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:**		**12**
(a)	**List four different types of process characteristics. Describe any one in brief.**		**04**
Ans.	**Process Characteristics:** i) Process Equation ii) Process Load iii) Process Lag iv) Self Regulation **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	**½ Mark for each characteristic** **02 Marks for Description (any one characteristic)**	

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.

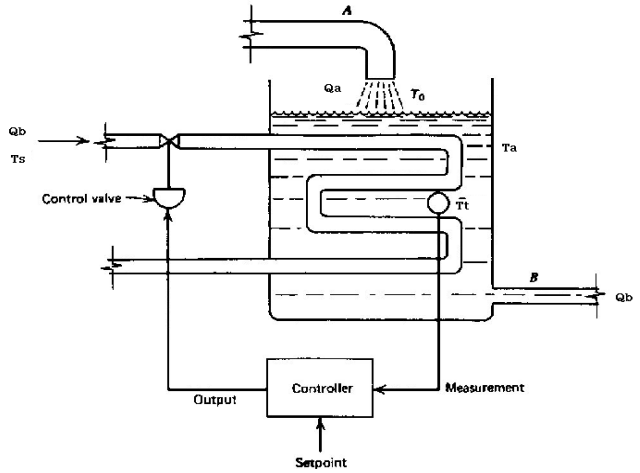


Fig. Control of temperature by process control

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.

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.

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.

An example of a process without self regulation is a tank from liquid is pumped at a fixed rate. Assume that the influx just matches the outlet rate. Then the liquid in the tank is fixed at some nominal level. If the influx increases slightly, however, the level rises until the tank overflows. No self regulation of the level is provided.

(b) **State the difference between Strip Chart and X-Y Chart recorder.(any four points)** **04**

Ans.

S. N.	**Strip Chart Recorder**	**X-Y Chart Recorder**
1	Data is recorded w.r.t. time	Data is recorded one input w.r.t. another input
2	The paper is movable	The paper(graph) is stationary
3	It requires only one servo-motor to drive the pen stylus	Requires two servomotor one for pen(stylus) & other for arm.
4	Used to record any physical variable w.r.t. time	Used to plot speed torque & diode characteristic

01 Mark each point (Any four points)

(Any other relevant point can be considered)

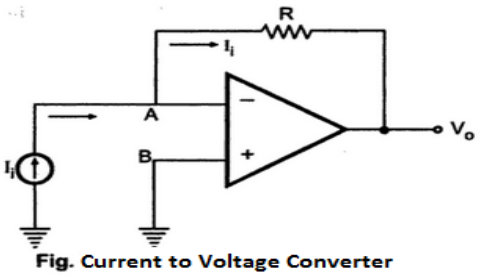
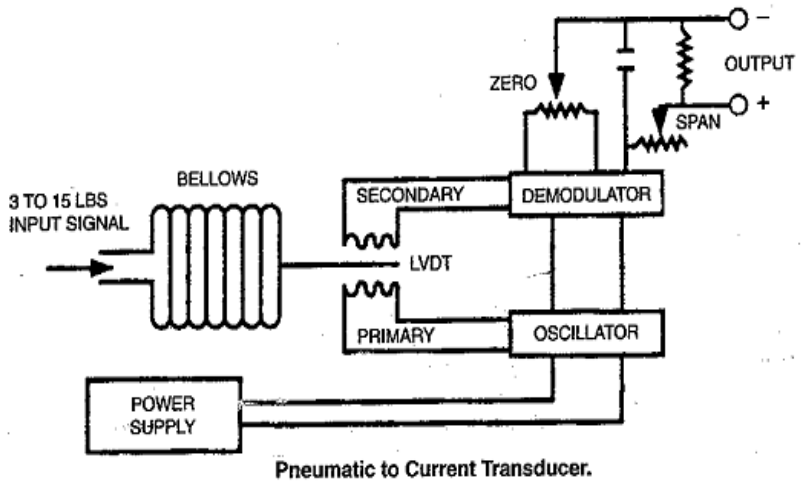
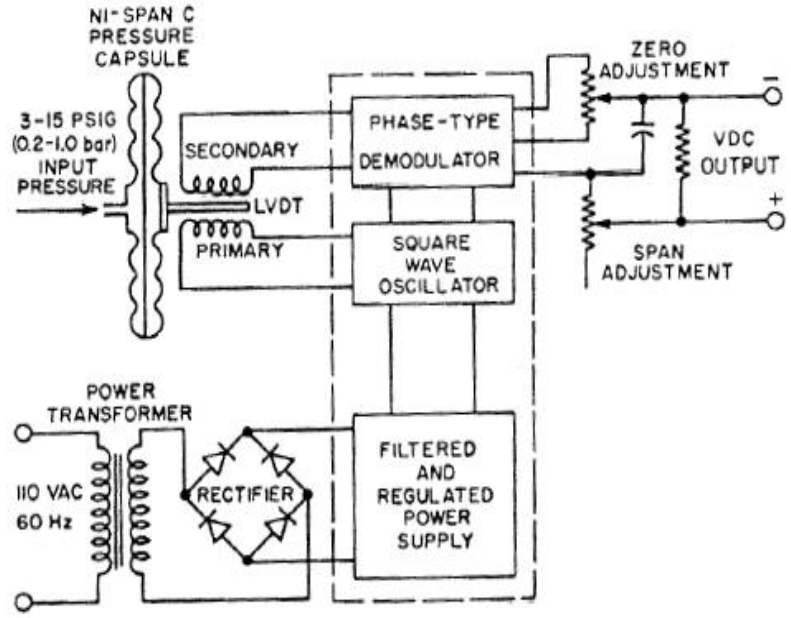
(c)	**State the standard range of electronic and pneumatic signal transmission. Describe live zero in brief**		**04**
Ans.	**Standard range :** 1. Standard range of electronic signal transmission: 4-20mA 2. Standard range of pneumatic signal transmission: 3-15psi **Live Zero:** A live zero is a loop signal where the zero value is some number higher than zero. 4-20 mADC, 1-5 VDC, 10-50mV, etc., are all examples of live zero. The significant advantage of a live zero is it allows the control room staff to distinguish between a valid process condition of 0% and a disabled transmitter or interrupted pressure line or a broken wire or a failed power supply by seeing that the loop reading is zero.	**01 mark for each range** **02 Marks for description**	
(d)	**Draw and explain current to voltage converter.**		**04**
Ans.	**Diagram:**  **Fig. Current to Voltage Converter** **Description:** The current which is to be converted into voltage is applied at inverting terminal of the OPAMP. The o/p of the above circuit is Vo = -Ii R, provided that the OPAMP saturation voltage has not been reached. The resistor of value equal to feedback resistor R at the non-inverting terminal provides temperature stability. $I_i = \frac{V_A - V_o}{R} = -\frac{V_o}{R}$ $V_o = -I_i R$ $V_o \propto I_i$	**02 Marks for Diagram** **02 Marks for Description**	
(B)	**Attempt any ONE:**		**06**
(a)	**Draw and explain Pressure to current converter.**		**06**
Ans.			

Diagram:



Pneumatic to Current Transducer.

