WINTER-14 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.

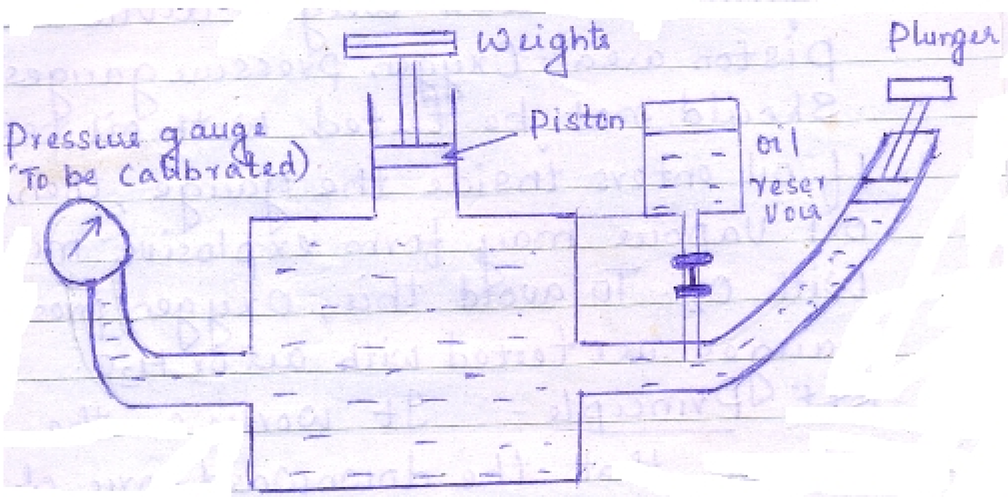
<table>
<tr><th>Q No.</th><th>Answer</th><th>marks</th><th>Total marks</th></tr>
<tr><td>1A-a</td><td>i)Speed of response: It is the rapidity with which an instrument response to changes in the measured quantity.
ii) Accuracy:_ It is the instruments ability to indicate or record the true value of the variable being measured.</td><td>2

2</td><td>4</td></tr>
<tr><td>1A-b</td><td>Different temperature scales
1.Centigrade or Celsius
2. Kelvin
3. Fahrenheit
4. Rankine,
5. Reaumur
<table><tr><td>Temperature scale</td><td>Ice point</td><td>Steam point</td></tr><tr><td>Centigrade or Celsius</td><td>0°C</td><td>100°C</td></tr><tr><td>Kelvin</td><td>273K</td><td>373K</td></tr><tr><td>Fahrenheit</td><td>32°F</td><td>212°F</td></tr><tr><td>Rankine</td><td>491.69°R[1]</td><td>671.69 °R[1]</td></tr><tr><td>Reaumur</td><td>0°R</td><td>80 °R</td></tr></table></td><td>½ marks eachfor any four.

½ marks each for any four.</td><td>4</td></tr>
<tr><td>1A-c</td><td>Difference between direct and indirect level measurement :
In direct level measurement, the varying level of liquid is measured directly. In indirect level measurement, a variable which changes with the level of liquid is measured and level is calculated using that variable.
Eg for direct level measurement: Sight glass method, float type level Indicator
Eg for indirect level measurement: Pressure gauge, air purge .radioactive,</td><td>2

1

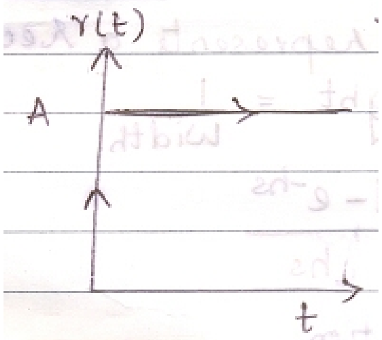
1 mark for</td><td>4</td></tr>
</table>

	ultrasonic, capacitive.	any two.	
1A-d	**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 is being filled and emptied in that period is counted which when multiplied by the volumetric capacity of the chamber gives the total flow.	4	4
1B-a	**Dead weight tester:** **Diagram:**  **Principle:** It works on the principle that the downward force of the weights on the top of the piston is balanced by the pressure exerted by the fluid beneath the piston. **Working:** It consists of a cylinder with piston, displacement pump to suck the oil from the reservoir on upward stroke and pressurize the oil on downward stroke and the gauge to be tested. At the top of the piston, there is a platform on which	2 2 2	6

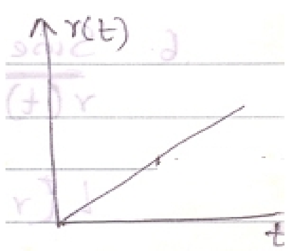
	standard known weights are placed. The weight pressurizes the oil into pressure gauge. The pressure in the tester is build up till the weights are seemed to float, when the fluid gauge pressure equals the dead weight divided by piston area.		
1B-b	**Differentiation of Open loop and closed loop control system:**	1 mark each for any 6 points	6

