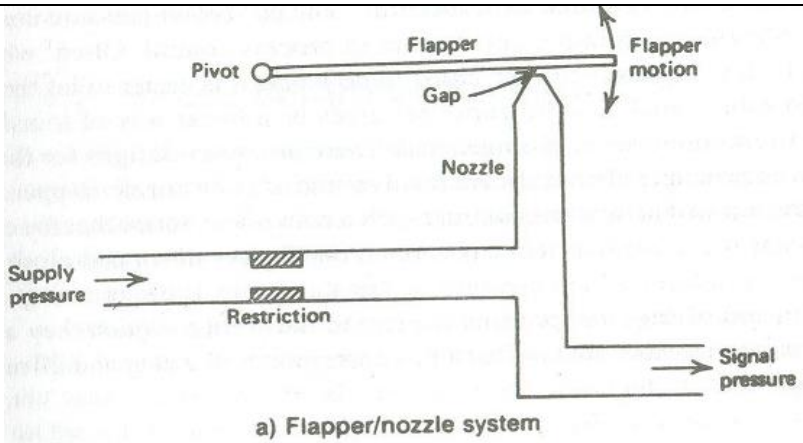
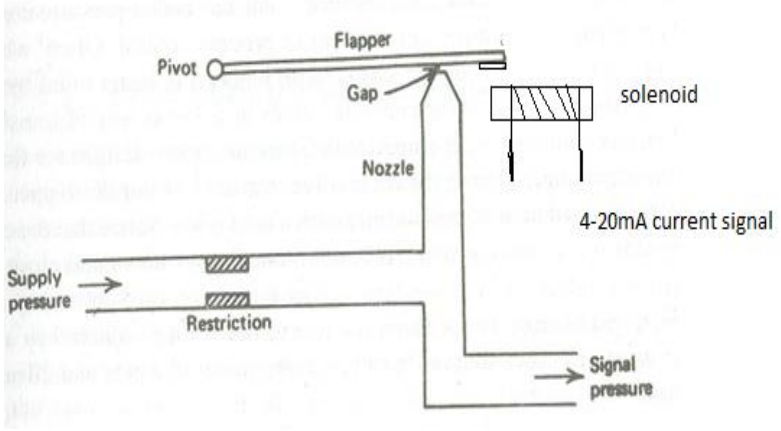
Important Instructions to examiners:

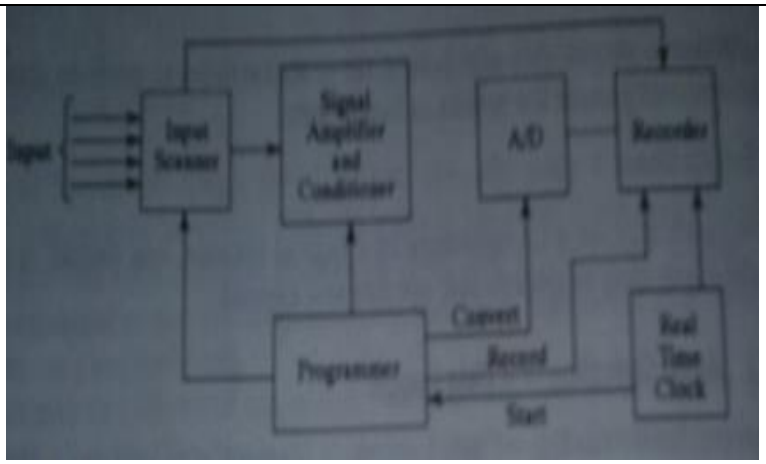
1) The answers should be examined by keywords and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not 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	Question & its answer	Remark	Total marks
01 A)	**Attempt any THREE of the following**		12
a)	**Define Process Control System (PCS). Give the classification of process variables involved in PCS.**	04	
Ans.	**Definition of process Control System:-** A Combination of components/systems that act together and perform a certain control objective to control industrial processes may be called a process control system. **Classification of Process variables:** Some of the normally controlled process variables associated with process industries are, 1) Temperature 2) Flow 3) Level 4) pressure	**02 marks for definition** **02 marks for classification**	
b)	**Draw and explain the flapper-nozzle system.**	04	
Ans.	Diagram of flapper-Nozzle system:	**02 marks for diagram**	

	 a) Flapper/nozzle system **Explanation:** It consists of a fixed orifice restriction and a variable nozzle restriction in series. A flapper is pivoted near the nozzle. Pressurized air is fed into the nozzle through the orifice and the air is ejected from the nozzle towards the flapper through clearance 'X'. The nozzle diameter must be larger than the orifice diameter. As the flapper approaches the nozzle (gap is reduced) restriction to the flow of air through the nozzle increases and thus the nozzle back pressure 'Pb' also increases. If the nozzle is completely closed by the flapper the nozzle back pressure becomes equal to the air supply pressure 'Ps'.	**02 marks for explanation**	
c)	**State the need of converts in process instrumentation. List the four examples of converters.**	**04**	
Ans.	**Need of Converters:** Following are the circumstances when a converter is required for signal transmission 1. For forming link between electronic and pneumatic system. 2. If field devices are pneumatic operated and controllers are electronic type in nature. 3. Field control signal feedback is pneumatic and interfaced with DCS/PLC in control room. 4. Transmission of signal over large distance. 5. If field area is hazardous in nature. 6. Input to electronic controller 7. Converting the measurand from one electrical form to another	**02 marks for need**	

	List of converters: 1) Current to pressure converter (I/P) 2) Pressure to current converter (P/I) 3) Voltage to current converter (V/I) 4) Current to voltage converter (I/V) 5) Resistance to voltage converter (R/V)	**02 marks for list**	
d)	**State the need of Data Acquisition System(DAS). State its four industrial applications.**	**04**	
Ans.	**Need of data Acquisition system:** Data Acquisition systems interface between the real world of physical parameters, which are analog and the artificial world of digital computation and control. With the current emphasis on digital systems, the interfacing function has become an important one. Digital systems are used widely because, they are low cost, accurate and relatively simple to implement. In addition there is a rapid growth in the use of micro computers to perform difficult control and measurement functions. Computerized feedback control systems facilitates reliability and greater productivity. DAS Systems does the process of collecting physical parameters related to process/ environment in digital form as rapidly, accurately and economically as necessary. DAS systems can be custom made to suit various applications in both favourable and hostile environments, to perform tasks oriented more towards making sensitive measurements.	**04 marks**	
01 B)	**Attempt any ONE of the following**		**06**
a)	**Draw and explain the construction and working of current (I) to Pressure(P) converter. State its industrial usage.**	**06**	
Ans.	**Diagram of I/P Converter:**	**02 marks for diagram**	

	 **Construction & Working:** The I/P converter consists of a movable flapper which is positioned against an open nozzle. The current signal to be converted is connected to a solenoid which is kept near the flapper. Flapper is attached with a soft iron piece near the solenoid. This makes the flapper move according to changes in the current signal. This movement of the flapper increases or decreases the distance between flapper and nozzle. The T section pipe with nozzle is supplied with the constant air pressure of 20 psi through a restriction of orifice. When the current is 4mA, flapper is away from nozzle, therefore, distance is maximum which generates very low back pressure. Device is calibrated by adjusting the spring tension on flapper in such a way that the back pressure is 3psi when the current measured is 4mA. When the current is max. ie., 20mA flapper comes very near to nozzle; therefore distance is minimum which generates very high back pressure. This back pressure is 15 psi o/p pneumatic signal. Thus an I/P converter converts 4-20mA into 3-15 Psi. **Usage:** To supply pneumatically operated field devices, eg. Pneumatic control valves.	**03 marks for working** **01 mark for usage**	
b)	**Draw the block diagram of data logger, explain its working and state its two applications.**	**06**	
Ans.	**Block diagram of Data Logger:**	**02 marks for diagram**	



Working:

Data logger is a digital recording system that automatically make a record of the readings of instruments located at different parts of the plant. It measures and record data effortlessly, quickly and accurately. It can measure electrical output of any sensor. Various functions include,

1) Scan channels sequentially
2) Accept input from any electrical sensor
3) Eliminate error
4) Log the data in scientific units

The input scanner is operated by a scanner drive for selecting the input channels in sequence. The signals are conditioned to match the output of transducer to that of the ADC input requirements. ADC convert analog signal from the scanner into digital, which are compatible to programmer. The programmer does control of the overall operation from scanner to recording data. Recorder permanently records the digital data by any type of recorder. Data may be printed on paper or recorded in digital form.

