Important suggestions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a 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 some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1	**Attempt any TEN of the following :** **20 Marks**
a)	**Define : (i) Accuracy (ii) Precision**
Ans :	**i) Accuracy:** **(1 Mark)** The degree of exactness (closeness) of a measurement compared to the expected (desired) value. **OR** Closeness with which the instrument reading approaches the true value of the quantity being measured is known as accuracy **(ii) Precision:** **(1 Mark)** It is the measure of consistency or reproducibility of measurements. i.e successive readings do not defer. **OR** It prescribes the ability of the instrument to reproduce its readings over and over again for a constant input signal
b)	**List out any 4 dynamic characteristics.**
Ans :	**Dynamic characteristics**: **(Each Characteristics: 1/2 Mark, total 2 marks)** 1. Speed of response 2. Measuring lag

	3. Fidelity 4. Dynamic error
c)	**State the principle of calibration.**
Ans :	Principle of calibration: (2 Marks) The process of deriving the value of a quantity by comparing that quantity with a standard quantity is called as calibration. OR Calibration is nothing but comparing the measuring instrument with standard instrument to find out error in the instrument under test OR Calibration of instrument is done to obtain correct unknown value of each scale reading on measuring instrument. There are 3 main reasons for having instrument calibration: • To ensure reading from an instrument are consistent with other measurements. • To determine the accuracy of the instrument reading. • To establish the reliability of the instrument i.e. it can be trusted.
d)	**Define : (i) Repeatability (ii) Reproducibility**
Ans :	**i) Repeatability**: **(1 Mark)** Repeatability conditions are when replicate measurements are made in one laboratory, by a single analyst, using the same equipment over a short time period. It is defined as variation of scale reading and it is random in nature. **(ii) Reproducibility:** **(1 Mark)** Reproducibility describes the closeness of output readings for the same input when there are changes in the method of measurement, observer, measuring instrument, location, conditions of use, and time of measurement. **OR** It is the closeness among a number of repeated measurements of the output for same value of input

e)	**Give two examples of Active and Passive transducer.**
Ans :	**Examples Active Transducers :** **(Any Two expected: 1/2 each, Total 1 Mark)** 1. Thermocouple 2. Piezoelectric Transducer 3. Solar Cell/ Photovoltaic cell 4. Tacho generator **Examples Passive Transducers :** **(Any Two expected: 1/2 each, Total 1 Mark)** 1. Thermistor 2. RTD 3. LVDT 4. Strain Gauge 5. Electromagnetic flowmeter. 6. Capacitive transducers. Etc.
f)	**Define Gauge factor.**
Ans :	**Gauge factor:** **(2 Marks)** It is defined as the ratio of per unit change in resistance to per unit change in length $$GF(K) = \frac{\Delta R/R}{\Delta l/l}$$ OR The measurement of the sensitivity of a material to strain is called as Gauge factor (GF)
g)	**State seebeck effect.**
Ans :	**Seebeck effect :** **(2 Marks)** Seebeck effect state that whenever two dissimilar metals are connected together to form two junctions, out of which, one junction is subjected to high temperature and another junction is subjected to low temperature then emf is induced proportional to the temperature difference between two junctions.
h)	**Define : (i) Stress (ii) Strain**
Ans :	**(i) Stress:** **(1 Mark)** **It** is defined as the force experienced per unit area **OR** The amount of push and pull force applied over a cross sectional area right angle to the action of force is called stress.

(ii) Strain: **(1 Mark)**

It is defined as the ratio of change in length to original length

OR

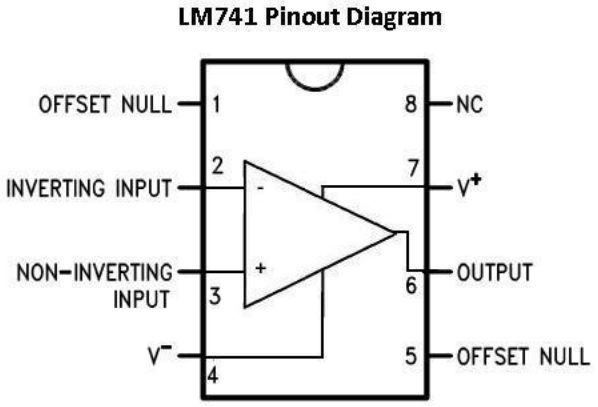
The ratio of change in dimension to the original dimension is called strain

OR

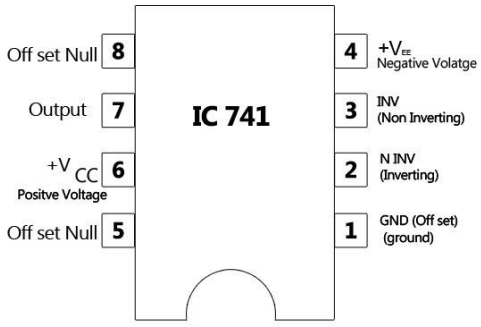
The deformation due to the effect of applied force is called Strain.

i) Draw neat labelled pin diagram for IC 741

Ans : **Labelled pin diagram for IC 741:** **(2 Marks)**



OR



OR equivalent diagram

j) Define : (i) CMRR (ii) Slew Rate

Ans : **(i) CMRR:-** **(1 Mark)**

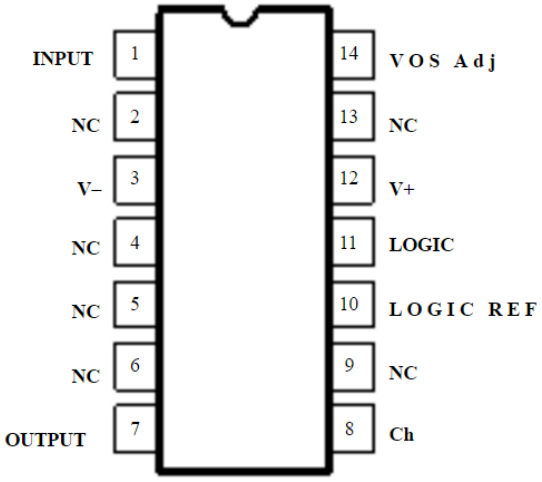
The CMRR is defined as the ratio of the powers of the differential gain over the common-mode gain, measured in positive decibels (thus using the 20 log rule): As differential gain should exceed common-mode gain, this will be a positive number, and the higher the better.

