MODEL ANSWER

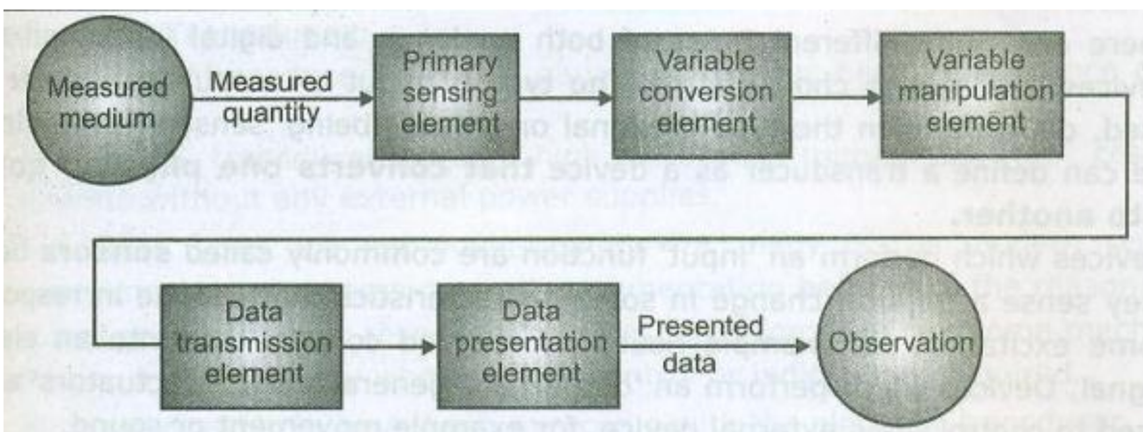
SUMMER– 17 EXAMINATION

Subject Title: Industrial Instrumentation Subject Code: 17414

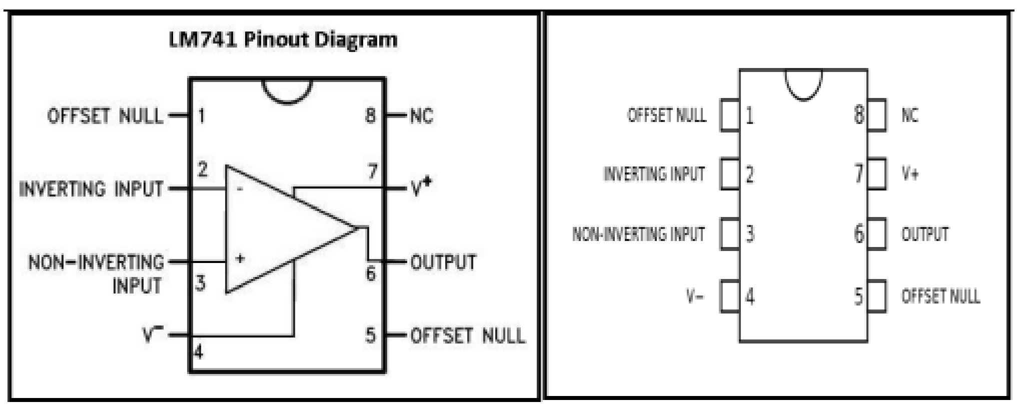
Important Instructions to examiners:

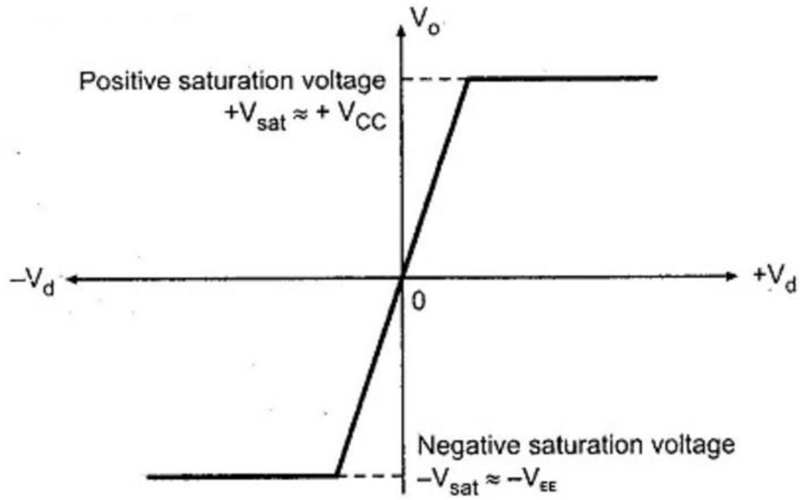
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent 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.	Sub Q.N.	Answer	Marking Scheme
Q.1		**Attempt any TEN:**	**20-Total Marks**
	a)	**Define** **i)Accuracy ii)Precision**	**2M**
	Ans:	**Accuracy:** The degree of exactness (closeness) of a measurement compared to the expected (desired) value. **OR** It is the ability of a device or a system to respond to a true value of a measured variable under reference conditions. **OR** Closeness with which the instrument reading approaches the true value of the quantity being measured is known as accuracy. **Precision:** It is a measure of the reproducibility of the measurements that is given a fixed value of a quantity, precision of measure of the degree of agreement within a group of measurements. **OR** A measure of the consistency of measurements, i.e. successive readings does not defer.	**1M each**