03 marks for working

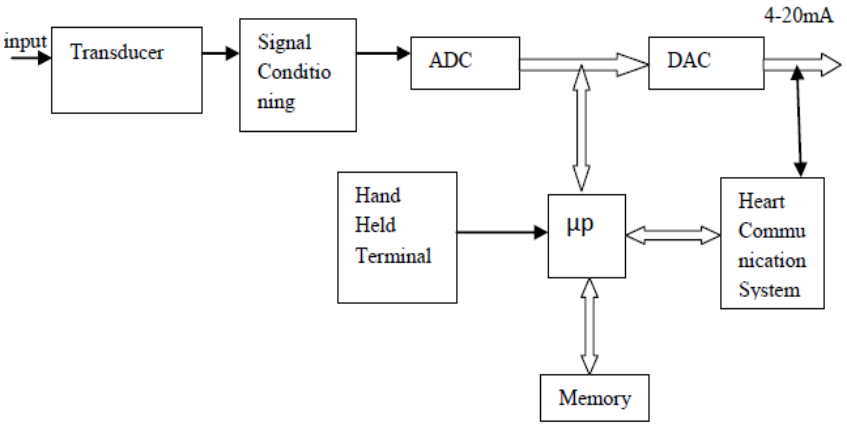
Application:

Data loggers are used to scan and record data at a fast rate in,

1) Power generation plants
2) Petrochemical installations
3) Continuous process plants
4) Engine testing
5) Component evaluation

01 mark for application

(½ mark each)

02	**Attempt any TWO of the following**		**16**
a)	**Draw the block diagram of SMART transmitter and explain its four salient features.**	**08**	
Ans.	**Block diagram of SMART Transmitter:**  **Salient features(any Four):** 1. Wider range of span due to microprocessor. 2. Less error due to increased rangeability. 3. Can change engineering units, zero, span and range. 4. Can be provided with standby sensors or multiple sensors. 5. Allows 2-way communication with the control room. 6. Automatic span switching. 7. Inclusion of control functions and other algorithm due to microprocessor in the SMART. 8. They can memorize and recall tag number, location and specification of transducers. 9. Measurement data can be expressed in engineering unit. 10. Linearization, characterization and correction of the characteristic of transducer are possible due to the microprocessor.	**04 marks for diagram** **04 marks for features**	
b)	**Name the different types of control panels. Explain in detail any two control panels.**	**08**	
Ans.	**According to shape of structure** 1) Vertical flat panel 2) Slant top section 3) Standing console	**02 marks for types**	

4) Desk console
5) Break front panel
6) Operator console

03 marks for Break Front panel

Break Front panel: It allows greater use of front plane board. In this instrument located in lower rows are angled upwards to convenient height. The top portion of panel is angled downwards to an angle normal to line of sight allowing better visibility. The additional rows of instrument obtained with this layout on the overall panel length. The higher instrument density however significantly reduces space for maintenance and for mounting. It occupies small space counter room.

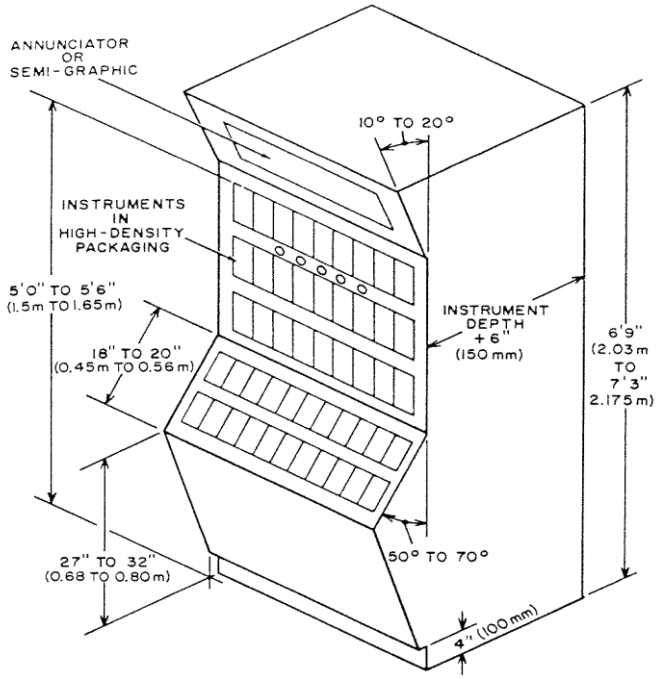


Fig.1 Break front panel

03 marks for Flat panel

Flat panel: It is less expensive, simple to describe and equal to construct.
The straight vertical plane of panel allows an orderly. Layout of electrical work, tubing arrangement and miscellaneous equipment.
Instrument and auxiliary equipment components' can be arranged so that all are accessible for maintenance and calibration. This type of panel requires more control space.

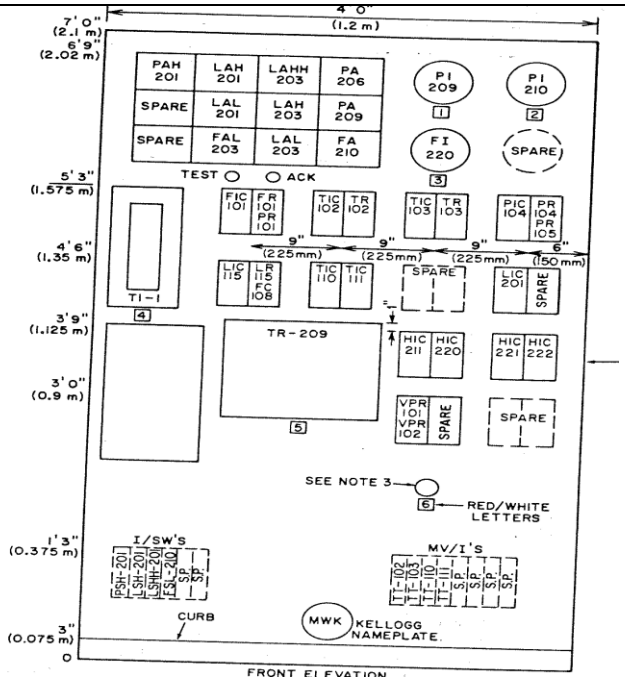
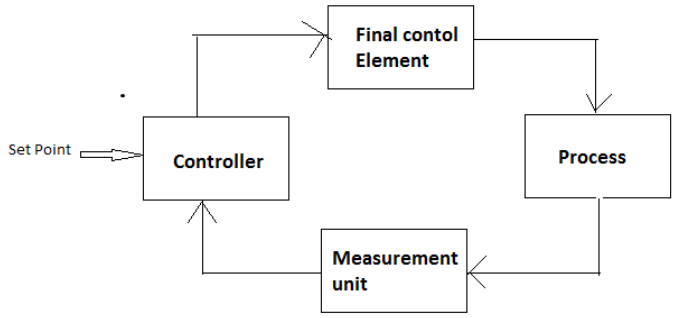