Sr No.	Open loop control system	Closed loop control system
1	Feedback doesn't exists	Feedback exists
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

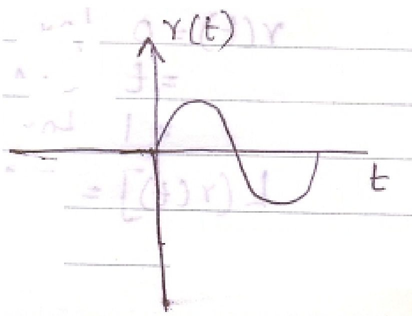
2-a	**System input for** **i)Step :**	1 mark each	4



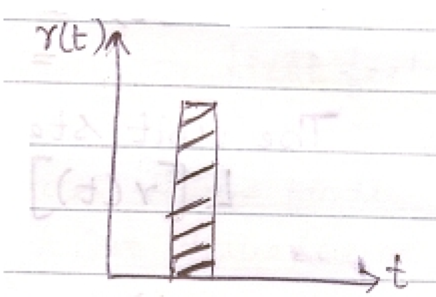
ii)Ramp :

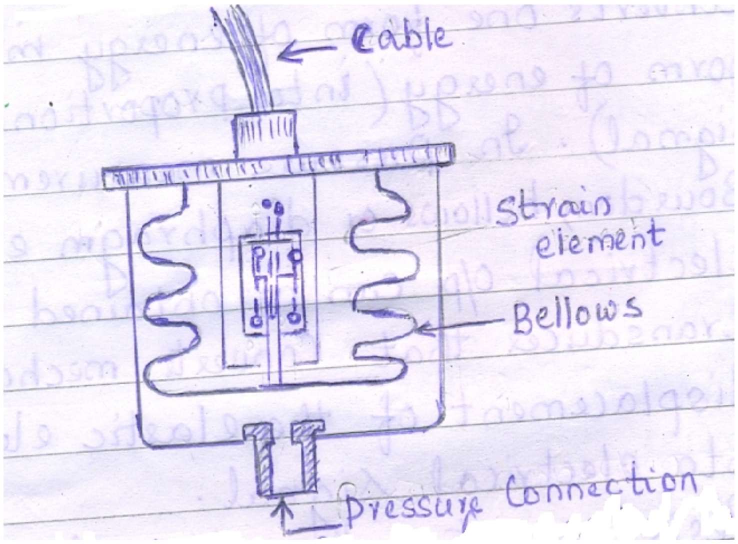


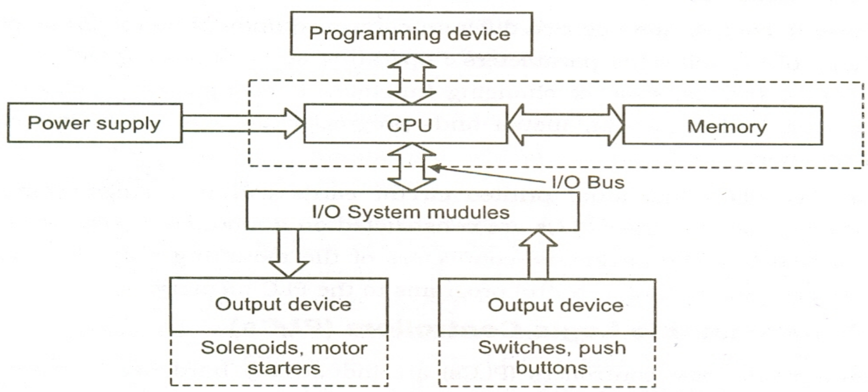
iii)Sinusoidal :

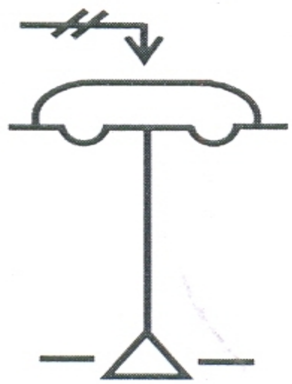
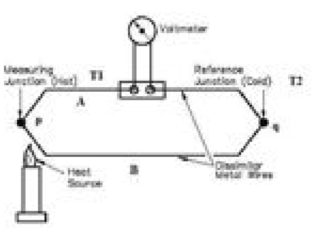


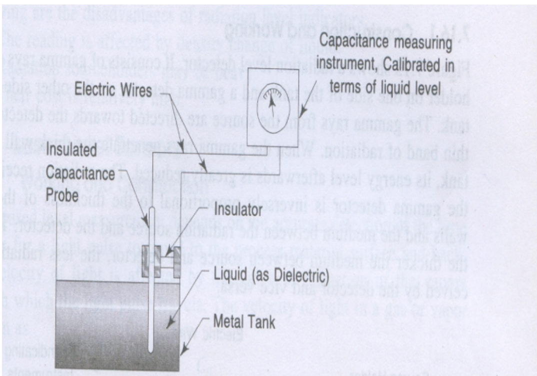
iv)Pulse:

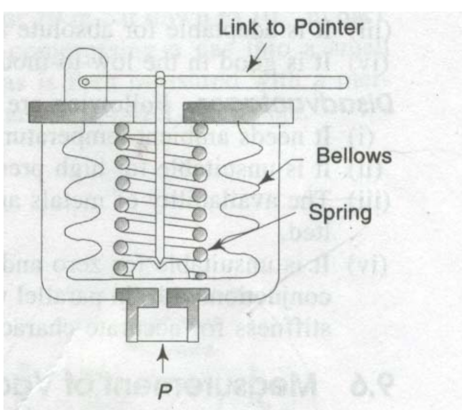


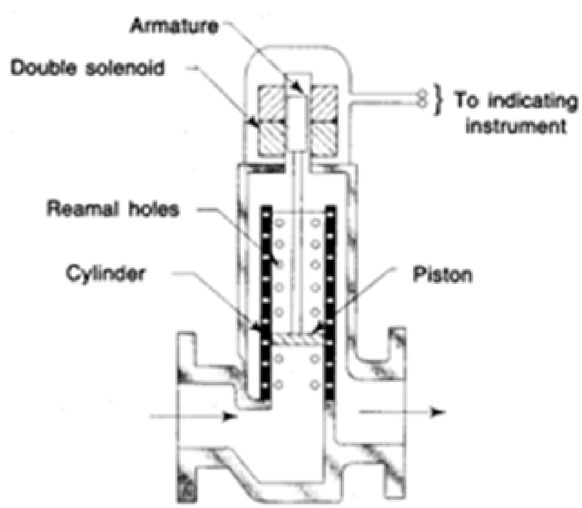
2-b	**Strain gauge:** **Diagram:**  **Principle**: Strain gauge consists of an elastic element and strain element attached to it. When pressure acting on elastic element changes, the strain element gets strained so that its length and cross sectional area changes which in turn changes its electrical resistance. This change in electrical resistance of strain element can be used for calibrating the instrument in terms of pressure.	2 2	4
2-c	**Function of valve positioner:** 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. **Function of valve actuator:** it is that 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.	2 2	4

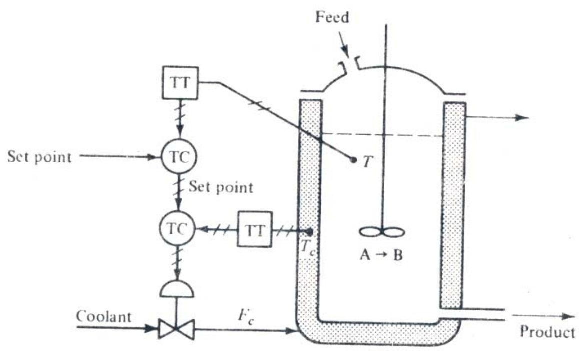
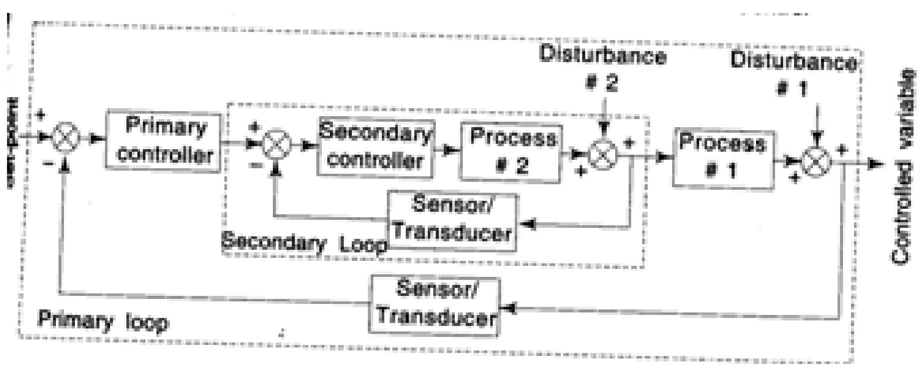
2-d	**Block diagram Of PLC:** 	4	4
2-e	**Application of PLC:** 1) PLC can be a vital part of industrial automation as it produces on/off voltage outputs to actuate elements such as electric motors, solenoids etc. 2) It can also be used in sequential controllers used for periodical on/off of fans, heaters 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
2-f	**Working of air to open control valve:**	4	4