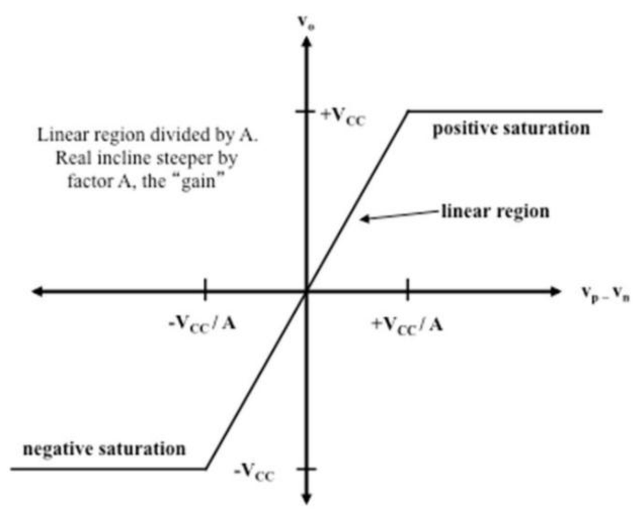
	b)	**List dynamic characteristics of instruments.**	**2M**
	Ans:	• **Speed of Response:** It is the rapidity with which a measurement system responds to changes in the measured quantity. • **Measuring Lag:** It is the retardation or delay in the response of a measurement system responds to changes in the measured quantity. There are two types of it: i) Retardation type, ii) Time delay type. • **Fidelity**: It is the degree to which a measurement system indicates changes in the measured quantity without dynamic error. • **Dynamic Error:** It is the difference between true values of quantity changing with time and the value indicated by the measurement system if there is no static error.	**½ M each**
	c)	**Explain principles of calibration.**	**2M**
	Ans:	The process of deriving the value of a quantity by comparing that quantity with a standard quantity is called as calibration. Calibration of instrument is done to obtain correct unknown value of each scale reading on measuring instrument	**2M**
	d)	**Draw block diagram of instrumentation system.**	**2M**
	Ans:	**Diagram :**  **Block Diagram of Instrumentation System**	**2M**
	e)	**List any 4 undesirable characteristics of instruments.**	**2M**
	Ans:	1. Drift 2. Dead zone 3. Static error 4. Dynamic error 5. Lag	**1 M each for any 4**

		Note: Any other relevant characteristics	
	f)	**State the effect of hysterisis on instument.**	**2M**
	Ans:	**Hysteresis effect :** Hysteresis effect is due to magnetic effects of the metals. It gives the relation between field current and the output voltage. The magnetization of ferromagnetic substances due to a varying magnetic field lags behind the field. This effect is called hysteresis, and the term is used to describe any system in whose response depends not only on its current state, but also upon its past history.	**2M**
	g)	**Define:** **Dynamic error ii)Tolerance**	**2M**
	Ans:	**i)Dynamic Error**: It is the difference between true values of quantity changing with time and the value indicated by the measurement system if no static error. **ii) Tolerance** : Ability of an item or system to withstand high levels of stress or overloading without suffering irreparable harm. **OR** Allowable departure from a specification or standard, considered non-harmful to the functioning of a part, process, or product over its life cycle. **OR** The difference between standard instrument reading and measuring instrument reading is known as error and if this error is permissible then it is called as tolerance	**1M each**
	h)	**Define:** **i)CMRR ii) SVRR**	**2M**
	Ans:	**CMRR**:- 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. $CMRR = \frac{A_{DM}}{A_{CM}}$ **OR** It is defined as the ratio of differential voltage gain Ad to common mode voltage gain Acm **SVRR :** Supply Voltage Rejection Ratio: It is defined as the ratio of change of input offset voltage to the change in one supply voltage while keeping other supply voltage constant. Ideally, SVRR=0	**1M each**
	i)	**Define the term Transducer and sensor.**	**2M**
	Ans:	**Transducer :** Transducer is defined as a device which converts one form of energy into another form. **Sensor :** Sensor is a device which detects or measures a physical property and records, indicates, or otherwise responds to it.	**1M each**

j)	**Give 2 examples each of Active and Passive Transducer.**	**2M**
Ans:	**<u>Active Transducers :</u>** 1. Thermocouple 2. Piezoelectric Transducer 3. Solar Cell/ Photovoltaic cell 4. Tacho generator **<u>Passive Transducers :</u>** 1. Thermistor 2. RTD 3. LVDT 4. Strain Gauge 5. Electromagnetic flowmeter. 6. Capacitive transducers. Etc. ***<u>Note :Any other relevant example.</u>***	**(1M for any 2)** **(1M for any 2)**
k)	**Give pin functions of IC'S 741.**	**2M**
Ans:	**<u>Diagram :</u>** 	**2M**
l)	**Draw ideal voltage transfer curve for op-amp.**	**2M**
Ans:	**<u>Diagram :</u>**	**2M**