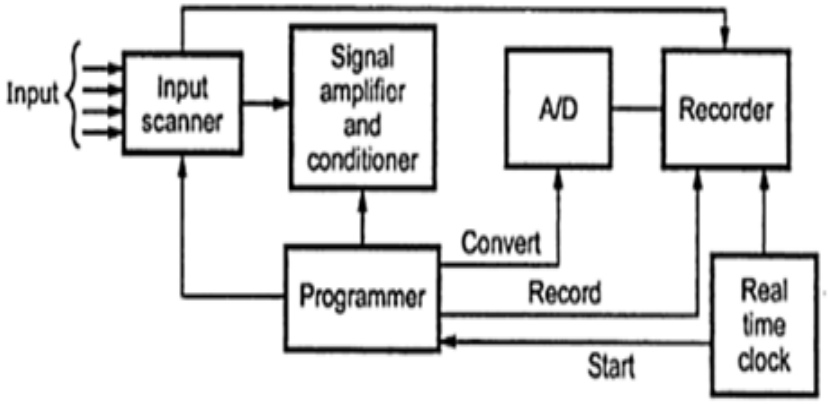
OR

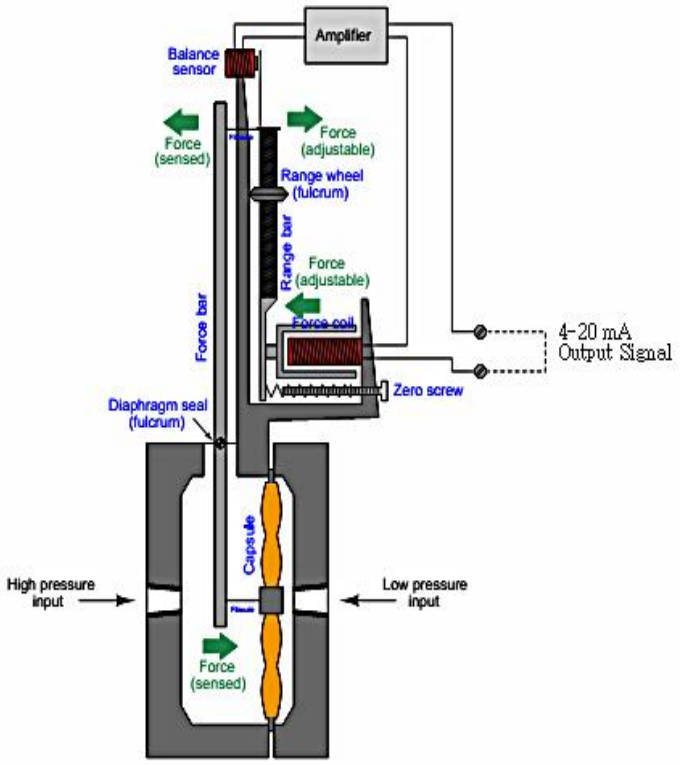
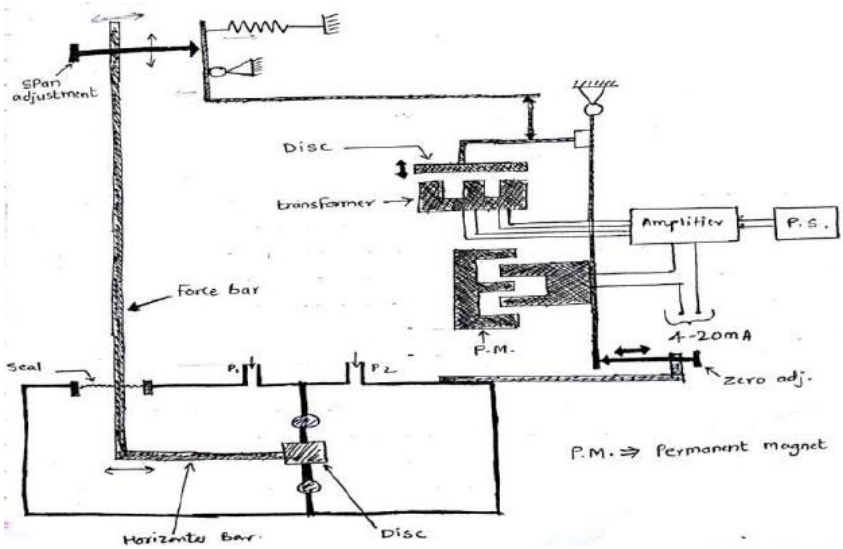


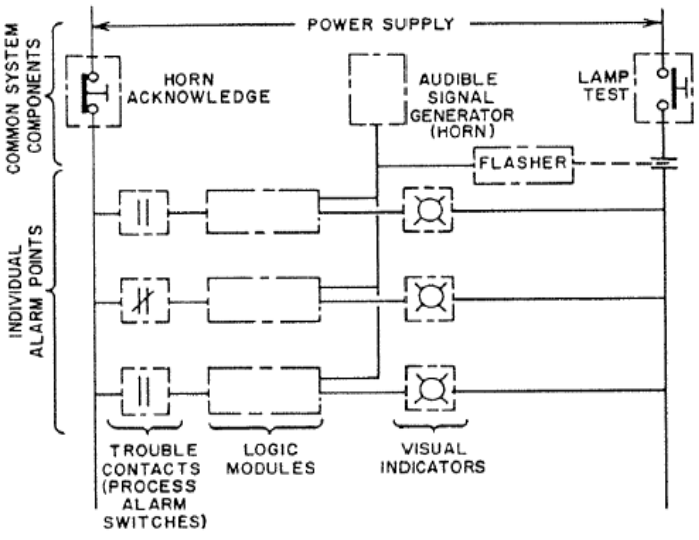
03 Marks for Diagram

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.

03 Marks for Description

(b)	**Draw the block diagram of Data Logger and explain its working.**		**06**
Ans.	**Block Diagram:**  **Block Diagram of Data Logger** **Description:** It is a highly advanced DAS. **I/P Signals:** Variety of signals is recorded by data logger like o/p of transducer, pressure, temperature, AC signals, Digital, Pneumatic signals etc. **I/P Scanner:** it is multi way switch which is operated by scanner drive unit for selecting i/p channel. It selects each input signal in sequence, so require only one signal conditioner circuit and ADC. Modern i/p scanner have scan rate of 150 inputs per sec. **Signal amplifier and filter circuit:** It linearizes the o/p of nonlinear transducer or signals. Low level signals are amplified. Noise and harmonics are removed by filter. **ADC:** It convert analog signal from scanner into digital, which are compatible to programmer. More the number of digital o/p bits, higher the resolution of ADC. **Programmer:** It is a processor which does the control of overall operation from scanner to recording data, like setting of amplifier gain, linearization etc. It sets high, low level for alarm unit that will initiate audio or video indication when variable crosses the set limit. It gives command to recorder for displaying and recording of data. **Recorder**: It permanently records the digital data by any type of recorder. Data may be printed on paper or recorded in digital signal form.	**02 Marks for Diagram** **04 Marks for Description**	

2	**Attempt any TWO:**		**16**
(a)	**Draw a neat diagram of force balance type electronic DP transmitter. Explain its working.**		**08**
Ans.	**Force balance type electronic DP transmitter:**  **OR**  **(Any other suitable diagram can be considered.)**	**04 Marks for Diagram**	