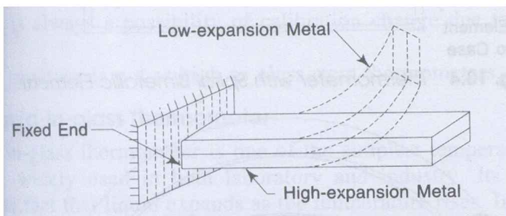
	 They are control valves operated through pneumatic actuators. It is designed in such a way that if the air supply fails, the control valve will be fully closed for safety requirement of the process. For eg if the valve is used to control steam or fuel flow, the valve should be completely shut off in case of air failure.		
3-a	**Seebeck effect:**  Thermocouple Circuit The Seebeck effect states that when two different or unlike metals are joined together at two junctions, an electromotive force (emf) is generated at the two junctions. The amount of emf generated is different for different combinations of the metals. **2) Peltier effect:** As per the Peltier effect, when two dissimilar metals are joined together to form two junctions, emf is generated within the circuit due to the different temperatures of the two junctions of the circuit.	2 2	4

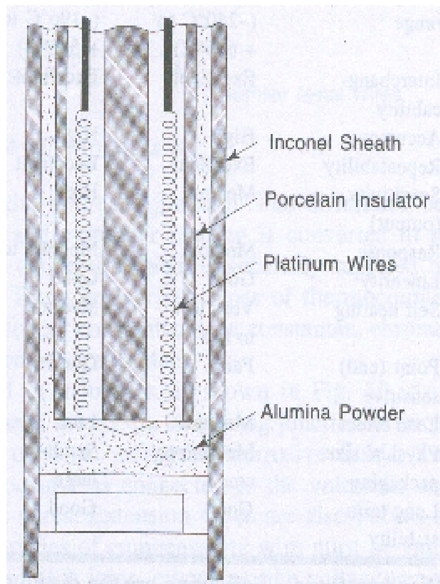
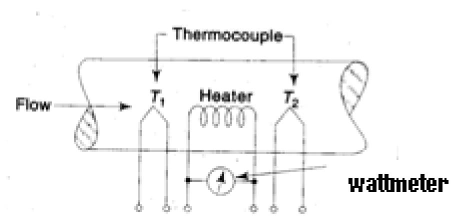
3-b	**Principle of capacitive level measurement:**  Fig. 7.12 Capacitance Level Indicator. The principle of operation of capacitance level indicator is based upon the familiar capacitance equation of a parallel plate capacitor given by $$C = K\frac{A}{D}$$ • Where • C= Capacitance, in farad • K= Dielectric constant • A= Area of plate, in m^2 • D= Distance between two plates, in m • From the above equation if A and D are constant, then the capacitance of the capacitor is directly proportional to the dielectric constant, and this principle is utilized in the capacitance level indicator. When the level in the tank increases or decreases the capacitance increases or decreases.	4	4
3-c	**Construction and working of bellows:**	4	4

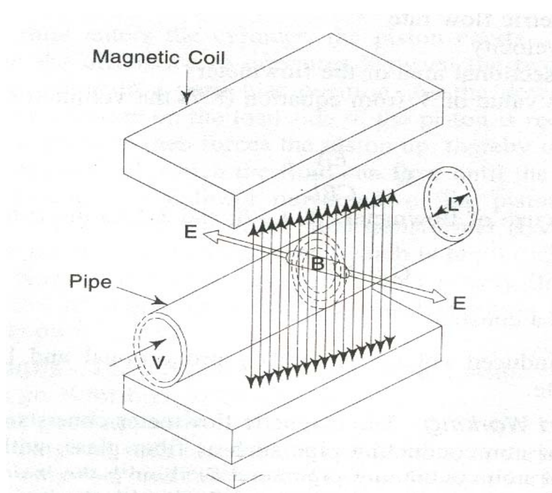
	Bellows are made of an alloy (phosphor bronze) which is ductile, has high strength and retains its properties over long use, i.e has very little hysteresis effect. In the above figure pressure is applied to one side of the bellow and the resulting deflection is counter balance by a spring. This arrangement indicates the gauge pressure. Spring opposed bellow elements are very sensitive and are quite useful in working signalling and tripping devices because of the considerable amount of movement for a given change in pressure. It is made of metallic bellows enclosed in a shell which is connected to pressure source. Pressure acting on the outside of the bellow compresses the bellows and moves its free end against the opposing force of the spring. A rod resting on the bellow transmits the motion to a pointer.  		
3-d	**Working of Piston type variable area meter:** Its operating principle is similar to rotameters. It consist of a cylinder and a piston fitted into it. A series of reamed holes are provided in the walls of the cylinder to provide passage for fluid flow as shown in the figure above.These holes are spaced helically around the cylinder in rows, to provide a continuous		4

	variation in area for various heights of the piston. By spacing the holes properly in the cylinder, the calibration of the instrument in made linear . As the weight of the piston is constant, the pressure differential is constant. The fow reading of the meter is transmitted using a reluctance – type transducer as shown in the figure below. 	2	
	Working: When the fluid enters the cylinder, the piston exerts a constant downwards force, and difference in pressures between the two sides of the piston places the piston in a particular position. As the down steam flow is increased, the pressure on the load side of the piston is reduced. The increased differential pressure then forces the piston up, thereby increasing the area of the openings through which the fluid can flow until the pressure differential is again balanced. The linear movement of the piston in the cylinder is sensed by LVDT.	2	