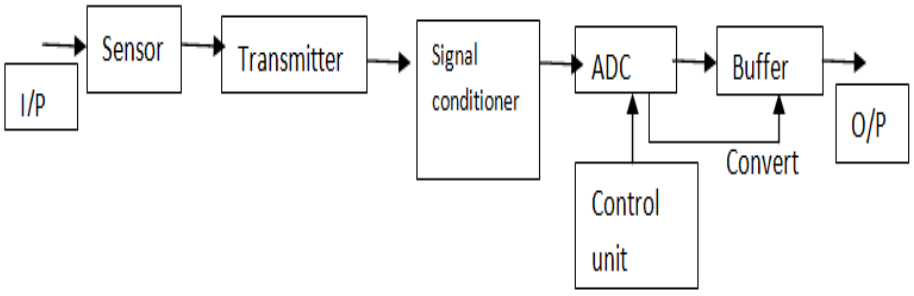
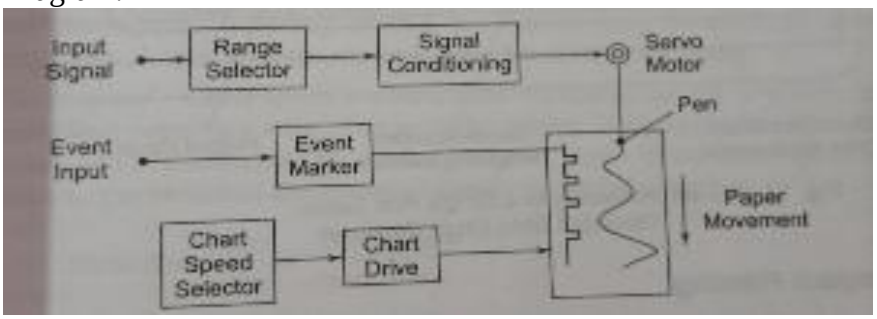
Fig.2 Flat panel

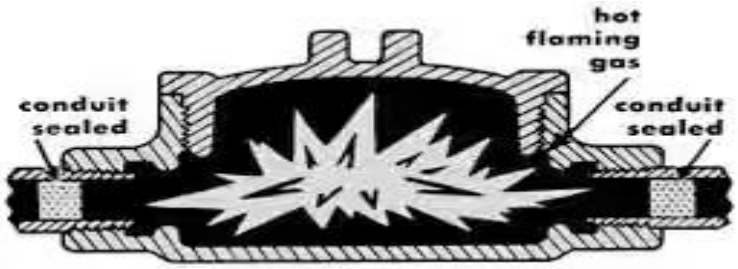
(Any other suitable diagram and type can be considered.)

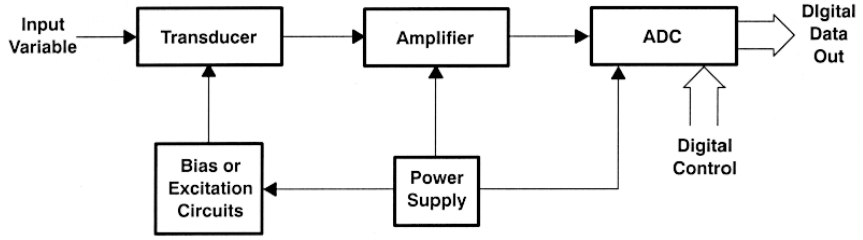
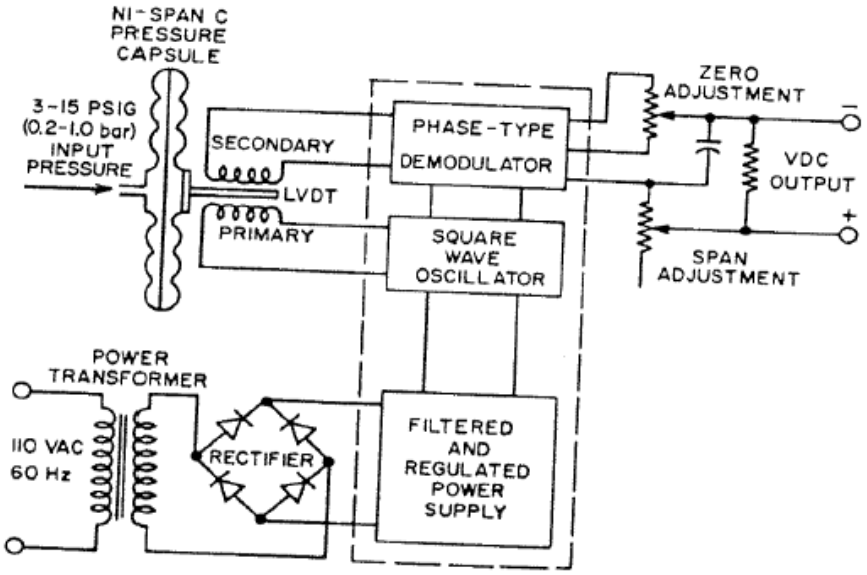
c)	**Define Hazardous area. Explain in detail classification of hazardous area according to material classification as per NEC standard.**	**08**	
Ans.	**Definition of Hazardous Area:** Any area in which there are fine particles or dust subject to explosion or spontaneous combustion is present is called a hazardous area. **Classification according to NEC:** According to NEC hazardous locations are broadly divided in terms of the kind & degree of hazard. The kind of hazard is specified by class & group. The degree of hazard is designated by division. For example, typical industrial locations may be classified as 1) Class I, group D, Division 1 2) Class II, Group G , Division 2 3) Locations that are not classified as div. I or 2 is considered non-hazardous. Area | Area Description	**02 marks for definition** **06 marks for description**	

		Designation		
		Class I	Locations made hazardous by flammable gases or vapour	
		Class II	Locations made hazardous by combustible dusts	
		Class III	Locations made hazardous by combustible fibers &flying	
		Division I	Locations which may contain hazardous mixtures under normal operating conditions.	
		Division II	Locations in which the atmosphere is normally non-hazardous but may become hazardous under abnormal circumstances such as equipment failure, failure, failure of ventilating systems.	
		Group A	Atmosphere containing acetylene.	
		Group B	Atmosphere containing hydrogen or equivalent gases or vapors of manufactured gas having an equivalent hazard.	
		Group C	Atmosphere containing ethyl/ether vapours, ethylene or cyclopropane.	
		Group D	Atmosphere containing gasoline, hexane, benzene, butane, propane, alcohol, acetone, benzol, lacquer solvent. Natural gas.	
		Group E	Atmosphere containing metal dust, including aluminium, magnesium or other metals of similar hazard.	
		Group F	Atmosphere containing carbon black, coal or coal dust.	
		Group G	Atmosphere containing flour, starch, grain dust	
03	**Attempt any FOUR of the following**			**16**
a)	**Draw the block diagram of feedback control system for process system and explain in brief.**		**04**	

Ans.	**Diagram:**  **Process :** It is natural or artificial progressively continuing operation that may be consisting of series of control actions. In industrial world, process refers to as an interacting set of operations that lead to the development of some product. **Measurement :** Measurement is necessary for control purpose because unless measurement one cannot judge at what level the process variable is to be maintained. This block consists of sensor and signal conditioner, which conditions the feedback signal in to the suitable form for the controller. **Controller :** This is the brain of control system that compares output signal with reference signal (set point) and accordingly commands the final control element to take corrective action. **Final Control Element :** Final control element alters the process conditions according to the control signal. Generally control valve is used as final control element in process industries.	**02 marks for Diagram** **02 marks for explanation**	
b)	**Explain the documents required for designing the control panel.**	**04**	
Ans.	1. Contractor or user generally furnishes drawing, schematic & diagram that develop physical design of panel. 2. Typically document that are required for designing of controi panel are Panel layout drawing, Schematic wiring diagram, Module wiring diagram. 3. Panel layout drawing contains the front view, rear view, side view, top view & bottom view of panel. 4. It covers all dimensional requirements from all side of the panel. 5. It also clarify cable entry either top or bottom with all dimensions. 6. Panel layout shows all MCB, TB position also cable tray layout with dimensions. 7. The schematic wiring diagram splits into power wiring and control wiring. 8. It shows actual wiring connection from MCB to terminal block. 9. It covers wiring gauging or specification for individual connection.	**04 marks for explanation**	