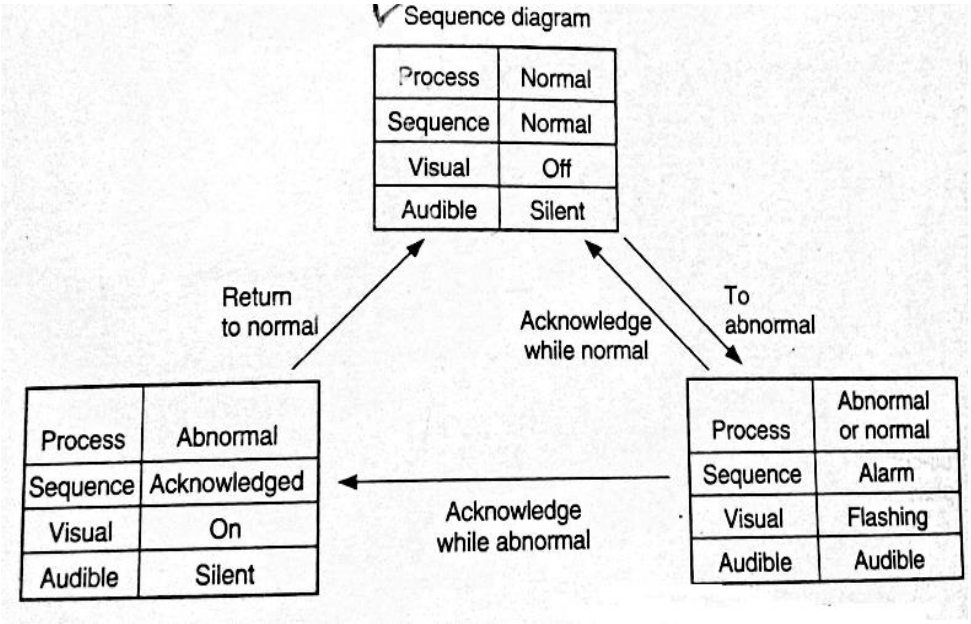
	Working: A DP cell senses an increasing pressure on the "High pressure" input port. As the pressure here increases, the large diaphragm capsule is forced to the right. The same effect would occur if the pressure on the "Low pressure" input port were to decrease. This is a differential pressure transmitter, so what it responds to is changes in pressure difference between the two input ports. This resultant motion of the capsule tugs on the thin flexure connecting it to the force bar. The force bar pivots at the fulcrum (where the small diaphragm seal is located) in a counter-clockwise rotation, tugging the flexure at the top of the force bar. This motion causes the range bar to also pivot at its fulcrum (the sharp-edged "range wheel"), moving the baffle closer to the nozzle. As the baffle approaches the nozzle, air flow through the nozzle becomes more restricted, accumulating backpressure in the nozzle. This backpressure rise is sensed by a highly sensitive electromagnetic sensor and converted to current. This current is amplified by the amplifier, which sends current signal both to the output line and to the electromagnetic coil at the bottom of the range bar. This current in electromagnetic coil causes it to apply force which push harder on the bottom of the range bar, negating the initial motion and returning the range bar (and force bar) to their near-original positions.	**04 Marks for Working**	
(b)	**Draw a schematic diagram of alarm annunciator. Describe its standard operational sequence.**		**08**
Ans.	**Alarm Annunciator:**  *FIG. Elements of basic annunciator system.* **(Any other relevant diagram can be considered.)**	**02 Marks for Schematic Diagram**	

Annuciator are usually made up of a lamp display cabinet with nameplates incorporating engraved messages, an audible device, manually operated push buttons, and sequence logic circuits. These circuits are used to co ordinate the response of lights, audible device and push button operation of the action of the alarm circuits being monitored. This is called "sequence."

Operational Sequence:

Typically an annuciator sequence may proceed as follows:

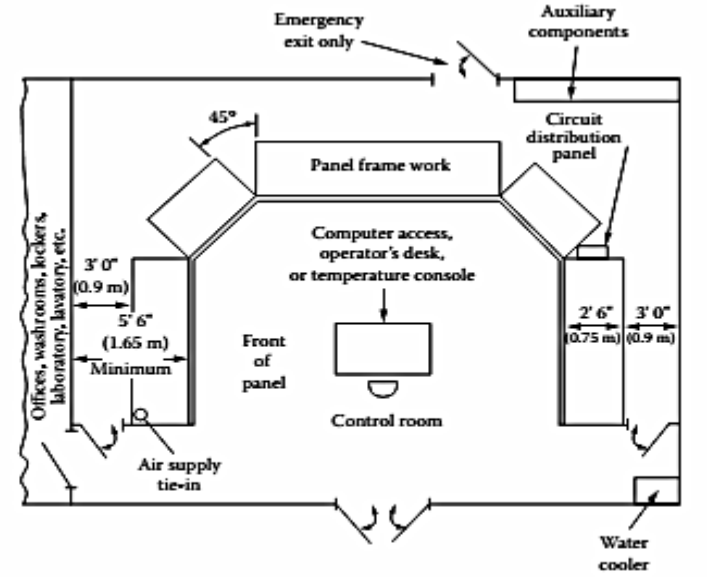
During normal, all visual and audible devices are quiescent. Upon an abnormality (off normal or alarm condition), an audible device, such as horn will sound. The horn thus advices an attendant or operator that an alert condition exists. The name plates that flash direct the attendant to their specific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

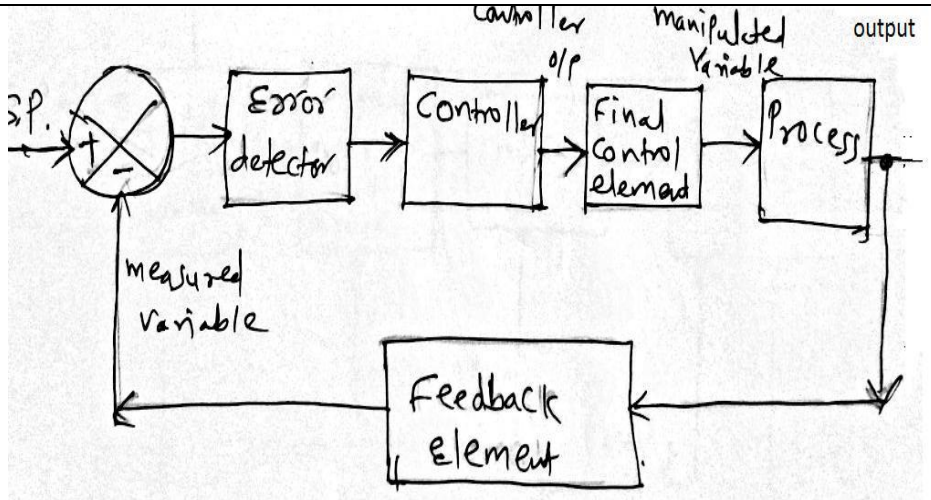


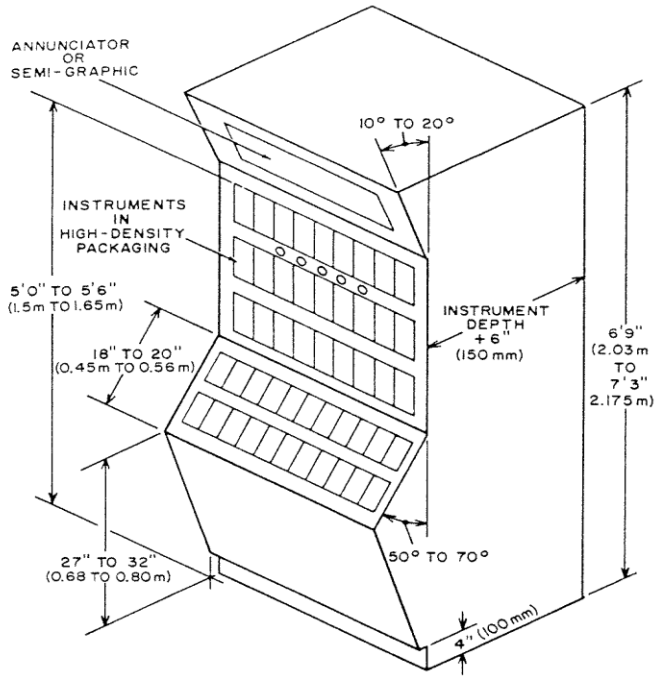
02 Marks for Sequence Diagram

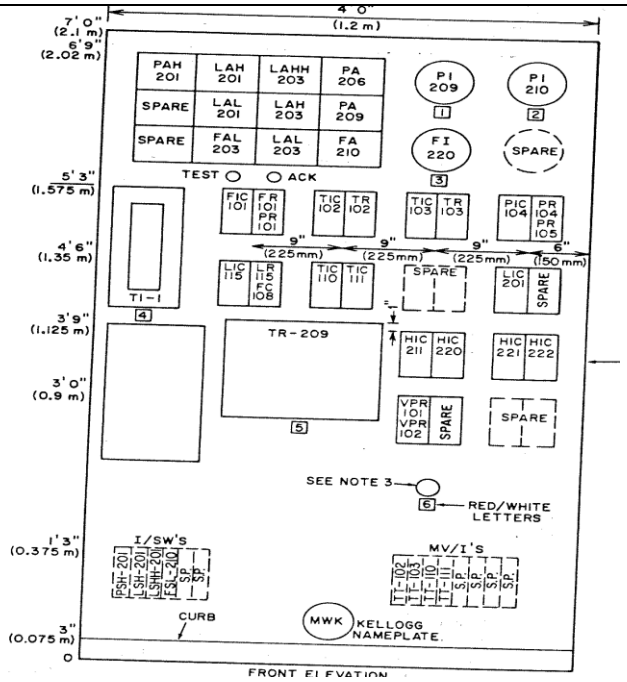
Each alarm point is synonymous with the circuit it is monitoring and the associated nameplate with its engraved message-describing the function being monitored.

