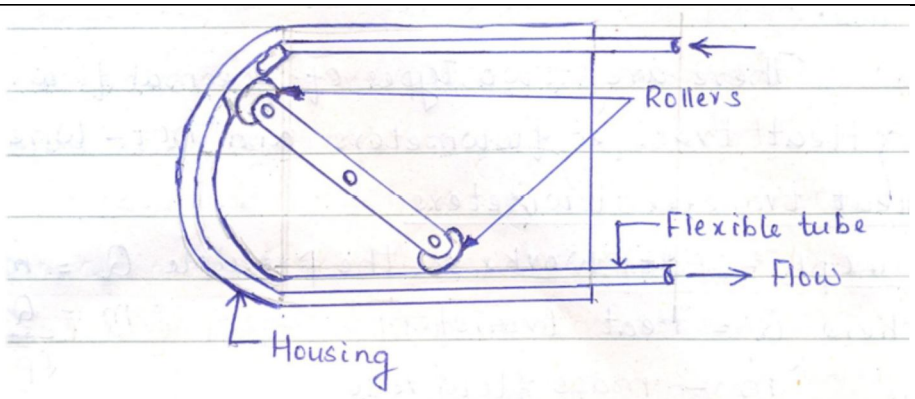
4A-b	**Ultrasonic flow meter**  *Time-difference Type Ultrasonic Flowmeter.* In ultrasonic flowmeters, the measurement of flow rate is determined by the variation in parameters of ultrasonic oscillations **Time Difference Type**These devices measure flow by measuring the time taken for ultrasonic wave 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 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 measures the transit time from upstream to downstream transducers and vice versa. The time TAB for ultrasonic wave to travel from transducer A to	2 2	4

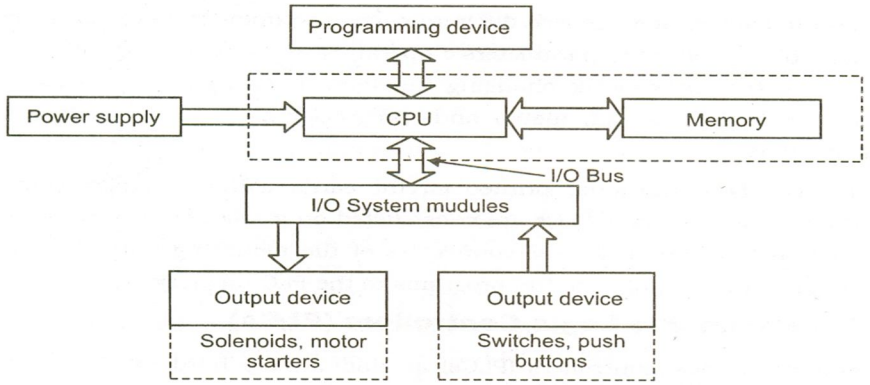
	transducer B is given by the expression: $$T_{AB} = \frac{L}{(C + V\cos\theta)}$$ and, the time (T_{BA}) to travel from B to A is given as, $$T_{BA} = \frac{L}{(C - V\cos\theta)}$$ where, L = the acoustic path length between A and B C = velocity of sound in the fluid θ = angle of path with respect to the pipe axis V = velocity of fluid in pipe The time difference between T_{AB} and T_{BA} can be calculated as, $$\Delta T = T_{AB} - T_{BA} = \frac{2LV\cos\theta}{C}$$ $V=\Delta TC/2L\cos\theta$ ***(Ultrasonic level measurement should also be given full credit)***		
4A-c	**Distributed Control System**  	4	4

4A-d	**LVDT**  *Linear Variable Differential Transformer (LVDT).*	4	4
4B-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 $m = \frac{1}{T_i}\int_0^t edt$ 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	1 mark each 2	6

	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.		
4B-b	**Control valve characteristic**  **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 • For on – off control • When maximum valve capacity must be obtained quickly **Equal Percentage** – In equal percentage valve equal increment of the stem	2 4	6

	travels give equal % change of the existing flow $Q = be^{ay}$ Q= Flow rate a& b = constant e = base of natural logarithms y = valve opening / valve stem travel • 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. **Linear Opening** – It can be represented by a straight line Q = by Q= Flow rate b = constant y = valve opening / valve stem travel • For slow process • When more than 40% of the system pressure drop occurs across the valve		
5-a	**Diagram:**	03	8