CMRR= ADM/ACM

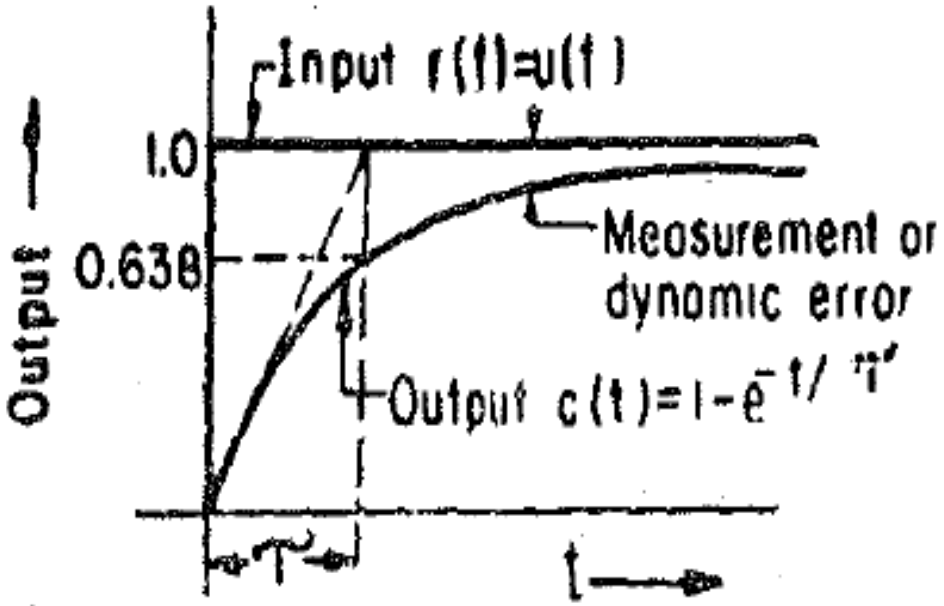
ii) Slew rate: **(1 Mark)**

The slew rate of an op amp or any amplifier circuit is the rate of change in the output voltage caused by a step change on the input. OR -The maximum rate at which an amplifier can respond to an abrupt change of input level

It is measured as a voltage change in a given time.

k)	**State the necessity of signal conditioning.**
Ans :	**Necessity of signal conditioning:-** **(2 Marks)** Transducers or sensors' output is not capable to drive next stages. Full scale output of most sensors/transducers is relatively small quantity. For accurate characterization of transducer output. To amplify, attenuate, add, subtract, filter the signal. Protection of devices and circuits of measurement. So conditioning is a manipulating a signal in such a way that it can meet the next stage for further processing.
l)	**Draw pin diagram of IC LF398.**
Ans :	**Pin diagram of IC LF398:** **(2 Marks)**  OR equivalent figure
Q.2	**Attempt any FOUR of the following :** **16 Marks**
a)	**Derive an expression for unit step response of first order system. Draw its response curve.**
Ans:	• Let a unit step input u(t) be applied to a first order system r(t)=u(t) and R(s)= 1/S • Transfer function of a first order system is $G(S) = \frac{K}{1+\tau s}$ – **(1 Marks)** • If system is dimensionless then K=1 Output; $C(S) = G(S) * R(S)$ $= \frac{1}{S*(1+\tau S)}$ $C(S) = \frac{1}{S} - \frac{\tau}{1-\tau S}$ – – – – – – – – – – – – – – – – – – **(1 Marks)** taking the inverse Laplace we get

$C(t) = 1 - e^{-t/\tau}$ – – – – – – – – – – – – – – – – – (1 Marks)



----------(1 Marks)

b) Define : (i) Speed of response (ii) Fidelity (iii) Dynamic error (iv) Settling time

Ans:

i) Speed of Response: (1 Mark)

It is the rapidity with which a measurement system responds to changes in the measured quantity.

ii) Fidelity: (1 Mark)

It is the degree to which a measurement system indicates changes in the measured quantity without dynamic error.

iii) Dynamic error: (1 Mark)

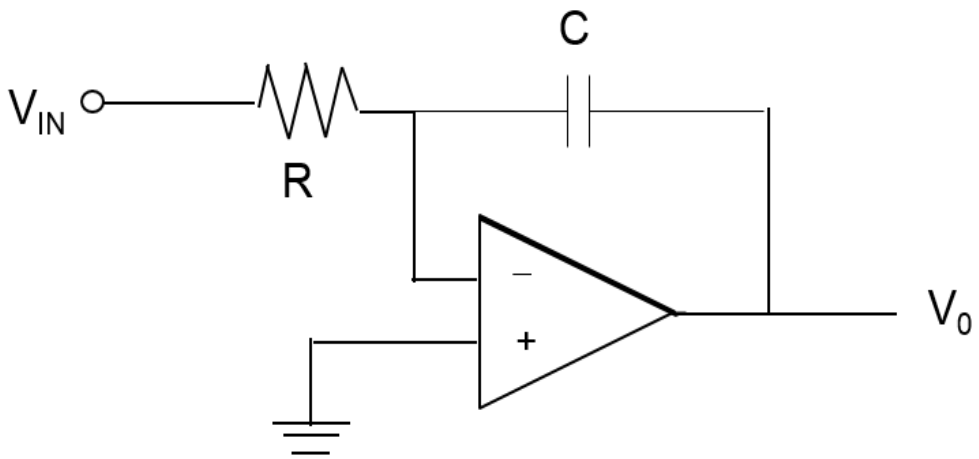
It is the difference between the true value of the quantity (under measurement) changing with time and the value indicated by the measurement system if no static error is assumed.

iv) Settling time: (1 Mark)

It is the time required for the output of any system to reach and stay within a specified tolerance band.