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.	**04 Marks for Description**	
(c)	**Draw a general layout of control room. Discuss any six ergonomic considerations of it.**		**08**
Ans.	**Control Rom Layout:**  *Traditional control room layout.* **Ergonomic Considerations: (Any six points)** 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 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	**02 Marks for Diagram** **06 Marks for Description (01 mark for each point)**	

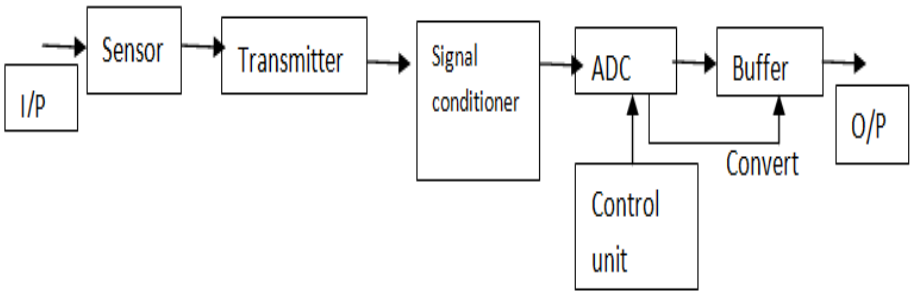
	signal drift. vi. Room pressurization is used where the plant atmosphere is explosive or flammable. The control room is pressurized by admitting into it fresh and clean air from a safe area. This permits the reduction of the area classification from either "hazardous" or "semi-hazardous" to unclassified, 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.		
3	**Attempt any FOUR:**		**16**
(a)	**Draw a labelled block diagram of process control system. Define the terms 1) Manipulated variable 2) Controlled variable**		**04**
Ans.		**02 Marks for Diagram**	

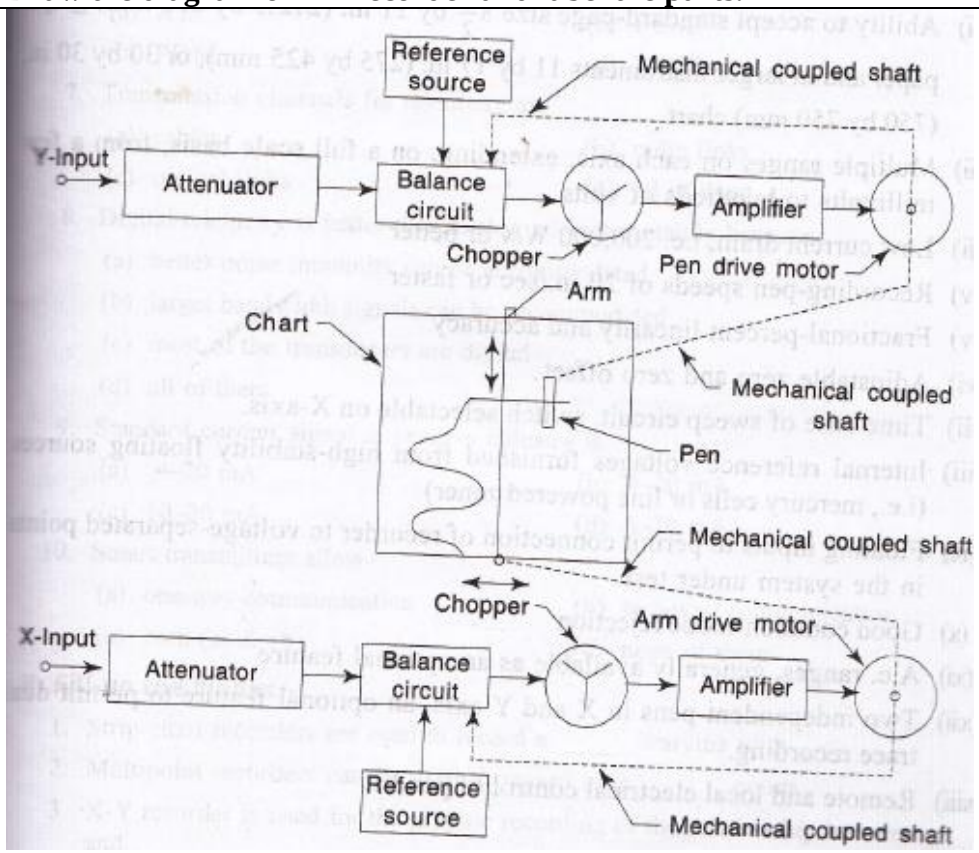
	Definition **1**. **Manipulated variable**: It is a variable that is manipulated to control the controlled variable. **2. Controlled variable**: It is variable that is being controlled in the process control system**.**	**01 Mark for each Definition**	
(b)	**State the need of control panel. Draw the layout of any one type of control panel.**		**04**
Ans.	**Need of control panels:** The basic function and purpose of the control panel is to provide a means of communication between the process and process operator. It contains the instrumentation network which gathers processes, control and display technical data necessary for efficient and safe plant operation. The control panel serves as the nerve counter for the reception and dispatching of information relative to plant operation. i.e, panels are required for the production monitoring and control of many operations going on in a factory at the floor level from a remote control room.  **Break front panel** **OR**	**02 Marks for Explanation** **02 Marks for Diagram**	

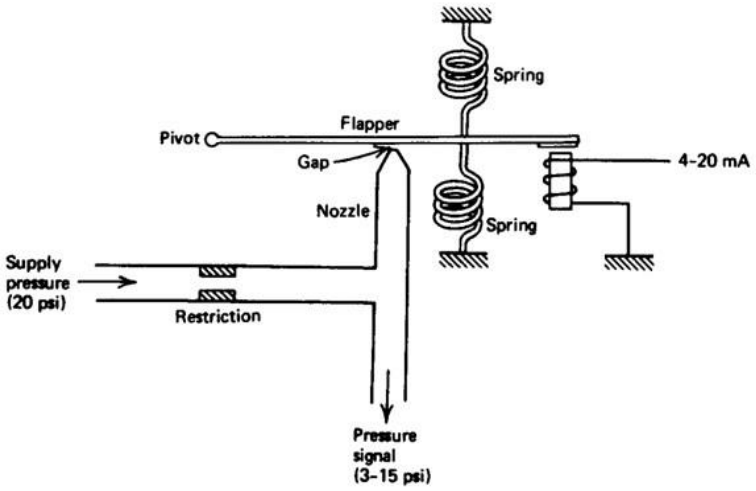


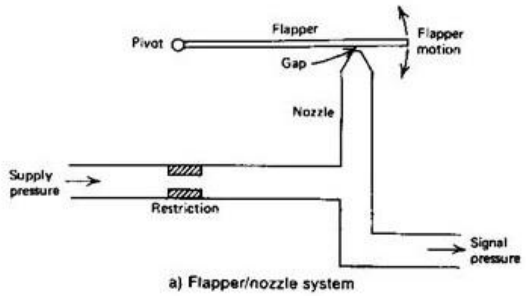
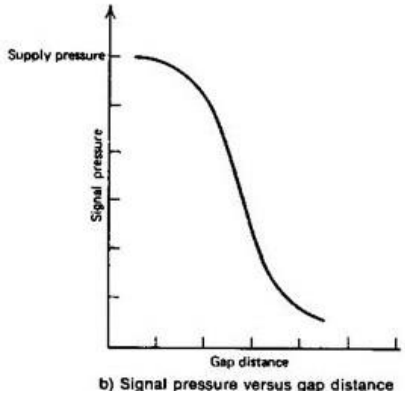
Flat panel

(Any other suitable diagram can be considered.)