	10. Module Wiring diagram specifies detail wiring of module or device which is placed in or on the panel 11. It cover both power and control wiring details		
c)	**Draw and explain the block diagram and working of single channel DAS.**	**04**	
Ans.	 A single channel DAS consists of a sensor, transmitter and signal conditioner followed by an ADC, performing repetitive conversions at a free running, internally determined rate. The outputs are in digital code. The digital outputs are further fed to storage or a printer, or a computer for analysis.	**02 marks for Diagram** **02 marks for explanation**	
d)	**Draw and explain the block diagram and working of strip chart recorder.**	**04**	
Ans.	Diagram:  Strip chart recorders are those in which data is recorded on continuous roll of chart paper moving at constant speed. The recorder records the variation of one or more variable with respect to time. The basic element of strip chart recorder consist of a pen (stylus) used for making marks on movable paper , a pen driving system , a vertical moving roll chart paper and chart paper drive mechanism and a chart selector switch as shown in diagram Most recorder uses a pointer attached to stylus, so that the instantaneous value of quantity being recorded can be measured directly on calibrated scale.	**02 marks for Diagram** **02 marks for explanation**	

	Most strip chart recorder use a servo feedback mechanism to ensure that the displacement of pen across the paper tracks the input voltage in the required frequency range. A potentiometer system is generally used to measure the position of the writing head. The chart paper drive system generally consists of a stepping motor which controls the movement of chart paper at uniform rate. **(Any other relevant diagram can be considered)**		
e)	**Draw and explain how explosion proof enclosures protect the instruments in hazardous area.**	**04**	
Ans.	**Diagram:**  1. The principle behind explosion-proof transducers and wiring is that any ignition of flammable material that occurs within the transducer or wiring will be contained. The hot gasses and flames will not be allowed to escape into the hazardous area and further propagate the fire or explosion. 2. All circuit wiring is run in conduit and junction boxes approved for explosion-proof installation. Explosion prevention is always preferable to explosion protection, particularly where an explosion is likely to result in emission of toxic material. 3. The material released from an explosion relief vent typically includes quantities of the original, unburnt substance in addition to combustion products. Alternative mitigation measures are available, including explosion suppression, or building the plant strong enough to withstand the anticipated explosion pressures. **(Any other relevant point can be considered)**	**02 marks for Diagram** **02 marks for explanation**	
04 A)	**Attempt any THREE of the following**		**12**
a)	**Draw and explain the construction and working of electronic temperature transmitter.**	**04**	
Ans.	**Temperature transmitter block Diagram:**	**02 marks for Diagram**	

	 1. A temperature transmitter combines a temperature sensor like RTD or thermocouple and transmitter in the same instrument. 2. The sensor measure temperature while transmitter amplifies and transmits the signal to the monitoring system or a control room. 3. A temperature transmitter measure temperature and convert it into a current signal of 4-20 mA that is proportional to temperature measured. 4. The two wire temperature transmitter accept a thermocouple or 3 wire PT-100 input and convert temperature into 4-20 mA current signal. **5.** The transmitter usually require a 24 V DC power supply. 6. The temperature signal is amplified by amplifier. **7.** The amplified temperature signal can be transmitted via long cable or converted into a digital format using analog to digital convertor. **(Any other relevant diagram can be considered)**	**02 marks for explanation**	
b)	**Draw and explain the construction and working of pressure (P) to current (I) converter. State its two applications.**	**04**	
Ans.	**Diagram of P/I converter:** 	**02 marks for Diagram**	

	Description: The input pressure to be converted is applied to a corrugated type capsule pressure sensor. It gives mechanical deformation of free end when input pressure applied increases. As the free end is connected to core of LVDT, the displacement of capsule sensor displaces the core. Primary winding of LVDT is excited by square wave oscillator. The o/p voltage between two secondary windings of LVDT is given to phase detector circuit. The reference signal for this circuit is given from square wave oscillator. The dc o/p voltage of Phase detector circuit is connected with zero adjustment and span adjustment circuit. **Application of P to I**: 1. If transmitter is installed in hazardous area, signal can transmit in pneumatic format in hazardous area and in safe can be converted in to current signal. Here P to I is must. 2. All pressure sensor or flow sensor works on differential pressure require P to I convertor to convert pressure or flow to current 4-20 ma signal	**01 mark for description** **01 mark for application**	
c)	**Explain in brief IP classification for enclosures.**	**04**	
Ans.	**Definition of IP code:** It is an international classification system defines the level of protection provided by enclosures to prevent the ingress of foreign objects and moisture into an electrical equipment. The classification system uses the "IP" code, or "Ingress Protection" code, to define the level of seal. The IP code uses a system of two numerical digits to define the level of both foreign object and moisture protection. The first digit of the IP code indicates the degree of protection against solid foreign objects from entering the electrical device. The second digit of the IP code indicates the degree of protection against the ingress of various forms of moisture (e.g. drip, spray, submersion, etc.) into the equipment. Eg. IP 65 or IP 34. **Degrees of Protection (Foreign Bodies) – 1st Digit(First Letter)**	**02 marks for first letter description**	

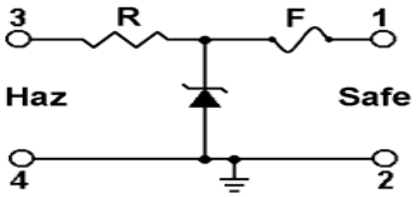
IP Level 1st Digit	Description of Protection Level
0	Not protected
1	Protected against solid foreign objects of 50 mm diameter and greater
2	Protected against solid foreign objects of 12,5 mm diameter and greater
3	Protected against solid foreign objects of 2,5 mm diameter and greater
4	Protected against solid foreign objects of 1,0 mm diameter and greater
5	Protected from the amount of dust that would interfere with normal operation
6	Dust tight

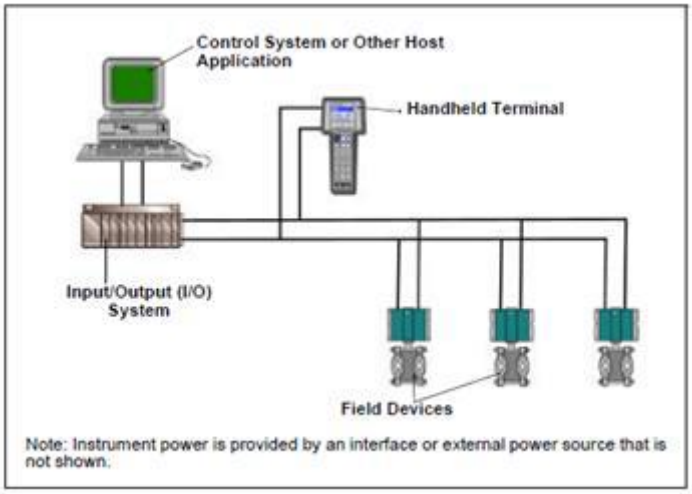
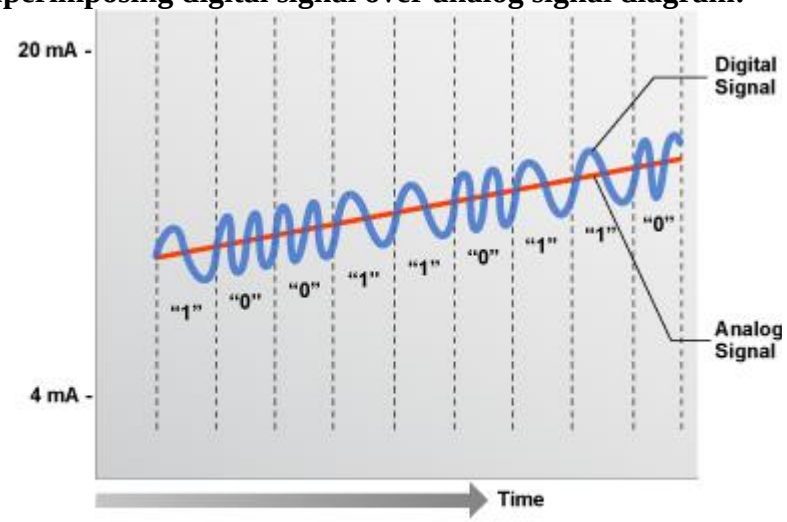
Degrees of Protection (Moisture) – 2nd Digit (Second Letter)