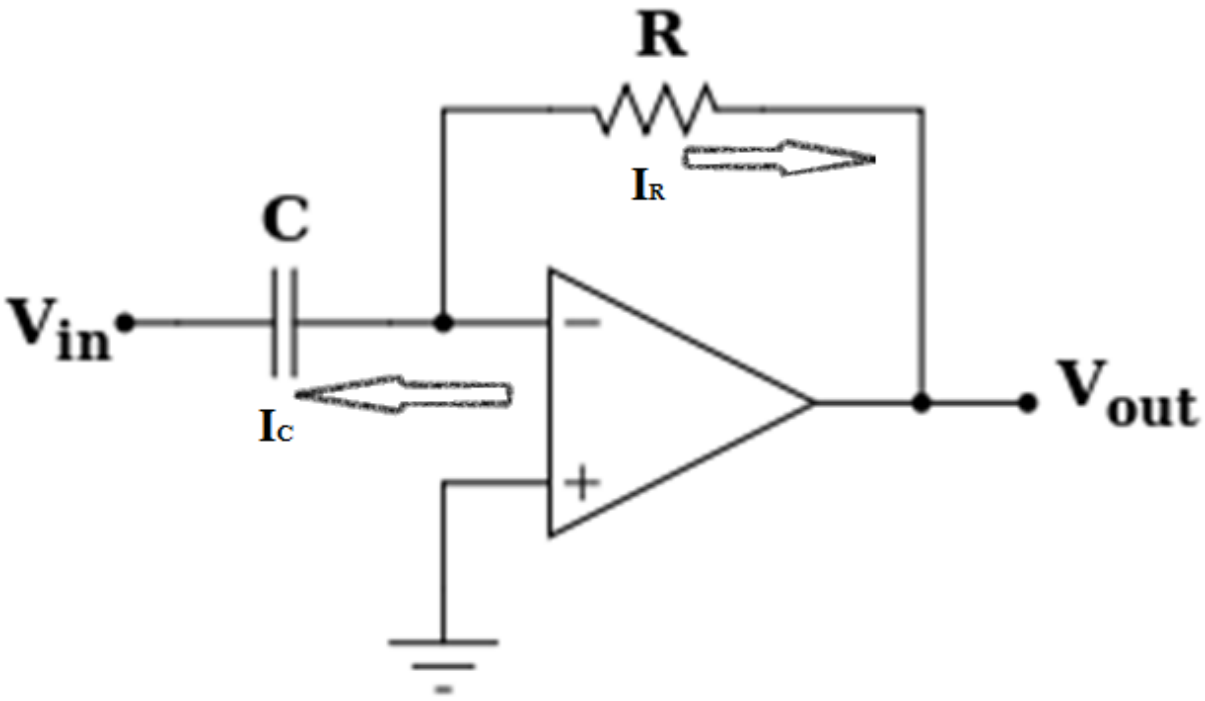
c)	**Define transducer. Give the classification of transducer with one example each.**
Ans:	**(Definition: 1 Mark & Any three type with one example expected: 1 mark each, Total 4 Marks)** **Transducer:** Transducer is the device which converts one form of energy into another. **Classification of transducer with one example each** 1) Based on Physical Phenomenon: i) Primary transducer. Ex- Bourdon tube ii) Secondary transducer Ex-LVDT 2) Based on Power type classification : i) Active transducer Ex- Piezoelectric Crystal, Thermocouple etc. ii) Passive transducer Ex-Thermistors, strain Gauges 3) Based on type of output : i) Analog transducer Ex- Strain Gauges, Potentiometers ii) Digital transducers Ex- Rotary Encoder 4) Based on Transduction phenomenon : i) Transducer (Electrical) Ex-Thermistor ii) Inverse Transducer(Mechanical) Ex- Bourdon Tube, Bellows
d)	**Define strain gauge. State different types of strain gauge.**
Ans:	**Strain gauge:** **(2 Marks)** It is a resistive transducer whose resistance varies with applied force; It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured. **Types of strain gauge: (Any Four types expected:1 Mark each, Total 2 Mark)** 1. Unbonded metal strain gauges 2. Bonded metal wire strain gauges 3. Bonded metal foil strain gauges 4. semiconductor strain gauges

e)	**Draw the circuit diagram of integrator and differentiator using Op-Amp.**
Ans:	**Integrator: -** **(2 Marks)**



or equivalent figure

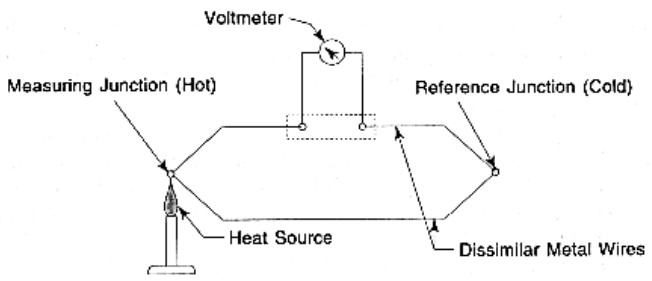
Differentiator: - **(2 Marks)**



or equivalent figure

f)	**Define thermocouple. State its working.**

Ans: **Thermocouple: (Meaning: 1 Mark, diagram: 1 Mark & Working: 2 Mark, Total: 4 Mark)**



or equivalent figure

Working Principle of thermocouple:

- The working principle of thermocouple is based upon seebeck effects.
- Seebeck effect state that whenever two dissimilar metals are connected together to form two junctions, out of which, one junction is subjected to high temperature and another junction is subjected to low temperature then emf is induced proportional to the temperature difference between two junctions
- The two dissimilar metals form an electric circuit, and current flows as a result of the generated emf. This current will continue to flow as long as T1>T2.
- It is an active transducer which does not require external power. It is widely used in industrial applications to monitor temperatures of liquid and gases in storage and flowing in pipes and ducts. They are used in industrial furnace as well as for temperature measurement in cryogenic range.

Q.3	**Attempt any FOUR of the following :** **16 Marks**
a)	**Draw the block diagram of instrumentation system and state the function of each block.**
Ans:	**Block diagram of instrumentation system : (Figure: 2 Mark & Explanation :2 Mark)**

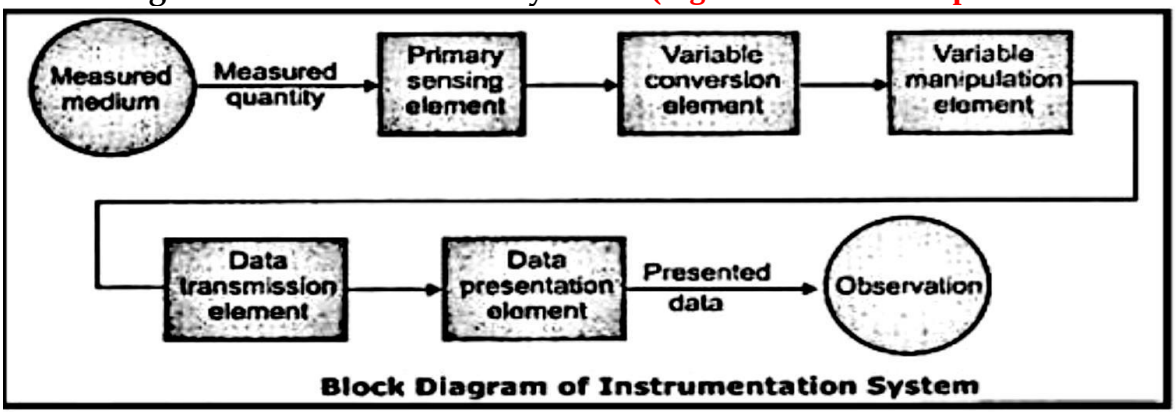


Fig. Block diagram of instrumentation system **or equivalent figure**

1. Primary Sensing Element:

Primary sensing element of system is that which first receives energy from the measured medium and produces an output depending in some way on the value of measured quantity.