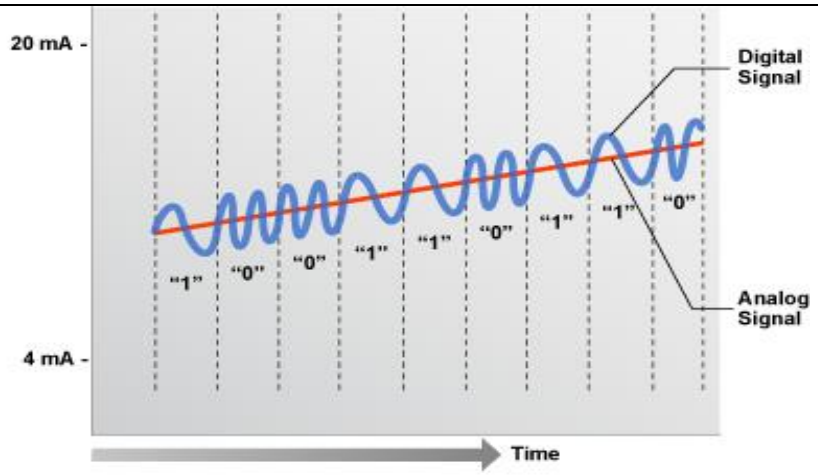
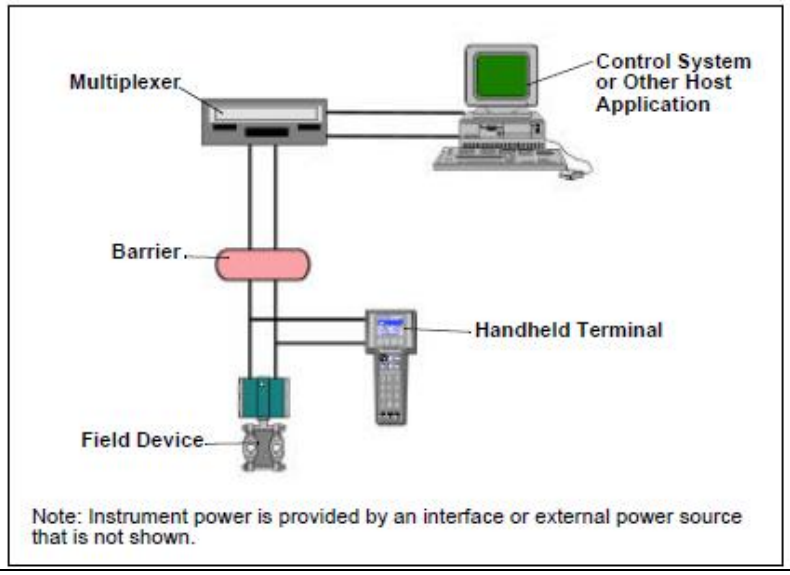
(c)	**Draw the block diagram of single channel data acquisition system. Explain each block in brief.**		**04**
Ans.	 A single channel DAS consists of a sensor, transmitter and signal conditioner followed by an ADC, performing repetitive conversions at a free running, internally determined rate. The outputs 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 the diagram of XY recorder and label the parts.**		**04**
Ans.	 **Fig: XY recorder**	**04 Marks for Diagram**	
(e)	**List the protection methods of Hazardous area. Explain the explosion proofing method in brief.**		**04**
Ans.	**List the protection methods: (Any four)** 1. Intrinsic safety 2. Explosion proofing 3. Purging/pressurizing 4. Sand filling 5. Oil immersion 6. Increased Safety 7. Potting 8. Dust ignition proof **Explosion proofing method:** An enclosure must be able to contain any explosion originating within its housing and prevent sparks from within its housing from igniting vapors, gases, dust, or fibers in the air surrounding it.	**02 Marks for List (1/2 Mark for each)** **02 Marks for explanation**	

	Therefore, explosion proof, when referring to electrical enclosures, does not mean that it is able to withstand an exterior explosion. Instead, it is the enclosures ability to prevent an internal spark or explosion from causing a much larger blast.		
4 (A)	**Attempt any 3:**		**12**
(a)	**State the need of converters. Draw and explain I to P convertor.**		**04**
Ans.	**Need of converters: (Any four points)** 1. For forming link between electronic and pneumatic system & vice versa. 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. If instrument air is not available at the receiver end**.**	**02 Marks for need (1/2 mark For each)**	
	I to P converter:  **(Any other relevant diagram can be considered.)**	**01 Mark for diagram**	
	Current 4-20ma is applied to a coil. The coil produces magnetic field. At the lower end of the coil is a flapper that operates against a nozzle to create a backpressure. The input current flows in the coil and produces a force between the coil and the flapper valve, which controls the output pressure. Thus the current is converted to pressure.	**01 Mark for Explanation**	

(b)	**Draw and explain flapper nozzle assembly.**		**04**
Ans.	The flapper nozzle assembly consists of movable flapper which is positioned against open nozzle. The measured physical quantity is supplied to flapper. The flapper moves according to change in physical quantity. This movement of the flapper increases or decreases the distance between flapper and nozzle. The nozzle is supplied with the constant air pressure of 20 psi through a restriction of orifice based on the change in the value of measured physical quantity, flapper moves near and away from the nozzle. Which decreases or increases the distance between the flapper and nozzle. i.e when the value of measured quantity is minimum flapper is away from nozzle, therefore, distance is maximum which generates very low back pressure. This back pressure is 3psi o/p pneumatic signal. When value of measured quantity is max., 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.  a) Flapper/nozzle system  b) Signal pressure versus gap distance	**02 Marks for explanation** **02 Marks for Diagram**	
(c)	**Explain the meaning of following IP codes:** **i) IP 65 ii) IP 34 iii) IP 22 iv) IP X3**		**04**
Ans.	**IP 65:** Totally protected against dust, Protected against low pressure jets of water from all directions **IP 34:** Protected against solid objects over 2.5mm (tools and wires).	**01 Mark for each**	

	Protection against water sprayed from all directions **IP 22:** Protected against solid objects up to 12mm, Protection against direct sprays of water up to 15^o from the vertical. **IP X3:** X shows that there is no protection rating with regard to solids. Protected against direct sprays of water up to 60^o from the vertical.		
(d)	**Classify the following materials into appropriate hazardous areas:** **1) Hydrogen 2) Aluminium dust 3) Wheat 4) Coal**		**04**
Ans.	1) Hydrogen: class 1, group B 2) Aluminium dust: class II, group E 3) Wheat: class III, group G 4) Coal: class II, Group F	**01 Mark for each**	
(B)	**Attempt any 1:**		**06**
(a)	**Describe "HART" communication protocol with relevant diagrams.**		**06**
Ans.	"HART" is an acronym for Highway Addressable Remote Transducer. It is the global standard for sending and receiving digital information across analog wires between SMART devices and control or monitor systems. It is the bidirectional communication protocol that provides data access between intelligent field instruments and host systems. The HART system (and its associated protocol) was originally developed by Rosemount and is regarded as an open standard, available to all manufacturers. Its main advantage is that it enables the retention of the existing 4-20mA instrumentation cabling while using, simultaneously, the same wires to carry digital information superimposed on the analog signal. HART is a hybrid analog and digital system, as opposed to most field bus systems. It uses a Frequency Shift Keying (FSK) technique based on the Bell 202 standard to superimpose digital communication signals at a low level on top of the 4-20 mA . Two individual frequencies of 1200 and 2200 Hz representing digits '1' and '0' respectively, are used. The average value of the sine wave superimposed on the 4-20mA signal is zero; hence, the 4-20mA analog information is not affected.	**03 Marks for Explanation**	

	 Note: Drawing not to scale **Digital over Analog**  Note: Instrument power is provided by an interface or external power source that is not shown.	**03 Marks for Diagram**	
(b)	**State the application of DAS (any two). Draw the block diagram of multichannel DAS and label the parts. Explain in brief.**		**06**
Ans.	**Application of DAS: (Any two)** 1) It can be used for measurement of different variable such as temp, pressure, level, flow, speed torque etc for display & averaging purpose. 2) It can be use for control of variables such as temp, pressure, flow level in different process industry. 3) It can be use in laboratory research, quality control for accurate measure and analysis of important variables.	**02 Marks for Application (01 Mark each)**	

4) It can be used in aircraft control system, electrical power system and industrial process control system.