IP Level 2nd Digit	Description of Protection Level
0	Not protected
1	Protected against vertically falling water drops
2	Protected against vertically falling water drops when enclosure is tilted up to 15°
3	Protected against water sprayed at an angle up to 60° on either side of the vertical
4	Protected against water splashed against the component from any direction
5	Protected against water projected in jets from any direction
6	Protected against water projected in powerful jets from any direction
7	Protected against temporary immersion in water
8	Protected against continuous immersion in water, or as specified by the user

02 marks for second letter description

d)	**Explain how zener diode based intrinsic safety barrier protects control room instruments in hazardous plant.**	**04**	
Ans.	1. Zener barrier devices limit the availability of energy to the wiring in the hazardous area. 2. The figure here illustrates the internal schematic of a basic zener barrier.	**03 marks for explanation**	

	 3. The zener diode in the center of the circuit acts to clamp the voltage available to the circuit in the hazardous area. 4. Zener diodes are used because they have a very high resistance until the voltage rises to their conduction voltage. 5. Once in conduction the diode "clamps" the voltage to a maximum value. 6. It is this property of the zener diode that is exploited for use in instrumentation circuits in hazardous areas. 7. The resistor, R, limits the maximum current available to the hazardous area circuit wiring. Since the voltage and the current are limited, the power is, therefore, also limited. 8. As an additional safety method, the barrier device also contains a fuse. 9. The fuse will act to limit the current through the barrier circuit in the event that either the resistor or the zener should fault.	**01 mark for diagram**	
04 B)	**Attempt any ONE of the following**		**06**
a)	**Explain in detail HART communication technique. Draw the superimposing digital signal over analog signal.**	**06**	
Ans.	HART ("Highway Addressable Remote Transducer") is a communication protocol designed for industrial process measurement and control applications. It is called a hybrid protocol because it combines analog and digital communication. It can communicate a single variable using a 4-20 ma analog signal, while also communicating added information on a digital signal. The digital information is carried by a low-level modulation superimposed on the standard 4-to-20 mA current loop. The digital signal does not affect the analog reading because it's removed from the analog signal by standard filtering techniques. The HART communication protocol is based on the *frequency shift keying* (FSK) principle. In point-to-point mode, the traditional 4–20 mA signal is used to communicate one process variable, while additional process variables, configuration parameters, and other device data are transferred digitally using the HART protocol. The 4–20 mA analog signal is not affected by the HART signal and can be used for control in the normal way. The HART communication digital signal gives access to secondary variables and other data that can be used for operations, commissioning, maintenance, and diagnostic purposes.	**03 marks for explanation**	

	 **Superimposing digital signal over analog signal diagram:**  Digital over Analog	**03 marks for diagram**	
b)	**Draw and explain the block diagram and working of X-Y recorder. Name its 2 applications.**	**06**	
Ans.	**Diagram:**		

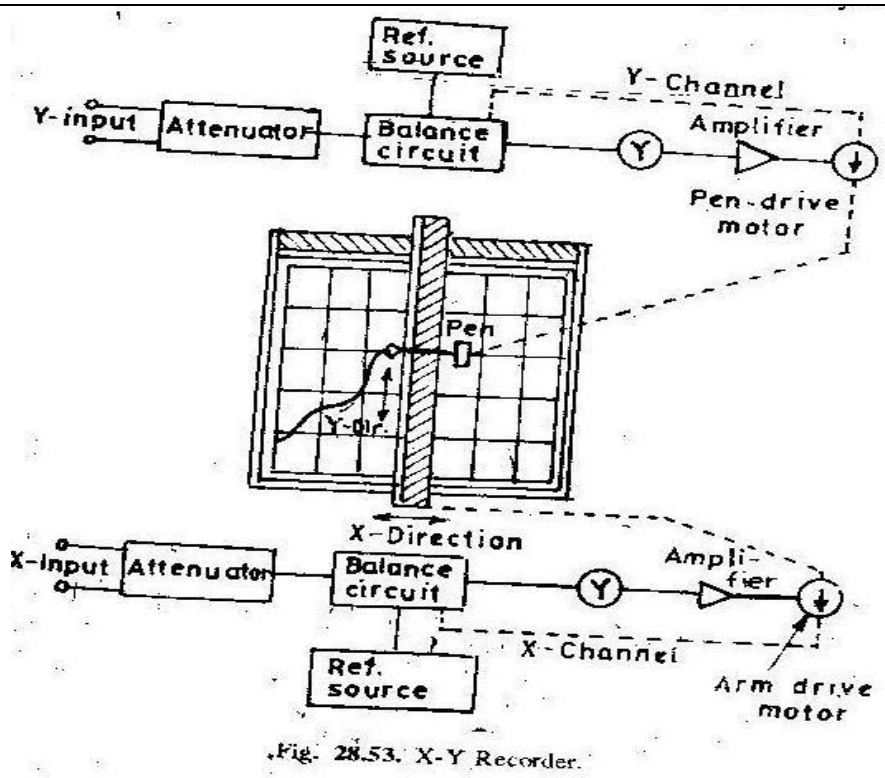


Fig. 28.53. X-Y Recorder.

02 marks for Diagram

02 marks for explanation

A strip chart recorder records the variations of a quantity with respect to time while X-Y recorder is an instrument which gives a graphic record of the relationship between two variables.

In strip recorders, usually self-balancing potentiometers are used. These self-balancing potentiometers plot the emf as a function of time. In X-Y recorders, an emf is plotted as a function of another emf. This is done by having one self-balancing potentiometer control the position of the rolls. While another self-balancing potentiometer controls the position of the recording pen.

In some X-Y recorders, one self-balancing potentiometer circuit moves a recording pen in the X direction while another self-balancing potentiometer circuit moves the recording pen in the Y direction at right angles to the X direction, while the paper remains stationary.

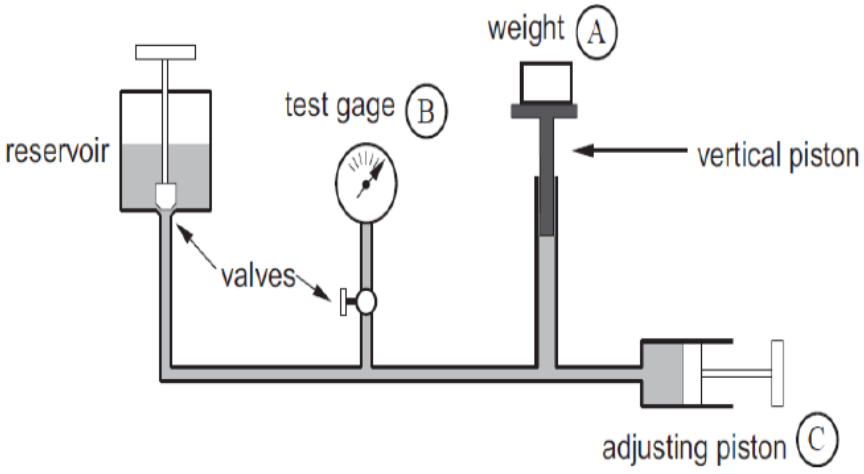
There are many variations of X-Y recorders. The emf, used for operation of X-Y recorders, may not necessarily measure only voltages. The measured emf may be the output of a transducer that may measure displacement force, pressure, strain, light intensity or any other physical quantity. Thus with the help of X-Y recorders and appropriate transducers, a physical quantity may be plotted against another physical quantity.