2. Variable Conversion Element:

A variable conversion element merely converts the output signal of the primary sensing element into a more suitable variable or condition useful to the function of the instruments.

3. Variable Manipulation Element:

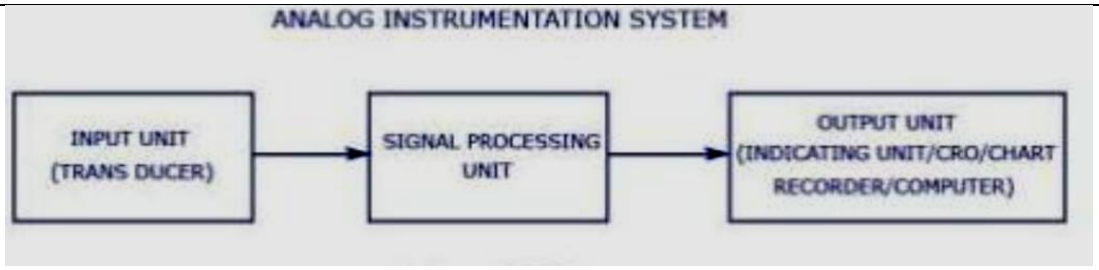
It manipulates the signal represented by some physical variable, to perform the intended task of an instrument. In the manipulation process, the physical nature of the signal is preserved.

4. Data Transmission Element: It transmits the data from one element to other element.

5. Data presentation Element:

It performs the translation function, such as the simple indication of a pointer moving over a scale or recording of a pen moving over a chart.

OR



or equivalent figure

1. The Primary Element/Transducer:

The input receives the quantity whose value is to be measured and is converted into its proportional incremental electrical signal such as voltage, current, resistance change, inductance or even capacitance. Thus, the changed variable contains the information of the measured variable. Such a functional element or device is called a transducer.

2. The Secondary Element/Signal Processing Unit :

The output of the transducer is provided to the input of the signal processing unit. This unit amplifies the weak transducer output and is filtered and modified to a form that is acceptable by the output unit. Thus this unit may have devices like: amplifiers, filters, analog to digital converters, and so on.

3. The Final Element/Output Unit:

The output from the signal processing unit is fed to the input of the output unit. The output unit measures the signal and indicates the value to the reader. The indication may be either through: an indicating instrument, a CRO, digital computer, and so on

b) Distinguish between sensitivity and resolution.

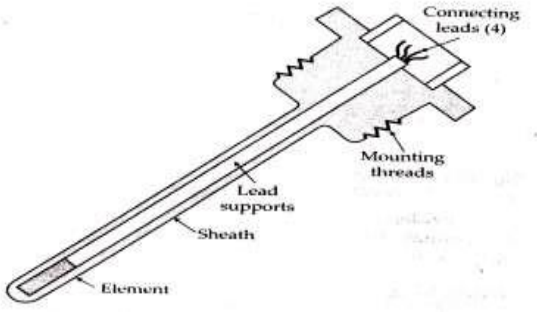
Ans: **(Any Four types expected:1 Mark each, Total 4 Mark)**

Sr.no	**Sensitivity**	**resolution**
1.	The ratio of change in output of an instrument to the change in input is known as sensitivity	It is defined as smallest increment in input (quantity being measured) which can be detected with certainty by an instrument

		2.	Sensitivity = Change in output/ Change in input	the smallest increment of change in the measured value that can be determined	
		3.	Accuracy will not be affected by **Sensitivity**	Accuracy will be affected by resolution	
		4.	Better reading, Sensitivity of the sensor must be high	higher resolution will be able to read smaller readings or detect a smaller change.	

c) Draw the diagram of RTD and state its working principle.

Ans: **Diagram of RTD:** **(Diagram: 2 Mark, Working : 2 Mark, Total 4 Marks)**



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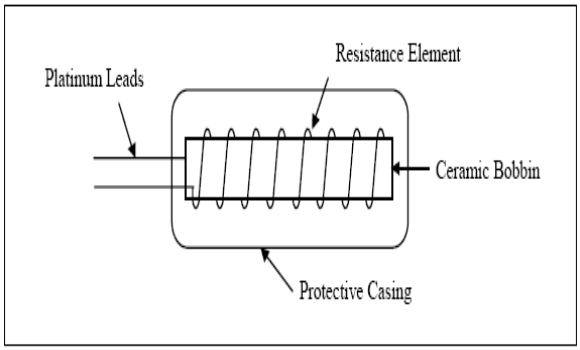


Or equivalent figure

Resistance thermometer:

The resistance of a conductor changes when its temperature is changed. The resistance thermometer or RTD is an instrument used to measure electrical resistance in terms of temperature.

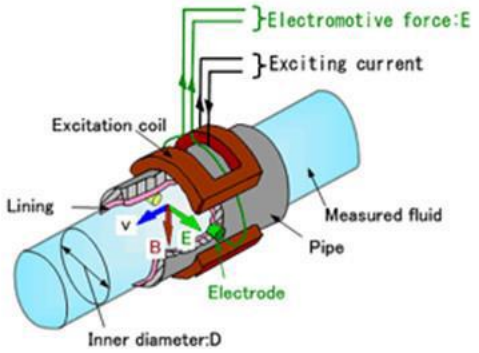
Variation of resistance of a metal with the temperature can be represented by the following relationship:

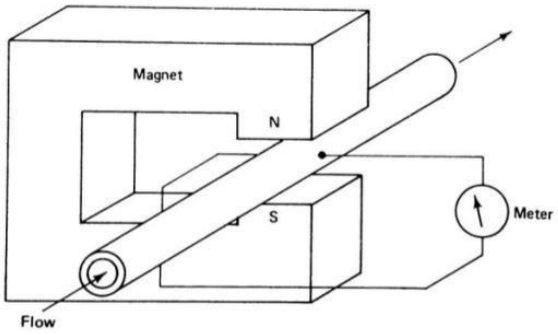
$$Rt = R0\,(1 + \alpha\, t + \beta\, t^2 + \gamma\, t^3 + ...)$$

d) Describe working of an electromagnetic flow meter with neat diagram.