Multichannel DAS:

The individual analog signals are applied directly or after amplification and/or signal conditioning, whenever necessary, to the multiplexer. These are further converted to digital signals by the use of A/D converters, sequentially.

02 Marks for Explanation

For the most efficient utilization of time, the multiplexer is made to seek the next channel to be converted while the previous data stored in the sample/hold is converted to digital form.

When the conversion is complete, the status line from the converter causes the sample/hold to return to the sample mode and acquires the signal of the next channel. On completion of acquisition, either immediately or upon command, the S/H is switched to the hold mode, a conversion begins again and the multiplexer selects the next channel. This method is relatively slower than systems where S/H outputs or even A/D converter outputs are multiplexed, but it has the oblivious advantage of low cost due to sharing of a majority of sub-systems.

02 Marks for Diagram

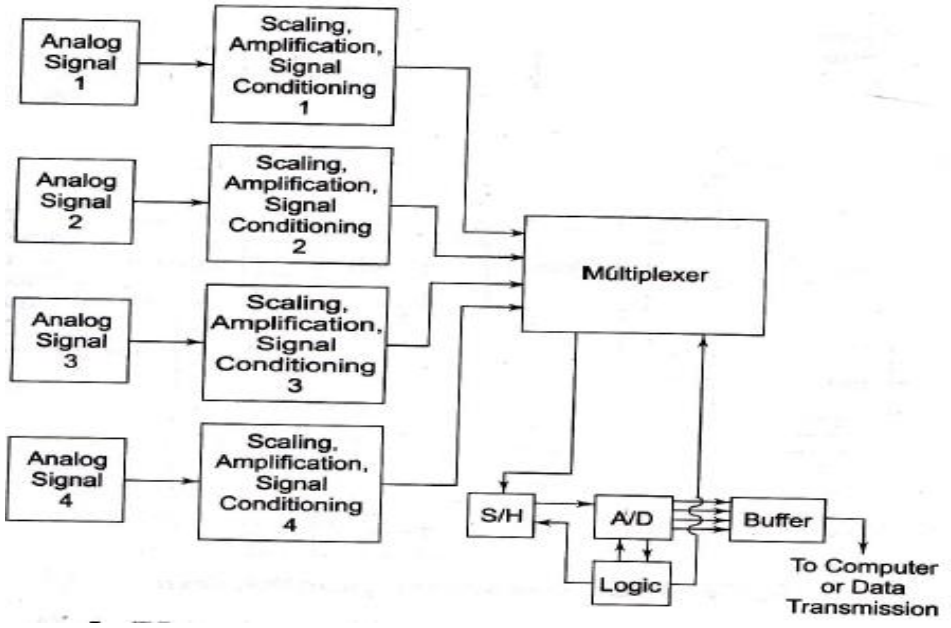


Fig: Multichannel DAS

5	**Answer any 2:**		**16**
(a)	**Give the classification of hazardous area location in detail.**		**08**
Ans.	**Hazardous Zone categories (IEC classification)** **For Gases, Vapor and For dust particles:**	**08 Marks For entire classification**	

Area Designation	Area Description
Zone 0	Ignitable concentrations of flammable gases or vapors are present continuously or present for long periods of time. Examples include, · Interior of tanks · Locations near vents
Zone 1	There may be ignitable concentrations during normal operating conditions or concentrations exist frequently from repair or maintenance of the equipment. Examples include, · An area where the breakdown of equipment could lead to a release · Remember that pumps and compressors can have small leaks.
Zone 2	There may be ignitable concentrations during temporary situations. Examples include, · Storage where hazardous materials are in containers. · Areas adjacent to Zone 1 with no hazards of its own · Ventilation could prevent the hazard, but it could fail during a leak

Area Designation	Area Description
Zone 20	A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
Zone 21	A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.
Zone 22	A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but if does occur, will persists for a short period only.

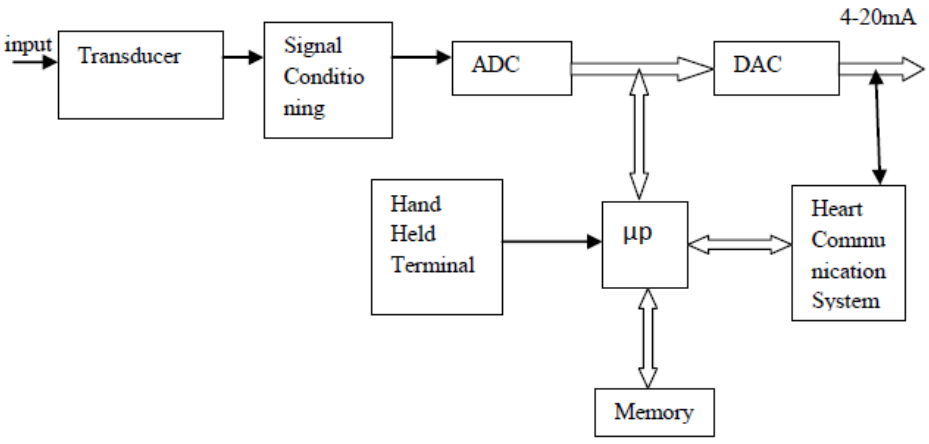
OR

NEC Classification

Area Designation	Area Description
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

Note - with minimum materials mentioned, it can be in any format.

(b)	**Draw the block diagram of SMART transmitter and explain its working.**		**08**
Ans.	**Block diagram of SMART transmitter:**  **(Any other relevant diagram can be considered.)**	**04 Marks for diagram**	

	Working: **SMART(Single Module Auto Ranging Transmitter):** It is a transmitter which uses a microprocessor along with a sensor/ transducer combined with a processing unit and a communication interface. The working of the functional blocks are as under. 1. Transducer: connected directly to the process, it detects and converts the process variable in to a suitable electrical quantity. 2. Signal conditioning and ADC: Signal conditioning circuit does common signal modification or conditioning techniques like, filtering, amplification and linearization as per the input requirement of ADC. ADC converts the signal into digital for effective transmission. 3. Microprocessor with memory: These components provide SMART features, which makes it different from other analog transmitters. It conditions the signal remotely before converting into standard form. For example, it can normalize gain and offsets, linearize sensors having known nonlinearities by converting to digital and processing with arithmetic algorithms in the µp. 4. DAC: It converts the output of microprocessor back to analog for transmitting the signal on the loop as a standard current. 5. Communicator: It allows data transfer between the transmitter and control room. In a HART communicator system, the communication channel allows both analog and digital versions of the measured variable to be transmitted over the twisted pair wires, as well as control signals and diagnostic data relevant to the transmitter. 6. Hand held communicator: A hand –held device allows digital instructions to be delivered to the smart transmitter. It can be connected directly to the transmitter, or in parallel anywhere on the loop (remotely).Testing, configuring, supply or acquiring data are all done through the communicator. The display allows the technician to see the information. **(Any other suitable explanation can be considered.)**	**04 Marks for explanation**	
(c)	**State the meaning of the code IP. Explain IP classification in detail.**		**08**
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	**02 Marks for Meaning**	

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)