	 **Construction:** It consists of a flexible tube container with rollers fitted inside. This container is usually a tube that can be made out of any material that possesses a property to recover its original shape immediately after compression. There is variety of methods used for squeezing the tube. The rollers connected to a rotating body squeeze the tubing against a circular housing. **Working:** The peristaltic pump produces a wave like motion on an alternate contraction and refilling of a tubular type vessel to produce a pumping action. In this pump the fluid is moved forward by progressively squeezing a flexible container from the entrance to discharge. The flow rate is adjusted by changing the speed of squeezing mechanism.	02 03	
5-b	**Block diagram Of PLC:**		8



3

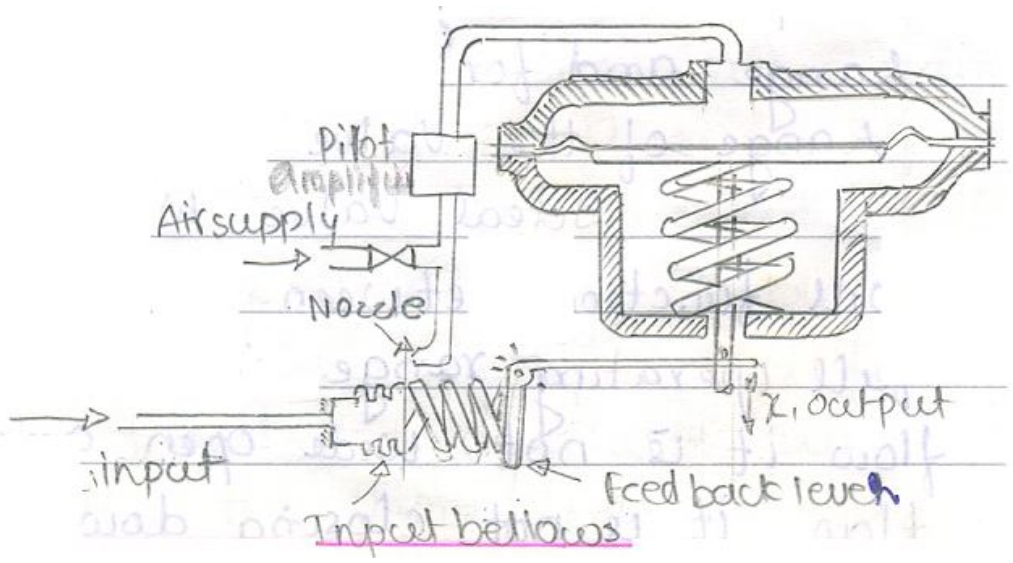
Description:

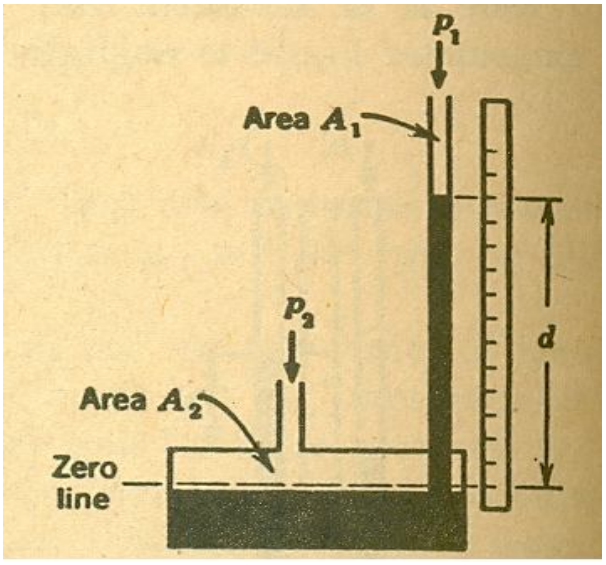
PLCs are industrially hardened microcomputers that perform discrete or continuous control functions in a variety of processing plant and factory environments. APLC architecture consists of the following main units.