Ans: Diagram of electromagnetic flow meter

(Diagram: 2 mark & Working; 2 mark. Total 4 Marks)





OR

or equivalent figure

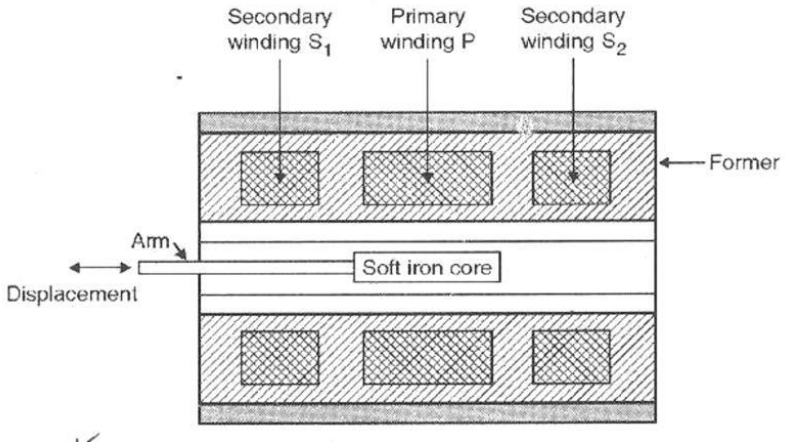
Working Principle:

- The electromagnetic flow meter uses Faraday's Law of electromagnetic induction to measure the process flow.
- When an electrically conductive fluid flows in the pipe, an electrode voltage E is induced between a pair of electrodes placed at right angles to the direction of magnetic field. Under Faraday's law of induction, moving conductive liquids inside of a magnetic field generates an electromotive force (voltage) in which the pipe inner diameter, magnetic field strength, and average flow velocity are all proportional. In other words, the flow velocity of liquid moving in a magnetic field is converted into electricity.
- (E is proportional to V × B × D)
- The electrode voltage E is directly proportional to the average fluid velocity (V).

e) Draw constitutional diagram of LVDT. State its working principle.

Ans: Constitutional diagram of LVDT:

(Diagram: 2 Mark & Working: 2 Mark, Total 4 Marks)



or equivalent diagram

Working Principle:

It works on the principle of variable inductance. The inductance is varied according to the displacement. This is achieved either by varying the mutual inductance between the two coils. It is having a primary & two secondary windings wound over a hollow former and a soft iron core slides inside the hollow former. The position of movable core determines the flux linkage between the AC excited primary winding and each of the secondary winding.

f)	**State the four applications of instrumentation amplifier.**
Ans:	**(Any four-point expected: 1 Mark each, Total 4 Mark)**

Applications of instrumentation amplifier

1. For amplification of week signals e.g. loadcell output
2. Noise eliminator in precision DAS
3. In Medical instrumentation, Navigation, Radar instrumentation e.t.c
4. In Audio applications involving low amplitude audio signals in noisy environments to improve the signal to noise ratio;
5. High-speed signal conditioning for video data acquisition and imaging
6. High frequency signal amplification in cable RF systems.
7. Preamplifier in any measurement system

Q.4	**Attempt any FOUR of the following : 16 Marks**
a)	**Compare between primary transducer and secondary transducer.**
Ans:	**(Any Four types expected:1 Mark each, Total 4 Mark)**

Sr.no	**Primary transducer**	**Secondary transducer**
5.	The Mechanical device which converts physical quantity to be measured into a mechanical signal	The Electrical device which converts this mechanical signal to the electrical signal.
6.	Primary transducer is that which comes in contact with the medium being measured	The secondary transducer does not come in direct contact with the medium being measured
7.	Output of primary transducer will not directly used in process system	Output of secondary transducer directly used in process system
8.	It is mechanical device	It is electrical device
9.	Example :- Bordon tube, bellows, Load cell	Example :- LVDT, Strain Gauge

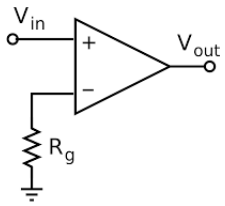
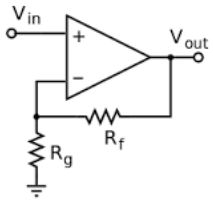
b) List the two materials each for core of LVDT, strain gauge, diaphragm and thermistor.

Ans: **(Each Point: 1 Mark)**

Sr.no	**Transducer**	**Materials**
1.	LVDT	The core's material is ferromagnetic metal such as iron or ferrimagnetic compounds such as ferrites
2.	**Strain gauge**	Nichrome, Constantan, Isoelastic, Nickel, Platinum, Aluminum ,Copper, Steel, Magnesium, Bronzes
3.	**Diaphragm**	Polythene , Neoprene , Animal membrane, Silk, and Synthetic materials
4.	**Thermistor**	sintered mixture of metallic oxides such as manganese , nickel, cobalt, copper, iron and uranium

c) Compare open loop and closed loop configuration of Op-Amp.

Ans: **(Any four point expected: 1 Mark each, Total 4 Mark)**

S.No.	Point	open loop configuration of Op-Amp	closed loop configuration of Op-Amp
1	Circuit diagram		
2	Gain	Voltage gain is very high. Gain is uncontrollable	Voltage gain is low as compared to open. Gain is controllable & depends on external passive components.
3	Bandwidth	bandwidth is low	bandwidth is high
4	Application	Comparator, Square wave generator, wave shaping circuit, zero crossing detection	It is used ac, dc signal amplifier, oscillator, Instrument amplifier circuits etc
5	Feedback signal	No feedback is taken from output	A feedback signal is taken from the output

d) Compare RTD and thermistor.

Ans: **(Any four point expected: 1 Mark each, Total 4 Mark)**

S.No.	RTD	thermistor
1	Made of metals like copper, platinum, nickel and tungsten	Made of metallic oxides such as cobalt, manganese, nickel etc.
2	Have positive temperature coefficient of resistance that is their resistance increases as the temperature increases.	Thermistors of both positive and negative temperature coefficient of resistance are available but thermistors having NTC are used,

		that is, their resistance will decrease as the temperature increases.
3	Temperature range: -100 C to 650 C.	Temperature range: -50 C to 300 C
4	Temperature versus resistance characteristics are linear.	Temperature versus resistance characteristics are nonlinear.
5	Less sensitive to temperature than thermistor	Thermistors are more sensitive to temperature in the specified range than RTDs
6	Cost is high	Less costlier than RTD
7	They have better reproducibility and low hysteresis.	They have less reproducibility and more hysteresis.
8	Relatively bigger in size.	Thermistors are quite small in size and in shapes like washer, bead, probe, disc, etc. .

e) Define DAS. Draw diagram for single channel DAS.

Ans:

DAS: **(2 Marks)**

Data acquisition systems are which is used to measure and record analog signals either in analog form or in digital form.