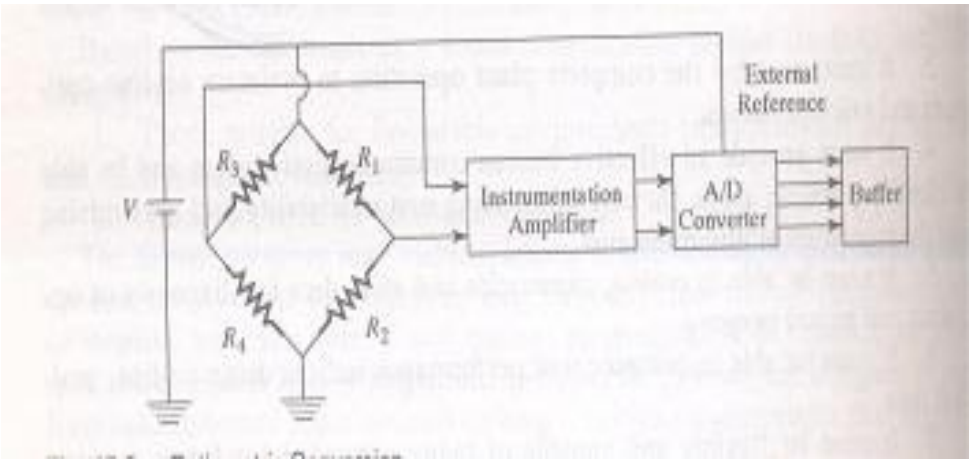
IP Level 1st Digit	Description of Protection Level
0	Not protected
1	Protected against solid foreign objects of 50 mm diameter and greater
2	Protected against solid foreign objects of 12,5 mm diameter and greater
3	Protected against solid foreign objects of 2,5 mm diameter and greater
4	Protected against 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

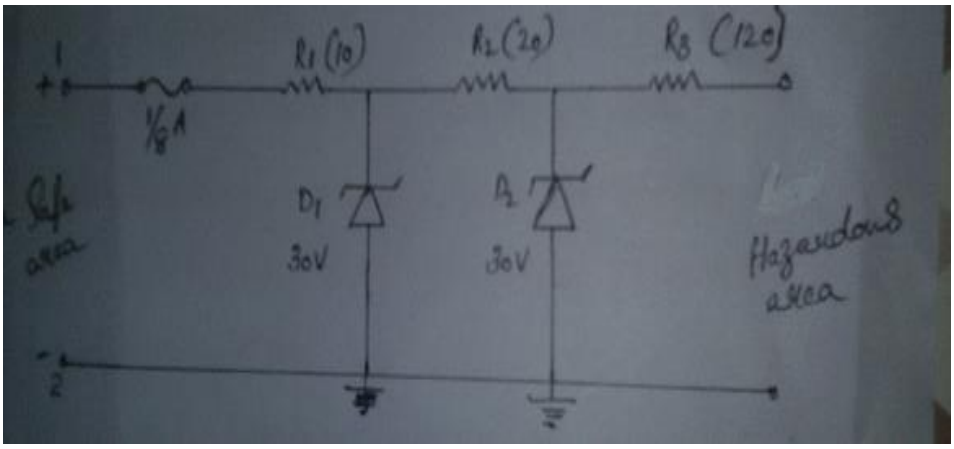
03 Marks for Description of First Letter

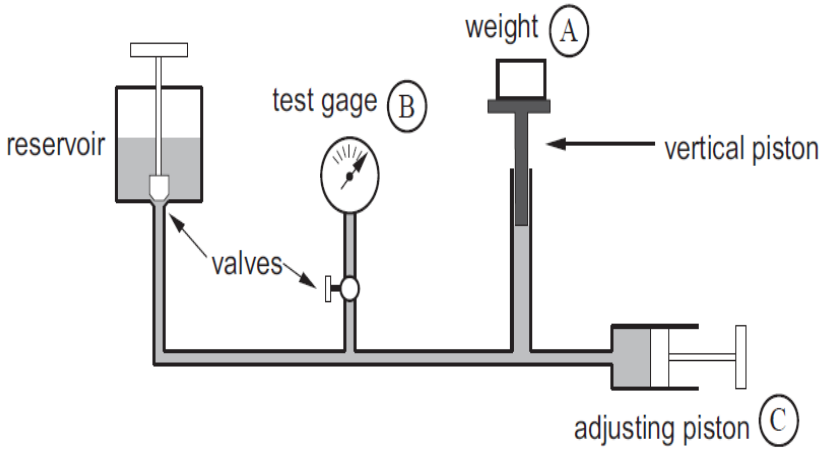
Degrees of Protection (Moisture) – 2nd Digit (Second Letter)

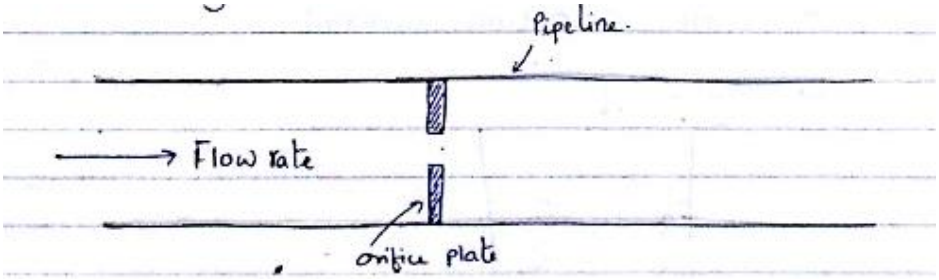
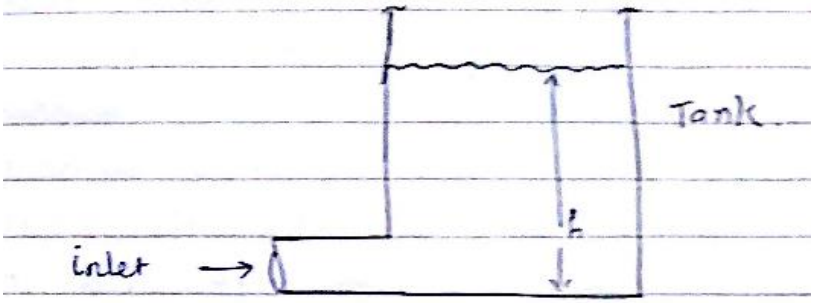
IP Level 2nd Digit	Description of Protection Level
0	Not protected
1	Protected against vertically falling water drops
2	Protected against vertically falling water drops when enclosure is tilted up to 15°
3	Protected against water sprayed at an angle up to 60° on either side of the vertical
4	Protected 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

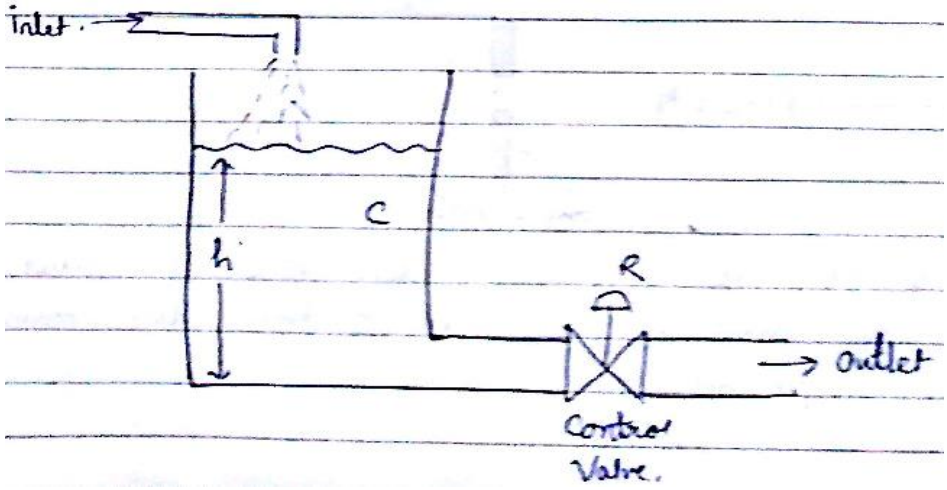
03 Marks for Description of Second Letter