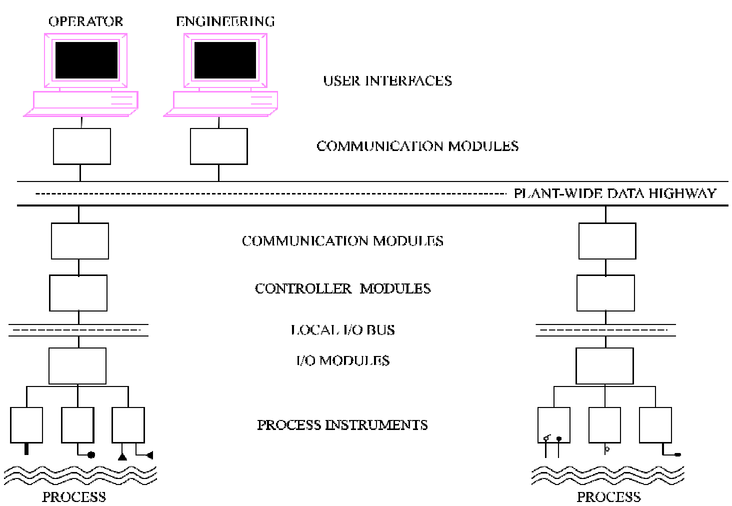
3-e	**Cascade control:**  (b) TT, temperature sensor and transmitter TC, temperature controller  • In cascade control we have one manipulated variable and more than one measurement • The control configuration with two loop is know as cascade control loop • In cascade control loop there is a primary controller and secondary controller • The output of primary controller is given as a set point to secondary	2 2	4

	controller. • Disturbance arising the secondary loop are corrected by the secondary loop before the affect the value of the primary controlled output.		
4A-a	**Bimetallic thermometer** **Diagram:**  Fig. 10.3 *Bimetallic Strips* **Working:** Bimetallic strip consists of two strips of metal such as invar and brass welded together, each strip made from a metal having a different coefficient of thermal expansion. Whenever the welded strip is heated, the two metals change length in accordance with their individual rates of thermal expansion. The two metals expand to different lengths as the temperature rises. This forces the bimetallic strip to bend towards the side with low coefficient of thermal expansion as shown in Fig above. If one end of the bimetallic strip is fixed so that it cannot move, the distance the other end bends is directly proportional to the square of the length of the metal strip, as well as to the total change in temperature, and is inversely proportional to the thickness of the metal. The movement of the bimetallic strip is utilized to deflect a pointer over a calibrated scale.	2 2	4
4A-b	**Resistance Temperature Detector:**	4	4

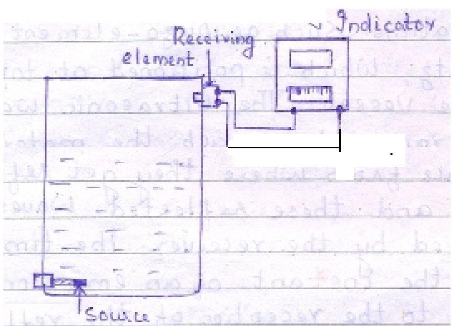
	 		
4A-c	**Working of thermal flow meter:**  A schematic diagram of a heat transfer flowmeter is shown in Fig. above, which consists of an electric immersion heater for the heating of flowing fluid. Two thermocouples (or resistance thermometers) T1 and T2 are placed at each side of the heater. The thermocouple T1 measures the temperature of fluid before it is heated, while the thermocouple T2 measures the temperature so after. The power supply to the heater equals the heat transferred to the fluid, i.e. Q, and is measured by a wattmeter. Thus by measuring the values of Q, T1 and T2 the flow rate W of liquid is determined from the equation $W=Q/Cp(T_2-T_1)$ Where	4	4