Diagram for single channel DAS: **(2 Marks)**

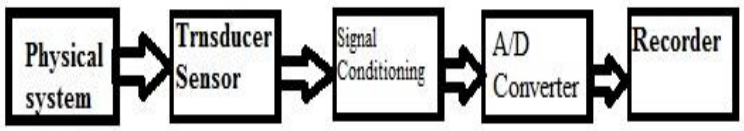


Fig. Single Channel DAS

or equivalent diagram

f)	**Draw instrumentation amplifier in three Op-Amp.**
Ans:	**Instrumentation amplifier in three Op-Amp:** **(4 Marks)**

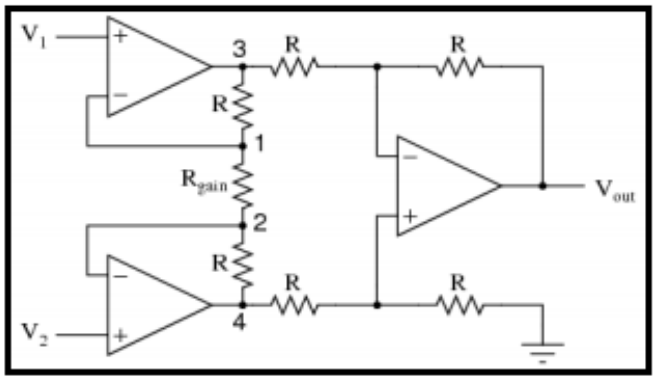
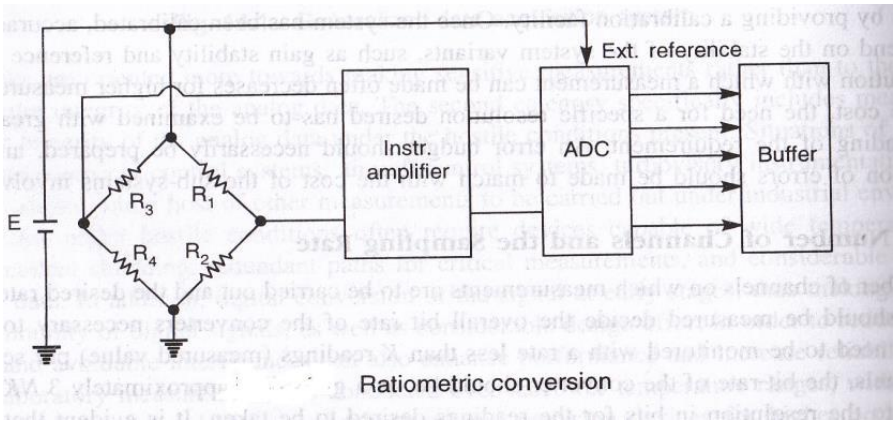


Figure:- Instrumentation amplifier

or equivalent diagram

Q.5	**Attempt any FOUR of the following :** **16 Marks**
a)	**Draw and explain ratio metric conversion in DAS.**
Ans:	**Diagram of ratio metric conversion in DAS:**

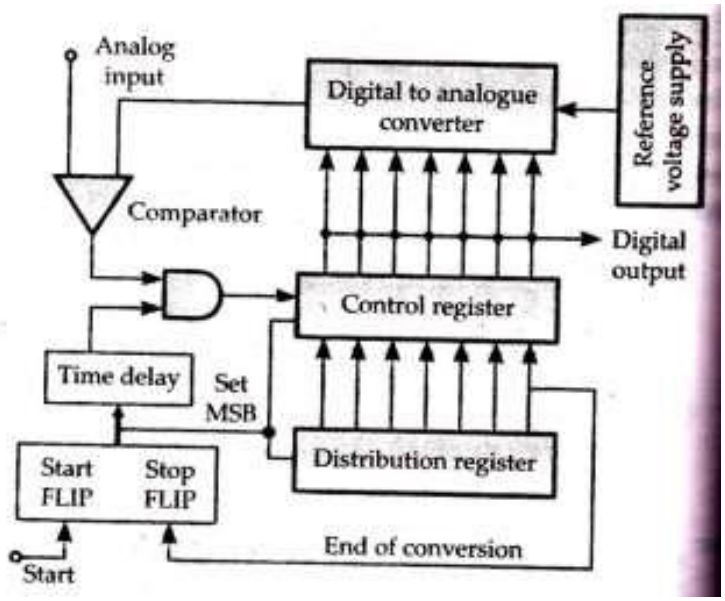
(Diagram: 2 Mark & Explanation: 2 Mark, Total 4 Marks)



or equivalent figure

Explanation of ratio metric conversion in DAS:

It is the method of signal conditioning in DAS. It is to feed the bridge excitation voltage as reference voltage for A/D converter. In A/D converter the conversion factor is inversely proportional to the reference voltage. The system sensitivity is independent of fluctuations in the bridge-excitation voltage.

b)	**Draw and explain the working of successive approximation type analog to digit converter.**
Ans:	**Diagram of successive approximation type analog to digit converter:** **(Diagram: 2 Marks & Explanation: 2 Marks, Total 4 Marks)**  **or equivalent figure**

Explanation:

- A generalized block diagram of a basic successive approximation converter is shown in figure.
- The converter uses a digital control register with gateable binary inputs of 1 and 0, a D/A converter with a reference voltage supply, a comparison circuit, a control timing loop, and a distribution register.
- At the start of conversion cycle, both the control register and distribution register are set with a 1 in the MSB and a 0 in all bits of less significance. Thus the distribution register shows that the cycle has started and the process is in the first phase.
- The control register shows 1000, and this causes an output voltage at D/A converter section of one half of reference supply.
- At the same time, a pulse enters the time delay circuitry. By the time that the D/A converter and the comparator have settled, this delayed pulse is gated with the comparator output.

- When the next MSB is set in control register by the action of timing circuit, the MSB remains in a one state or it is reset to 0 depending upon the comparator output.
- The single 1 in the distribution register is shifted to the next position and keeps track of the comparison made.
- The procedure repeats itself following the diagram of fig until the final approximation has been corrected and the distribution register indicates the end of the conversion.

c) Differentiate between single channel DAS and multichannel DAS.

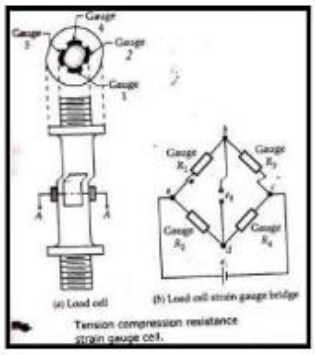
Ans: **(Each point: 1 Mark, Total 4 Mark)**

S.No.	Single channel DAS	Multichannel DAS
1	Only one parameter is acquired	More than one parameter
2	Multiplexer is not required	Multiplexer is required
3	Less number of transducer & signal conditioning is required	More number of transducer & signal conditioning is required
4	Simple circuitry	Complicated circuitry

d) Draw and explain force measurement using load cell.