6	**Answer any 4:**		**16**
(a)	**Explain the following terms w.r.to. DAS:** **i) Ratiometric conversion ii) Logarithmic conversion**		**04**
Ans.	**i) Ratiometric Conversion:** It is one of the methods of signal conditioning used in DAS. Consider a transducer using strain gauges in a Wheatstone bridge. In this case, if the excitation to the bridge varies the output also varies, accordingly making the measurement inaccurate. In such a case the bridge output needs to be conditioned in such a way that the output varies only according to the strain gauge input. The system uses an analog divider to which both the excitation supply and amplifier output are connected. The output of the divider is the ratio between the two inputs, which will eliminate the error in the output.  **ii) Logarithmic conversion:** Logarithmic signal conversion / compression is a method of signal conditioning for compressing wide dynamic range input signals to a range of an output utilization apparatus. A logarithmic law compresses signals by offering equal output amplitude changes in response to a given ratio of input amplitude increase. For eg., a scaling of 1V/decade means that the output would change by 1V when the input changes from 10-100mV, or from 100mv to 1V. ie., rather than amplifying, logarithmic amplifiers convert a voltage or current proportional to the ratio of input voltage or current to a reference voltage or current. **(Fig. optional)**	**02 Marks** **02 marks**	

(b)	**Define intrinsic safety. Draw and explain zener barrier circuit to achieve intrinsic safety.**		**04**
Ans.	**Intrinsic safety**: NEC defines intrinsically safe equipment & wiring as "incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture". **Diagram:** **Redding zener barrier circuit:** Figure shows the diagram of a Redding zener barrier circuit for 28V 93mA barrier.  **Description:** It consists of, 1) Wire wound resistors for limiting the current 2) Redundant zener diodes for limiting the voltage 3) A fuse in series with the resistors If a high voltage other than (-0.7v to 30v) appear across terminals 1&2, the zener diode starts conducting. If the fault voltage is high enough and appears for a longer period, the current through the diode D_1 increases until the fuse blows. If the fuse does not blow immediately and the power dissipation of D_1 is exceeded, the zener is designed to short circuit before the fuse opens. With shorting D_1, current will rise rapidly blowing the fuse. Thus an excess current is always diverted to the ground by the barrier and is never allowed to reach the hazardous area. Once fuse is blown off, the	**01 Mark for Definition** **01 Mark for Diagram** **02 Marks for Explanation**	

	entire circuit is replaced by new one. Proper grounding of installation is necessary in this case. It is simple to construct , maintain and economical.		
(c)	**Define calibration. Draw any one method to calibrate a pressure gauge. Label the parts.**		**04**
Ans.	**Definition**: Calibration defined as comparison of measured value to corresponding reference standard. It offers guarantee of accuracy with required specification. It also documents the performance of instrument in the field. **Pressure gauge calibration arrangement:**  **(Any other relevant diagram can be considered.)**	**02 Marks for Definition** **02 Marks for Diagram**	
(d)	**List different types of process dynamics. Explain any one.**		**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	**01 Mark For Listings**	

	1 . Resistance type 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. **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. **3. Time Constant Element:**	**03 Marks Explanation of any one process dynamics**	



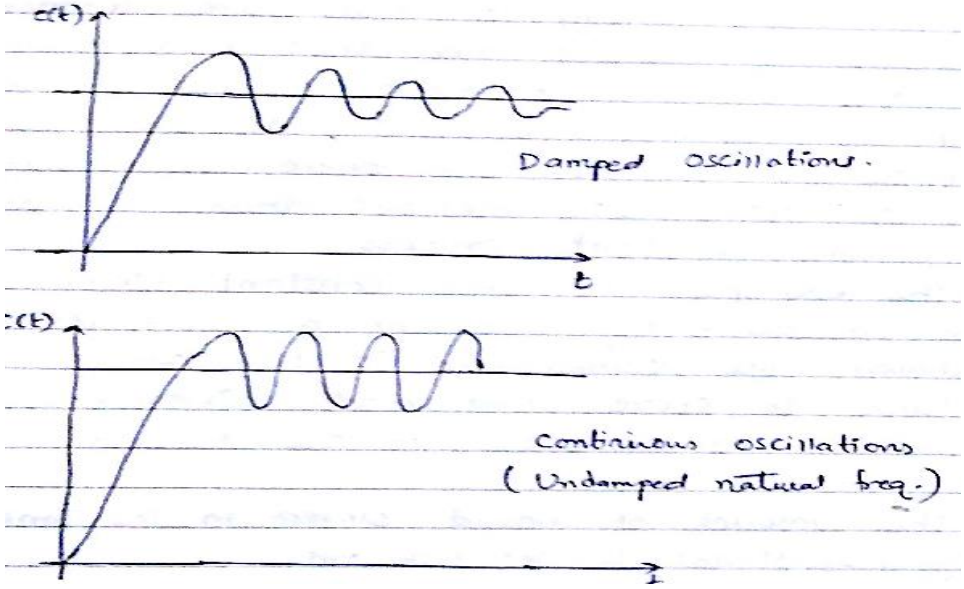
A combination of a resistance and capacitance element result in a time constant process. Those parts of the process that have the ability to store energy are termed as capacitance element and those parts that resist the transfer of energy or mass are termed as resistance element.

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.

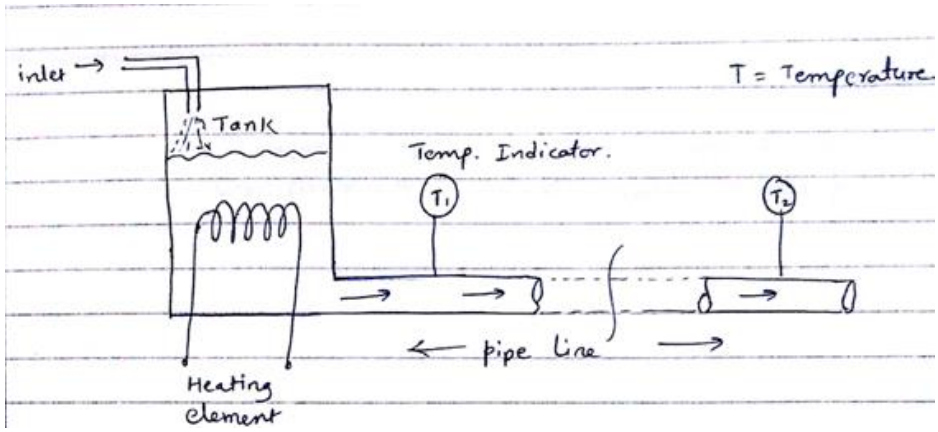
The amount of liquid stored is proportional to net flow.

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.



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 foll. System where hot water is to be passed through a tube having uniform cross section. In this syste , when hot water is transferred from one point to another no process action takes place, which creates the dead time in the process.

(e)	**State the benefits of process Instrumentation(Any 4).**		**04**
Ans.	**Benefits of process instrumentation : (Any four)** 1) Human operators are relieved from the tedious and repetitive	**04 Marks** **(01 Mark**	

	physical and mental tasks, associated with controlling a process. 2) Optimizes process control operations, thus ensure maximum quality of production. 3) Increase the durability of products, while minimizing the consumption of energy, raw materials and maximizing recycling and reuse. 4) Reduce variability: Process control can reduce variability in the end product, which ensures a consistently high-quality product. 5) Ensure safety and profitability: A run-away process, such as an out-of-control nuclear or chemical reaction, may result if manufacturers do not maintain precise control of all of the processing variables. The consequences of a run-away process can be catastrophic. Process control technology is the tool that enables manufacturers to keep their operations running within specified limits and to set more precise limits to maximize profitability, ensure quality and safety. **(Any other relevant point may be considered)**	**each)**	