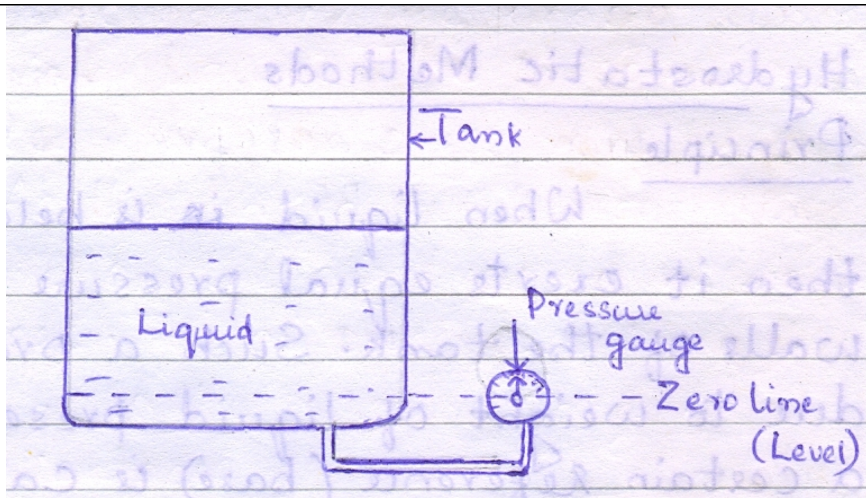
	Q=heat transfer W= mass flow rate of fluid Cp= specific heat of fluid T_1=initial temperature of the fluid after heat has been transferred T_2=final temperature after heating the fluid		
4A-d	**Principle of Magnetic Flow meter**  The meter utilize the principle of Faradays 's Law of Electromagnetic Induction for making a flow measurement. In magnetic flow meter electrically conducting liquid works as the conductor. The induced voltage is given by the equation 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	4	4

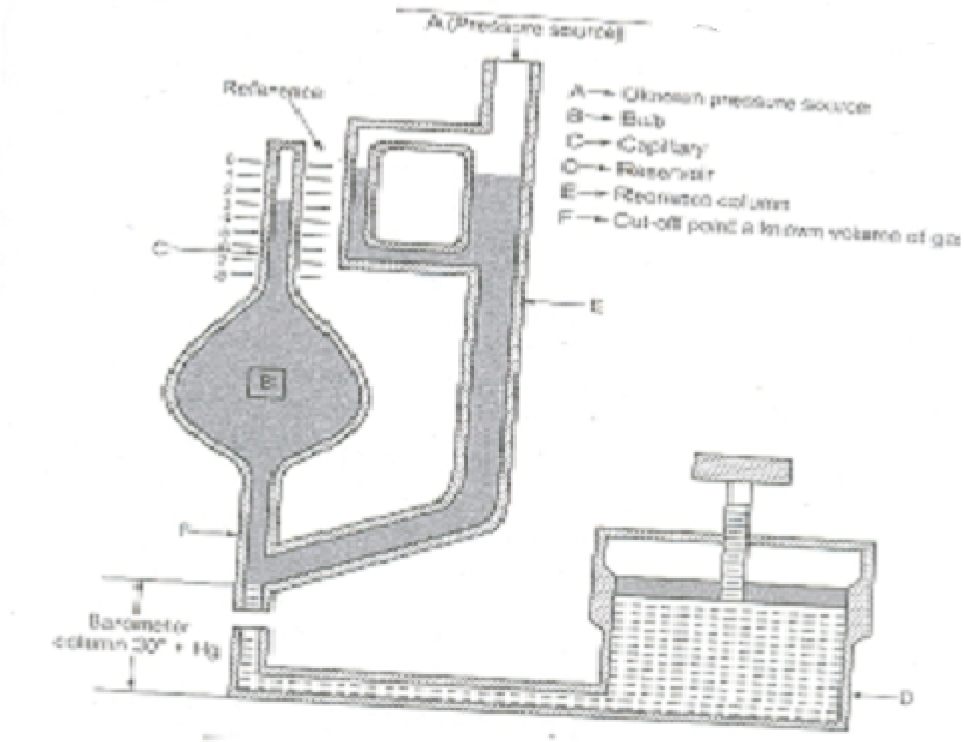
	V = velocity of the conductor in m/sec. Q = VA Q = Volumetric flow rate V = fluid velocity A = Cross sectional area of flowmeter If K = A / CBL Where A , C, B and L becomes constants Thus Q = KE **VOLTAGE is directly proportional and linear with VOLUMETRIC FLOW RATE.**		
4B-a	The basic steps in control valve selection 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.	1 mark each	6