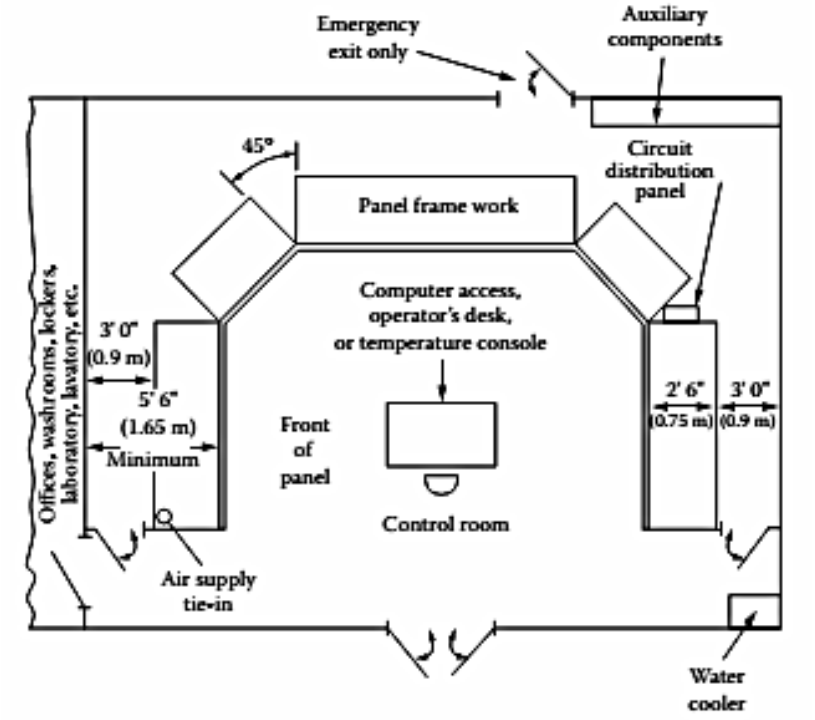
02 marks for application

(½ mark each)

Applications:

1. Speed torque characteristic of motors.

	2. Regulation curves of power supply. 3. Plotting characteristics of active devices such as vacuum tube, transistors, zener diode, rectifier diode etc 4. Plotting stress strain curves, hysteresis curve etc. 5. Electrical characteristics of material such as resistance versus temperature		
05	**Attempt any TWO of the following**		**16**
a)	**State the need of calibration. Explain the calibration procedure for pressure gauges using Dead weight Tester (DWT).**	**08**	
Ans.	**Need of calibration:** 1. Calibration of the instrument is needed to increase the accuracy of the instrument. 2. Calibration of the instrument gives increased production. 3. Calibration increases the product quality. 4. Calibration gives reduced product give away. 5. Calibration reduces product liability. **Calibration procedure for DWT** **Pressure gauge calibration arrangement:**  **(Any other relevant diagram can be considered.)** **Explanation:** For calibration purposes, 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	**02 marks (½ mark each) any four point** **03 marks for Diagram** **03 marks for explanation**	

	piston floats freely within the cylinder between stops .The errors in a dead weight tester is less than 0.1% In order to reduce the friction between the piston and the cylinder, the piston is generally rotated while a reading is being taken. No oil must enter the gauge when testing oxygen pressure gauges, because the oil vapor together with the oxygen will produce an explosive mixture for pressure up to 300psig, oxygen gauges may be tested with water or air.		
b)	**Draw the control room layout. Describe any six ergonomic considerations for designing control room.**	**08**	
Ans.	**Control Rom Layout:**  *Traditional control room layout.* **Ergonomic Considerations:** i. The control room itself must be so designed that only those operations necessary for the control of the plant are performed there. ii. The operators must not be distracted by un-associated functions. iii. The room should have limited access and should not act as a passageway. iv. Equipment must be arranged in such a way that unauthorized	**02 marks for Diagram** **01 mark each** **(any six points)**	

	personnel cannot tamper with the instruments or with the auxiliaries mounted close by. v. In the control room, air conditioning and room pressurization must be provided. Aside from ensuring operator comfort, maintaining a constant ambient temperature at the instruments will also minimize signal drift. vi. Room pressurization is used where the plant atmosphere is explosive or flammable. The control room is pressurized by admitting into it fresh and clean air from a safe area. This permits the reduction of the area classification from either "hazardous" or "semi-hazardous" to unclassified, with commensurate savings in instrument and installation cost. vii. The illumination in the control room must be of a level consistent with close work. The lighting intensity of the panel should average 75 foot-candles (807 lx) across its face. The back of the panel area should be lighted to 30 foot-candles (322.8 lx). viii. The lighting system should be designed to minimize reflections on instrument cases, and point sources of light should be avoided. Continuous fluorescent lighting, placed behind egg crate-type ceiling fixtures, will give adequate light and will minimize annoying highlights. ix. The most advantageous ratio of panel length to control room area is obtained by bending the panel to a U shape. Right-angled bends of the panel, as opposed to 45-degree bends, should be avoided. The slightly increased panel length that could be gained by the use of right angles is negated by the interference to opening instrument doors or withdrawing the chassis. Also, operators can monitor a greater length of panel if it bends around them.		
c)	**Name the different types of Alarm annunciator. Draw the schematic of typical alarm annunciator and explain its operational sequence.**	**08**	
Ans.	**Types of annunciator:** 1. Integral Annunciators 2. Remote Annunciators 3. Semi graphic Annunciators **Schematic of typical alarm annunciator:**	**02 marks for types** **02 marks for diagram**	

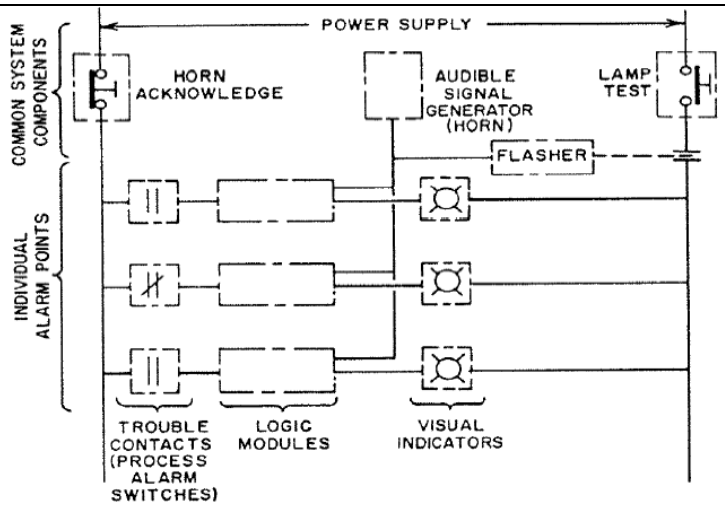
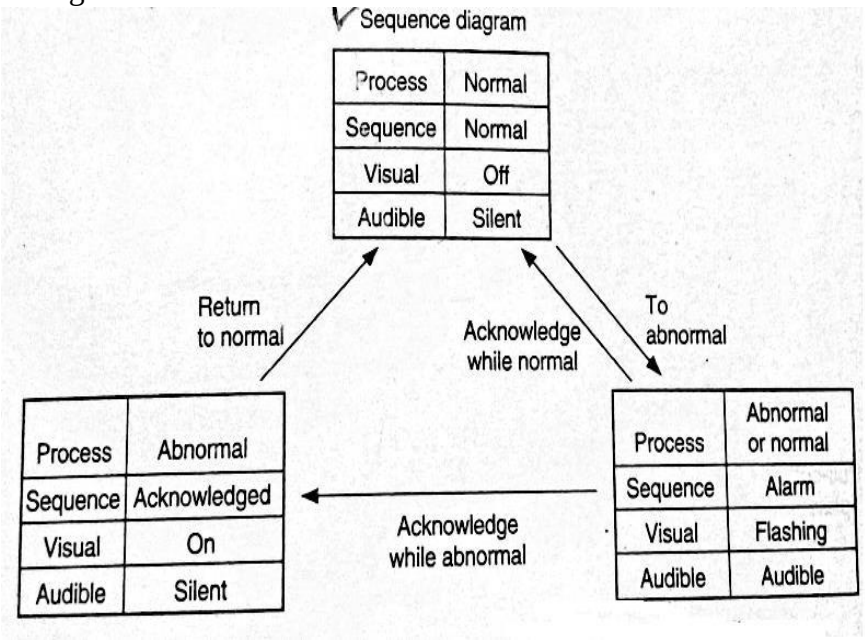


FIG.
Elements of basic annunciator system.