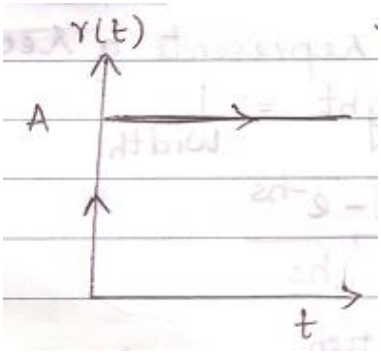
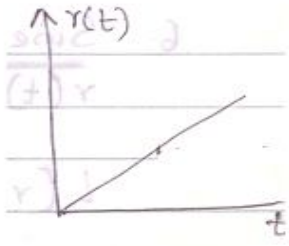
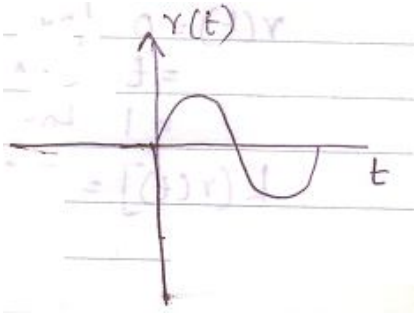
1. Power supply: Power supply unit converts power line voltages to those required by the solid state components.
2. Input / Output system: Inputs are real world signals of sensors. These signals can be Analog or Digital, low or high frequency, continuous or momentary.

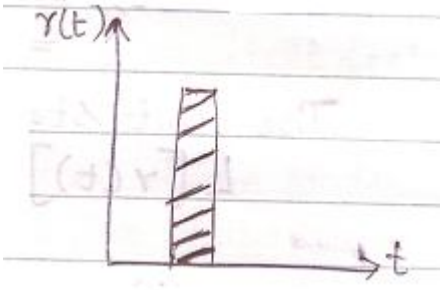
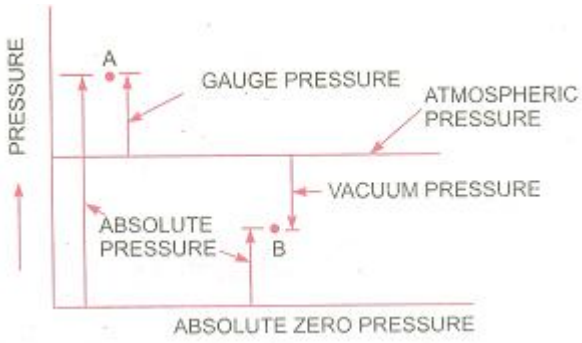
   Outputs can be of discrete, register or analog.
3. Central Processing Unit (CPU): It performs the tasks necessary to fulfill the PLC functions such as scanning, I/O bus traffic control, program execution, peripheral and external device communications, and data handling and self-diagnostics.
4. Memory 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.

5

	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	**Valve Positioner:** **Diagram:**  **Description:** It consists of an input bellows, a nozzle, a pilot amplifier and feedback lever. The controller output signal is fed to the input bellows that causes the flapper to cover the nozzle so as to increase the nozzle and pilot relay output. This amplified signal is admitted above the diaphragm that pushes the diaphragm along with the stem and the plug. ***(Any other type of valve positioner should also be considered.)*** **Function:** When static frictional forces are large, valve positioner is used along with actuator so as to correctly position the valve stem in response to the control signal. Valve positioner improves the speed of response and reduces the hysteresis effect.	3 3 2	8

6-a	**Application of PLC:** 1) PLC can be a vital part of industrial automation as it produces on/off voltage outputs to actuate elements such as electric motors, solenoids etc. 2) It can also be used in sequential controllers used for periodical on/off of fans, heaters and light switches. **Application Of DCS:** 1) DCS are designed for continuous process where the control signal is analog rather than discrete. 2) It is 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 factory, oil refinery, power plant etc.	2 2	4
6-b	**Diagram:**  **Working:** The pressure to be measured is applied to the well. As the diameter of the well	2 2	4

	is very large compared to the tube, zero level moves too little in the well. In this reading of only a single leg is required. High accuracy is achieved by setting the zero level of the well at the zero level of the scale before each reading is taken.		
6-c	**Step input:**  **Ramp input:**  **Sinusoidal input:**  **Impulse input:**	1mark each	4

			
6-d	**Scales of pressure:** 1) Gauge pressure 2) Absolute pressure 3) Atmospheric pressure. 4) Vacuum pressure **Relationship between absolute, gauge and atmospheric pressure:** Absolute pressure = atmospheric pressure + Gauge pressure **(or)** Absolute pressure = atmospheric pressure – Vacuum pressure 	2 2	4
6-e	**Principle of positive displacement flow meter** : These meters have two 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 flow over a certain period, the fluid is continuously filled and emptied from the chamber and then the number of times the chamber	2	4

	is being filled and emptied in that period is counted which when multiplied by the volumetric capacity of the chamber gives the total flow. **Types of positive displacement flow meter:** 1) Reciprocating piston type flow meter 2) Nutating disc flow meter 3) Rotating vane flow meter 4) Lobbed impeller flow meter **(*any other type also to be considered*)**	½ mark each	