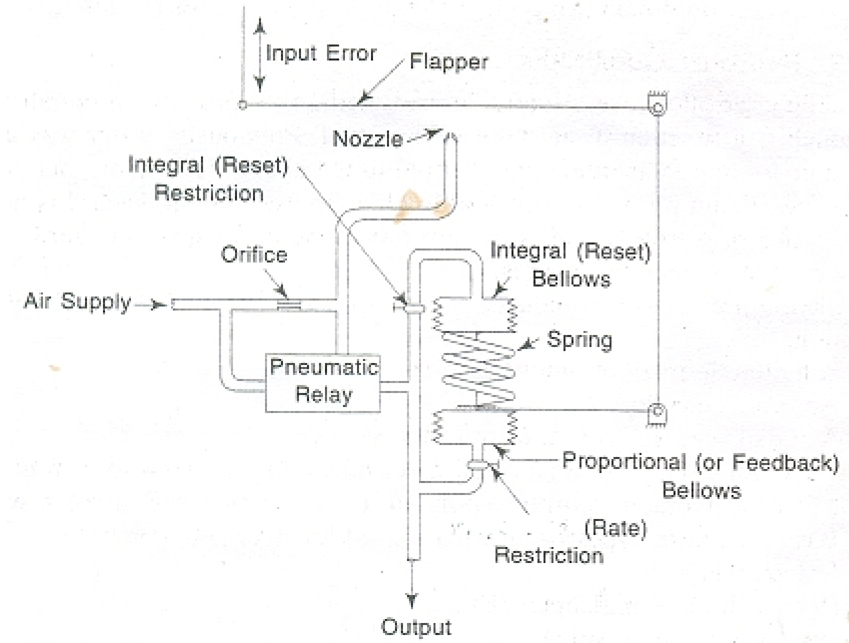
	4. The valve body can be selected. The valve size is either equal to the pipe size or slightly less, for example, a 3-inch pipe with a 2-inch globe valve body. When the valve size is smaller than the process piping, an inlet reducer and outlet expander are required to make connections to the process 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	DCS architecture:  A DCS is made up of many independent control modules that can operate	3	6

	simultaneously and independently. It has the ability to carry out rapid communications between these and other modules of communications link called a real-time data highway. There are six generic functional modules: 1) Input/ Output or I /O modules scan and digitize process instrument input/ output data. Some may perform elementary simple logic. 2) The local I/O bus links I/O modules to controller modules. 3) Controller modules read and update field data and perform control calculations and logic to make process changes. 4) User interface include operator interfaces and engineering workstations. 5) The data highway is a plant-wide communications network. 6) Communications modules provide a link between the data highway and other modules, typically controller modules and user interface.	3	
5-a	**Elecromagnetic flow meter:** **Advantages :** 1. Low pressure drop 2. Used for measuring the flow of slurries in which the liquid phase is electrically conductive. 3. Can be used for measuring the flow rate of corrosive fluids provided a suitable lining material is used. 4. Can handle small as well as large flow rates. 5. Flow measurement is not affected by viscosity, density and temperature of the fluid. **Disadvantages:** 1. Can be used for measuring the flow rate of conductive fluids only. 2. Insulating line is subjected to damage when abrasive fluids are handled.	1 mark each for any two 1 mark	4

	3. Expensive 4. It must be well protected when used in electrical areas to prevent explosion hazards. 5. It can't be used for metering gases, steam, petroleum products because they have low electrical conductivity	each for any two	
5-b	**Nuclear radiation method** is used for measuring the level of corrosive and abrasive liquids. **Working:**  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 3	4
5-c	**Pressure gauge method** **Diagram**	2	4

	 **Construction and working.** A pressure gauge is located at the zero level of the liquid in the tank. Any rise in level causes an increase in pressure, which can be measured by the gauge. The gauge scale is marked in units of level measurement.	2	
5-d	**McLeod gauge:** **Principle:** It operates on the principle of compressing a known volume of low pressure gas to high pressure and measuring the resulting change in volume. **Diagram:**	1 3	4

			
5-e	i) 10atm=10^6pa ii) 10atm =10bar iii) 10atm =7600 mm of Hg iii) 10atm = 10Kg_f/cm^2	1 mark each	4
6-a	**Pneumatic PID controller** **Diagram**		8



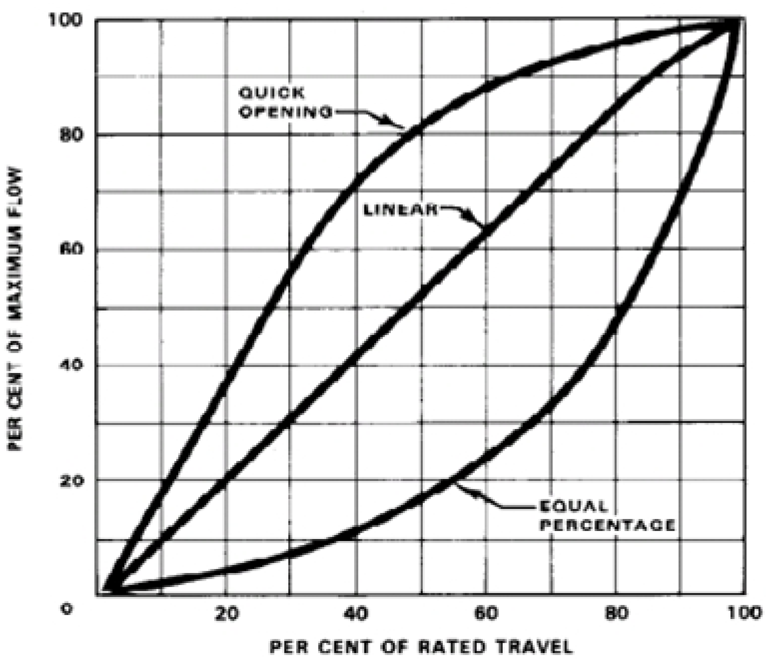
3

Description

It consists of a nozzle flapper assembly and a relay. As the input error increases baffle is moved towards the nozzle increasing the control output through the relay. This change in output pressure is applied to the bellows further closing the nozzle and increasing the output to the maximum. The nozzle back pressure iscontrolled by the nozzle flapper distance. A derivative restriction is introduced into the line leading to the feedback bellows. The addition of an integral (reset) bellows and the addition of an adjustable restriction (integral restriction) calibrated in time units, provide reset or integral control action. Reset or integral action increases the gain of the controller.