04 marks for operation

Operational Sequence:

Typically an annuciator sequence may proceed as follows: During normal, all visual and audible devices are quiescent. Upon an abnormality (off normal or alarm condition), an audible device, such as horn will sound.The horn thus advices an attendant or operator that an alert condition exists. The name plates that flash direct the attendant to their specific points which are in the alarm stage.



Each alarm point is synonymous with the circuit it is monitoring and the associated nameplate with its engraved message-describing the function being monitored.

Attendant response to the foregoing events involves pressing an

	acknowledgement push button. This results in silencing the horn as well as changing the flashing lights to a steady on state. The later will remain illuminated as long as the point remains off-normal. If the new points are alarmed, the horn will sound again and the back lighted windows associated with their alarm will flash. Note that the flashing mode. distinguishes newly alarmed point from those off normal points acknowledged previously and whose lights remain steady on. Upon acknowledgement, once again the audible device is silenced and all points which remain steady on lights. An operational (full-function) test can be accomplished by pressing a test push button.		
06	**Attempt any FOUR of the following**		**16**
a)	**List the different process characteristics (any four). Explain any one of process characteristics in brief with neat diagram.**	**04**	
Ans.	Process Characteristics: 1) Process equation 2) Process lag 3) Process lead 4) Self-regulation. **Explanation of any one process characteristics** **i) Process Equation:** A process control loop regulates some dynamic variables in a process. This controlled variable, a process parameter, may depend on many other parameters in the process and suffer changes from many different sources. We have selected one of these other parameters to be our controlling parameter. If a measurement of controlled variable shows a deviation from the setpoint, then the controlling parameter is changed which in urn changes the controlled variable. As an example consider the control of liquid temperature in a tank, as shown in figure. The controlled variable is the liquid temperature, *Tt*. This temperature depends on many parameters in the process e.g. the liquid input flow rate via pipe *A*, the output flow rate via pipe *B*, the ambient	**02 marks for characteristics** **02 marks for explanation** **(any one)**	

temperature, *Ta*, the steam temperature, *Ts*, inlet temperature, *To*, and the steam flow rate, *Qs*. In this case the steam flow rate is the controlling parameter chosen to provide control over the variable (liquid temperature). If any one of the other parameter changes results in a change in temperature. To bring the temperature back to the setpoint value, we change only the steam flow rate i.e. heat input to the process. This process could be described by a process equation where liquid temperature *Tt* is a function as

$$Tt = F\ (Qa,\ Qb,\ Qs,\ Ta,\ Ts,\ To)$$

Where, *Qa, Qb* = flow rates in pipe A and B
Qs = steam flow rate
Ta = ambient temperature
To = inlet fluid temperature
Ts = steam temperature

To provide control via *Qs*, we do not need to know the functional relationship exactly, nor do we require linearity of the function. The control loop adjusts *Qs*, and thereby regulates *Tt*, regardless of how the other parameters in equation above vary. In many cases, the relationship of equation above is not even analytically known.

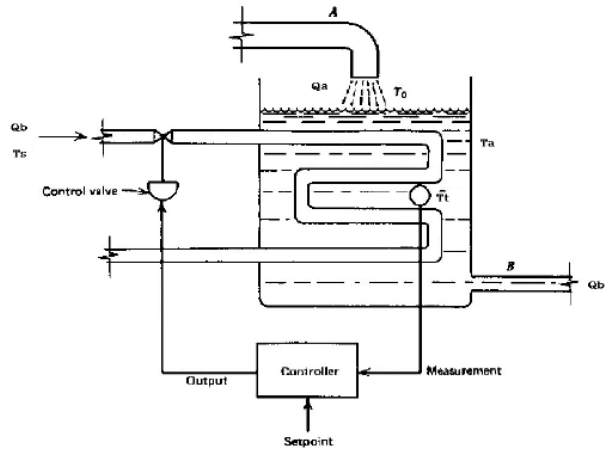


Fig. Control of temperature by process control

OR

ii) Process Load:

From the process equation, or knowledge of and experience with the process, it is possible to identify the set of values for the process parameters that results in the controlled variable having the setpoint value. This set of parameters is known as a nominal set. The term process load refers to this set of all parameters, excluding the controlled variable. When all parameters have their nominal values, we speak of nominal load on the system. The required controlling variable value under these conditions is the nominal value of that parameter. If the setpoint is changed, the controlled parameter is altered cause the variable to adopt this new operating point. The load is still nominal, however because the other parameters are assumed to be unchanged. Suppose one the parameters changes from nominal, causing a corresponding shift in the controlled variable. We then say that a process load change has occurred. The controlling variable is adjusted to compensate for this load change and its effect on the dynamic variable o bring it back to the setpoint. In the example of figure, a process load change is caused by a change in any of the five parameters affecting liquid temperature. The extent of load change on the controlled variable is formally determined by process equation such

as equation. In practice, we are concerned only that variation in the controlling parameter bring the controlled variable back to the setpoint. We are not necessarily concerned with the cause, nature, or extent of the load change.

OR

iii) Process Lag:

Process control operations are essentially a time variation problem. At some point in a time, a process load change or a transient causes a change in the controlled variable. The process control loop responds to ensure that, some finite time later, the variable return to the setpoint value. Part of this time is consumed by the process itself and is called the process lag. Thus, referring to figure above, assume the inlet flow is suddenly doubled. Such a large process load change radically changes (reduces) the liquid temperature. The control loop responds by opening the steam inlet valve to allow more steam and heat input to bring the liquid temperature back to the setpoint. The loop itself reacts faster than the process. In fact, the physical opening of the control valve is the slowest part of the loop. Once steam is flowing at the new rate, however, the body of liquid must be heated by the steam before the setpoint value is reached again. This time delay or process lag in heating is a function of the process, not the control system. Clearly, there is no advantage in designing control systems many times faster than the process lag.

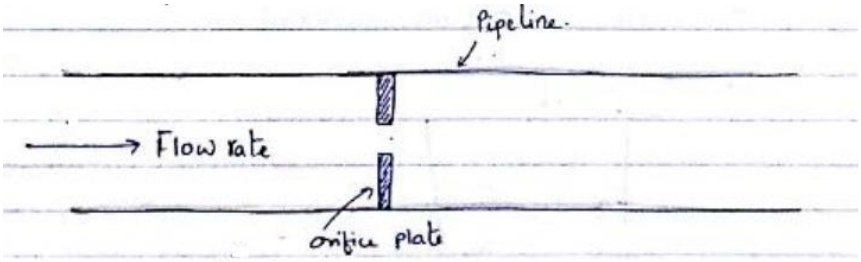
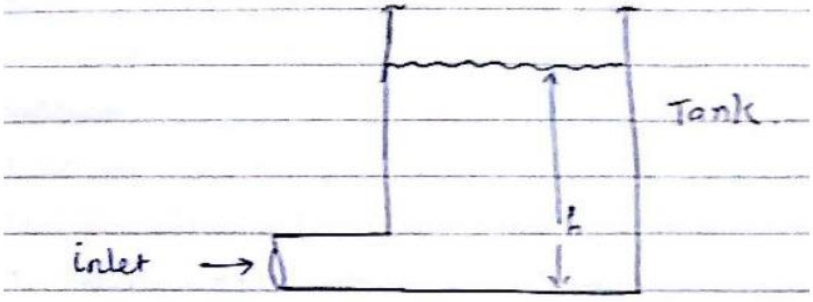
OR

iv) Self Regulation:

A significant characteristic of some process is the tendency to adopt a specific value of the controlled variable for nominal load with no control

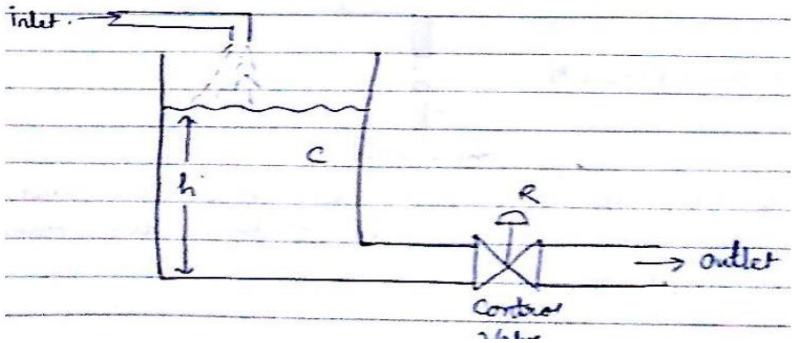
operations. The control operations may be significantly affected by such self regulation. The process in figure above has self regulation as shown by the following argument.