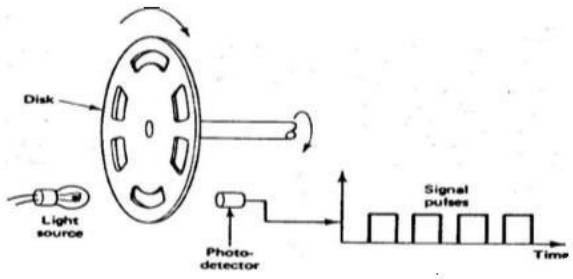
Ans: **Diagram of force measurement using load cell :**

(Diagram : 2 Mark & Explanation: 2 Mark, Total 4 Marks)



or equivalent figure

Working:

	1. Load cells utilize an elastic member as the primary transducer and strain gauges as secondary transducers. 2. Strain gauges may be attached to any elastic member, on which there exists a, suitable plane area to accommodate them. 3. This arrangement may then be used to measure loads applied to deform or deflect the member, provided that the resultant strain is large enough to produce detectible outputs. 4. When the strain gauge –elastic member combination is used for weighing it is called a load-cell.
e)	**Draw and explain rotary motion encoder using optical rotary encoder.**
Ans:	**Diagram of rotary motion encoder using optical rotary encoder:** **(Diagram: 2 Mark & Explanation: 2 Mark, Total 4 Marks)**  **or equivalent figure** **Measurement of rotary motion using optical encoder :** An optical encoder is an angular position sensor. It has a shaft mechanically coupled to an input driver which rotates a disc rigidly fixed to it. A succession of opaque and transparent segments is marked on the surface of the disc. On one side of the disc are LEDs and on the other side there are photosensitive receivers like photodiodes or photo transistors. When the disc rotates and opaque segments are between LEDs and receivers, no light reaches the receivers and output is zero. When the transparent segments are between LEDs and receivers, light is received by the receivers and output signal is obtained. In this way a train of pulses equivalent to the rotation is obtained as shown.

f) Differentiate between volumetric flow rate and mass flow rate.

Ans: **(Each point: 1 Mark, Total 4 Mark)**

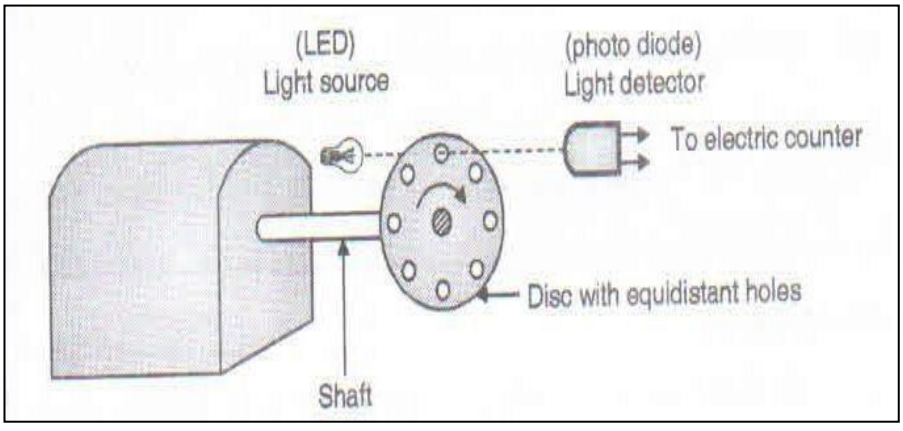
S.No.	Volumetric flow rate	Mass flow rate
1	Volumetric flow is the measure of a substance moving through a device over time.	Mass flow rate is the amount of Mass moving through an instrument over time
2	Units of measure for volumetric Flow rate are meter^3 /second, liters/second or feet^3/hour	The unit of measure is mass per unit of time. It can be expressed as pounds /hour or kilogram/second
3	To measure Volumetric flow rate, positive displacement meters, turbine flow meters are used.	To measure mass flow rate, Coriolis flow meters, thermal mass flow meters etc. are used.
4	Volumetric flow rate = Velocity of flowing fluid x Area.	Mass flow rate = volumetric flow rate x density

Q.6 Attempt any FOUR of the following : 16 Marks

a) Draw and explain working of photoelectric transducer.

Ans: **(Constructional diagram: 2 Marks Working: 2 Marks)**

Photoelectric Tachometer:



or equivalent figure

- **Working principle:**
- The light passes through the holes available on the rotating disc with a specific interval, depends on the angular speed of disc having equidistant holes. The frequency of this light pulses is measure of angular speed of the disc.
- It consists of an opaque disc on the rotating shaft. The disc has a number of equidistant holes on its periphery. At one side of the disc a light source is fixed like LED and on other side of the disc, and on the line of the light source, alight sensor like phototube or some photosensitive semiconducting device is placed.
- When a hole appears between two, the light following upon the sensor produces an output pulse.
- The frequency at which the pulses are produced depends on the number of holes in the disc and its speed of rotation. Hence the speed is given by

$$N = \frac{f}{H_s}$$

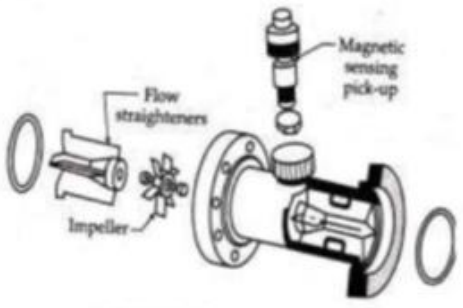
Where N=speed, f=frequency, Hs=holes on the disc

b) Draw and explain the working of turbine flow meter.

Ans: **Diagram of turbine flow meter:**

(Diagram: 2 Mark & Working: 2 marks, Total 4 Marks)

Diagram:

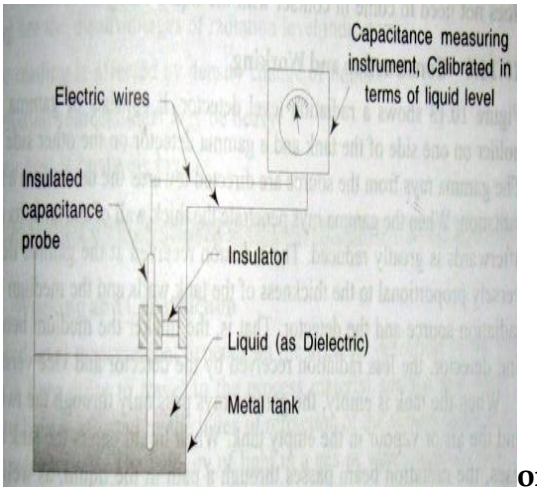


or equivalent figure

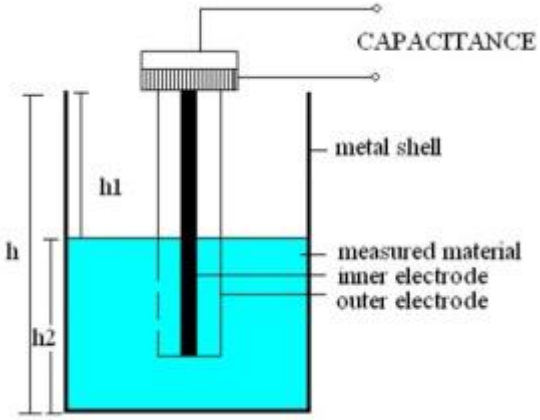
Working Principle:

	The flowing fluid impinges on the turbine blades (rotor), imparting a force to the blade surface which causes the rotation of the rotor. The speed of the rotation is directly proportional to the fluid velocity. The rotor consists of small permanent magnets. When rotor rotates this magnetic field also rotates. The speed of rotation monitored in most of the meters by magnetic pickup coil, which generates pulses. Total number of pulses gives the total flow. So the amount of emf induced depends upon the flow rate.
c)	**List any six criteria for selecting a proper transducer for an application.**
Ans:	Transducer is a device which transforms energy from one form to another. The **following points should be considered while selecting a transducer for particular application.** **(Any Four point expected: 1 mark each, total 4 Marks)** 1. Operating range: The range of transducer should be appropriate for measurement to get a good resolution. 2. Operating principle: The transducers are selected on the basis of operating principle it may be resistive, inductive, capacitive, optical etc. 3. Sensitivity: The transducer should be more sensitive to produce the output or sensitivity should be as per requirement. 4. Accuracy: The accuracy should be as high as possible or as per the measurement. 5. Frequency response and resonant frequency 6. Errors: The error produced by the transducer should be low as possible. 7. Environmental compatibility: The transducer should maintain input and output characteristic for the selected environmental condition. 8. Usage and ruggedness.: it should be rugged in construction 9. Electrical aspect. 10. Stability and Reliability: Transducer should produce stable and accurate output in any environmental condition. 11. Loading effect: The transducer's input impedance should be high and output impedance should be low to avoid loading effect.
d)	**Explain how level can be measured using capacitive method.**

Ans: **(Figure: 2 Mark & Explanation :2 Mark)**



or



equivalent figure

Capacitance level transducer :-

- The principle of operation of capacitance level indicator is based upon the familiar capacitance
- equation of parallel plate capacitor given by

$$C = K * (A/D)$$

Where, C= capacitance, in farad

K= dielectric constant

A=area of plate, in meters square

D= distance between two plates, in meter.

- Therefore, it is seen from the above equation that if A & D are constant, then the capacitance of a capacitor is directly proportional to the dielectric constant, and this principle utilized in the capacitance level indicator.

Construction & working:-

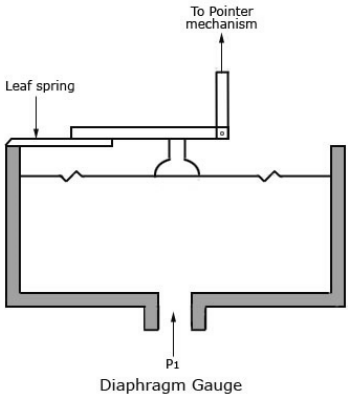
- Fig. shows a capacitance type liquid level indicator. It consist of an insulated capacitance probe (which is a metal electrode) firmly fixed near and parallel to the metal wall of the tank.

- If the liquid in the tank is **non-conductive**, the capacitance probe and the tank wall form the plates of a parallel plate capacitor and liquid in between them acts as the dielectric.
- If the **liquid is conductive** the capacitance probe and liquid form the plates of the capacitor and the insulation of the probe acts as the dielectric.
- A capacitance measuring device is connected with the probe and the tank wall, which is calibrated in terms of the level of the liquid in the tank.
- When the level of liquid in the tank rises, the capacitance increases.
- When liquid level of the tank decreases, the capacitance also decreases.
- Change in the capacitance is measured and is displayed on the indicator calibrated in terms of liquid level

e) Draw and explain working of pressure measurement using diaphragm type transducer.

Ans: **Diagram of pressure measurement using diaphragm type transducer:**

(Diagram: 2 Mark & explanation with working: 2 mark, Total 4 Marks)



or equivalent figure

Explanation:

A diaphragm type pressure transducer is used for low pressure measurement. They are commercially available in two types: Metallic and Non-metallic.

Working:

The diagram of diaphragm pressure gauge is shown in the figure. When a force acts against a thin stretched diaphragm, it causes a deflection of the diaphragm with its center deflecting the most.

If the pointer or mechanical movement is connected to the LVDT or other secondary transducer then it converts mechanical action into electrical output.

f) Describe the resistive method for liquid level measurement. Write its two advantages.

Ans: **Resistive method for liquid level measurement:**

(Diagram: 1 Mark, Explanation: 2 Mark & Advantages: 1 Mark, Total 4 Marks)

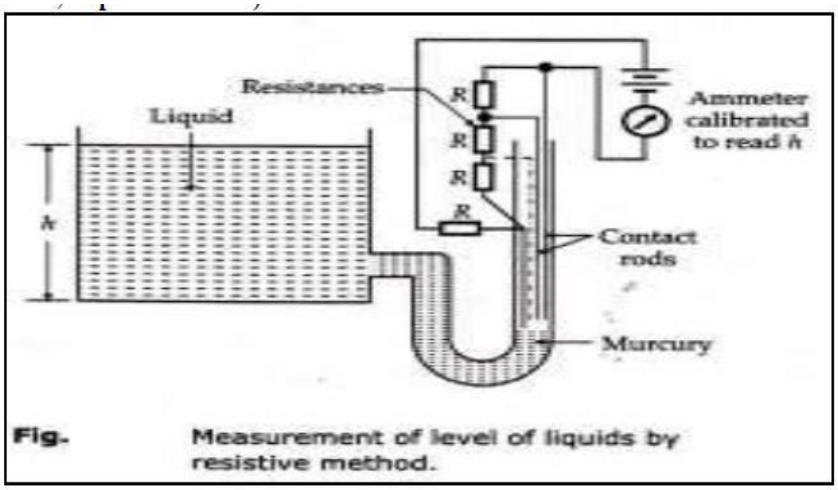


Fig. Measurement of level of liquids by resistive method.

or equivalent figure

Explanation:-

This method uses mercury as a conductor. A number of conduct rods are placed at various liquid levels. As head 'h 'increases, the rising level of mercury above the datum, shorts successive resistors 'R' and increases the value of 'h' directly.

Advantages of resistive method for liquid level measurement

1. Direct reading is possible
2. Simple
3. cost-effective measuring principle
4. Multi-point detection with one process connection

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