5

Greater the restriction imposed upon the flow of air to the feedback bellows, greater will be the pressure drop across the restriction and greater will be the increase of pressure due to derivative action. The rate at which integral action is applied depends on the rate at which air flows through the integral restriction.

	By causing both positive and negative feedback to lag the output pressure, both rate and reset action may be obtained which is known as PID control action.		
6-b	**Valve Characteristics:** 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.  **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	3 5	8

	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 heating and cooling medium. **Installed flow characteristics** are plotted when 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 • For on – off control • When maximum valve capacity must be obtained quickly.		
6-c	**Elements of computer aided process control hardware:**		8

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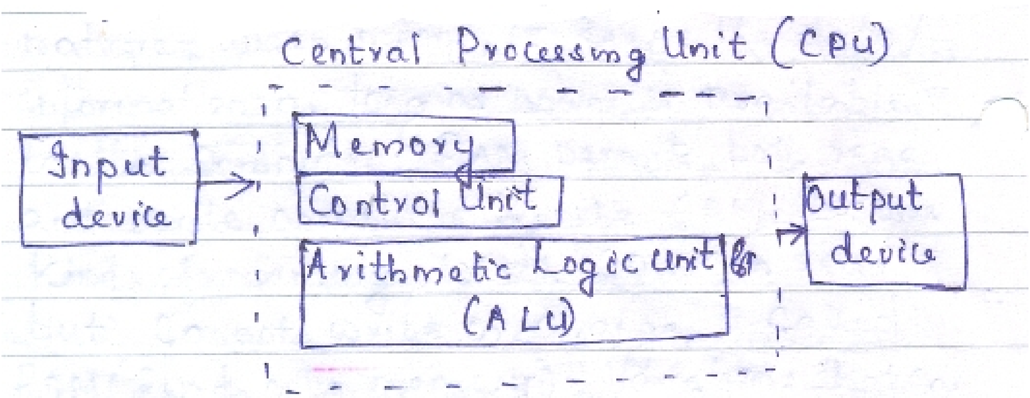
To make the computer useful for measurement and control, it should be equipped with suitable hardware and additional features such as ability of efficient and effective communication with both plant and operating personnel, capability of rapid execution of tasks (algorithm) to provide for real time control action



Computer aided process control hardware consists of four basic parts or subsystems.

1. Central Processing Unit(CPU)
2. Storage device
3. Input/ Output device
4. Bus interface

The Central Processing Unit(CPU) consists of control unit, arithmetic logic unit (ALU) , main memory(Primary storage) and general purpose registers. Computer fetches data from primary memory under the command of control unit. It places these in one of the registers, performs arithmetic operations using ALU based on application program requirements, saves them temporarily in accumulator(a type of register) and transfers it finally to primary storage after calculations / operations are over. The processed data is further transferred to input/output devices (I/O) as per the requirements of application program.
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	Storage: They are of three types- 1.Main storage or immediate access storage: It is a high speed random access memory (RAM) which is volatile in nature, which means it keeps the data as long as power is available to the computer. 2.Auxiliary or secondary memory (suchas tape or disk): It is nonvolatile and provides bulk storage 3. Cache memory :It is an auxiliary memory used in the process control computer for improvements in performance and utilization. **Input/output devices:** It is the sub system through which the CPU communicates with the outside world. The input-output (IO) devices of process control computers are divided into three types. (1) Operator IO devices: It is used to communicate with the operators (people). Process operators uses devices as keyboards, push button, switches etc to input data or command to the computer and they receive information from computer via devices such as VDU(Visual Display Unit),LED (Light Emitting Diode), numerical display etc. (2) Process IO devices : They communicate directly between CPU and all plant devices such as sensors, limit switches etc for input and control valves, motor starters etc for output. These devices are connected to the computer through ADC and DAC subsystem to convert them into analog or digital as the case may be. (3) Computer IO devices. These devices directly communicate with the CPU for data and information exchange with the peripheral devices. **Bus interface:** A bus is an electronic pathway in the computer that provides a communication path for data to flow between the CPU and its memory and amongst the CPU and the various peripheral devices connected to the computer. A bus contains one wire for each bit needed to specify the address of a device		

	or location in memory plus additional wires that distinguish among the various data transfer operations to be performed.		