1. Suppose the steam valve is fixed at 50% and open the control loop so that no change in valve position is possible.
2. The liquid heats up until the energy carried away by the liquid equals that input energy from the steam flow.
3. If the load changes, a new temperature is adopted (because the system temperature is not controlled).
4. The process is self regulating, however, because the temperature will not "run away", but stabilize at some value under given conditions.

b)	**Define process dynamics and Explain.**	**04**	
Ans.	The mathematical modeling and theoretical analysis of processes depends on certain dynamics that describe a process. Every process contains one or more such dynamic elements. Therefore the different elements with which a mathematical model may be formulated for a process are: 1. Resistance element 2. Capacitance element 3. Time constant element 4. Oscillatory element 5. Dead time element **1.resistance element :**  Figure shows the section of a pipeline in which the orifice plate is inserted. The insertion of orifice plate creates the obstruction to fluid. This resists the flow rate of fluid in the pipeline. Therefore in this system is resistance element system. **OR** 2. Capacitance element:  Capacitance is the ability of a system to store charge, mass or energy. An example of capacitance element is a tank with inlet as shown. The flow of the fluid into the tank is the output. This ability of the tank to store liquid is capacitance.	**02 marks for definition** **02 marks for explanation** **(any one)**	

OR

3.Time constant element :



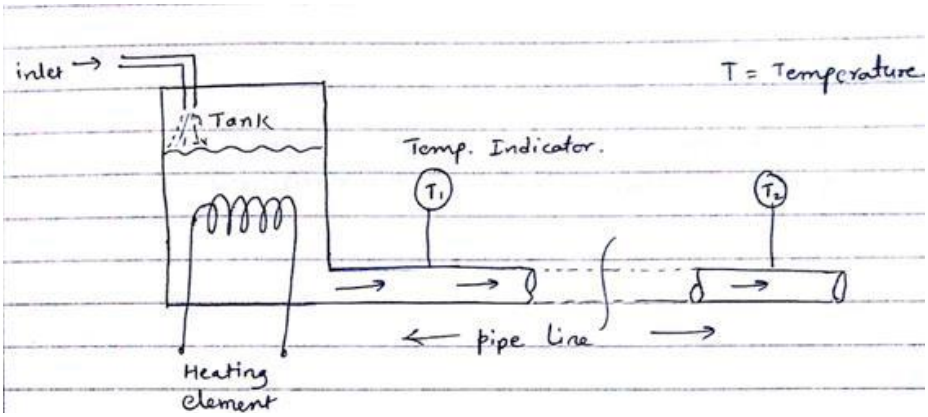
A combination of a resistance and capacitance element result in a time constant process. Those parts of the process that have the ability to store energy are termed as capacitance element and those parts that resist the transfer of energy or mass are termed as resistance element.
Hence in a process if there is a combination of both these elements then it is called a time constant process. Consider a liquid level system as shown. The capacitance is the ability of the tank to store fluid and resistance element is introduced at the outlet in the form of control valve.
The amount of liquid stored is proportional to net flow.

OR

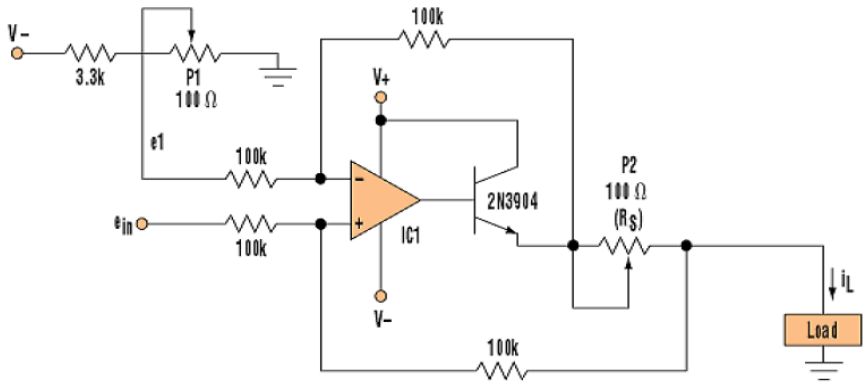
4.Oscillatory element :
His element is a typical characteristic of a higher order system. It can be proved that the response of a second order system show oscillations about the steady state value of input. fig is an example of an oscillatory element system.

OR

5.Dead time element



	A phenomenon often encountered during transfer of mass or energy is called dead time.it is also called transportation lag. Consider the above System where hot water is to be passed through a tube having uniform cross section. In this system , when hot water is transferred from one point to another no process action takes place, which creates the dead time in the process.		
c)	**State the need of foundation field bus. Name its types and give their specifications**	**04**	
Ans.	**Need :** 1. To reduce the wiring complexity. 2. To increase the speed of operation. 3. To reduce downtime. 4. To achieve self-diagnostics and calibration of the devices. 5. To enable remote operation of the devices. 6. To reduce the cost of the operation. **Types :** There are two types of foundation field bus : 1. H1 bus 2. High speed Ethernet (HSE) **Specification** 1. H1 bus operates on 31.25kbps speed 2. HSE bus operates on 100/1000Mbps 3. It replaces 4-20mA standard. 4. Uses bulk power supply 5. HSE supports IEEE 802.3 Ethernet Standard. **(Any other relevant specification can also be considered.)**	**02 marks for need** **01 mark for types** **01 mark for specification**	
d)	**Draw and explain working of voltage to current convertor.**	**04**	

Ans.	**Diagram:**  **Explanation:** This conventional circuit gives 4 to 20 mA of output for an input of 0 to 1V. First adjust P1 for zero (4mA), then P2 for span (20mA). The circuit needs a positive and negative supply (+,-15v). At the input, ein - e1 = IL RS Therefore, the load current is: $I_L = \frac{e_{in} - e_1}{R_s} = \frac{e_{in}}{R_s} - \frac{e_1}{R_s}$ The first term is proportional to the input voltage ein, and the second term is a constant. Here, e1 is derived from the negative power-supply through a potentiometer: IL = ein/RS + (-e1)/RS RS is selected so that the first term (ein/RS) gives 16 mA for full-scale input voltage, and the potentiometer is adjusted so that the second term provides a constant 4 mA. In effect, the output ranges from 4 to 20 mA corresponding with zero to full input voltage. 2N3904 is a NPN BJT acting as a low power (100mA) switch. **(Any relevant diagram can be considered)**	**02 marks for diagram** **02 marks for explanation**	

e) **Compare between any two types of DAS(4 points).** **04**

Ans.

Sr. No.	Single channel DAS	Multichannel DAS
1	This deals with data acquisition of only one parameter at a time.	This can acquire data from multiple devices at a time.
2	Resolution is lesser than multichannel DAS	We get improved resolution in multichannel DAS.
3	It has got limited application area	It has wide application area since available in different ranges i.e. 4 , 8,16 channel module.
4	It require more space as compare to multichannel DAS	This requires less space as compare to single channel DAS.
5	Single channel DAS is comparatively costly.	Multichannel DAS is comparatively less costly

01 mark each point

(Any other relevant point can be considered)