OR

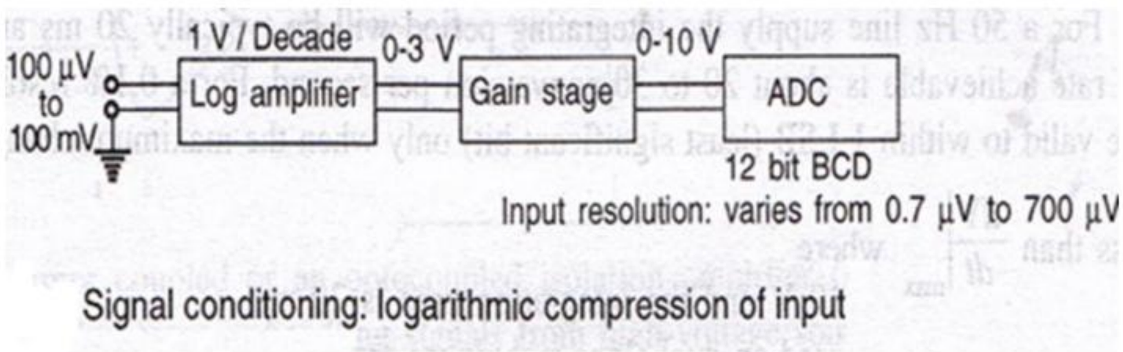


Q 2		**Attempt any Four:**	**16M**
	a)	**Explain why LVDT gives a residual output at null position. State its 2 applications.**	**4M**
	Ans:	**LVDT :** Residual voltage may be on account of I/P supply voltage and also due to harmonics produced in the o/p voltage on account of use of iron core. **OR** An incomplete magnetic or electrical unbalance or both which result in a finite O/P voltage at the null position. This finite residual voltage is generally less than 1% of the max. o/p voltage in the linear range. Other causes of residual voltage are stray magnetic fields and temperature effects.	**2M**
		Applications : LVDT is used as a secondary transducer as it can be used as a device to measure force, weight and pressure etc. The force measurement can be done by using a load cell as the primary transducer while fluid pressure can be measured by using Bourdon tube which	**2M**

acts as primary transducer. The force or the pressure is converted into a voltage. In these applications the high sensitivity of LVDTs is a major attraction.

b) **Describe logarithmic conversion signal conditioning in DAS.** **4M**

Ans: **<u>Diagram :</u>** **2M**

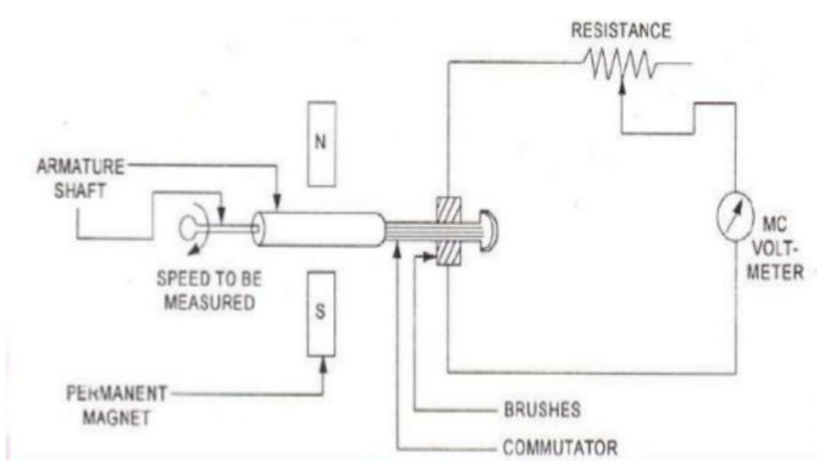


<u>Explanation :</u>

It is a signal conditioning method applicable with DAS. The logarithmic conversion circuit enables the measurement of fractional change in the input as a percentage of the input magnitude rather than a percentage of range. It improves the resolution **2M**

C) **Describe with neat diagram working of DC tacho-generator.** **4M**

Ans: **<u>Diagram :</u>** **2M**



<u>Explanation :</u>

The D.C Tachogenerators is a type of electrical type's tachogenerators which can also be used for speed measurement.The D.C tachogenerator is shown in above figure. **2M**

The armature of the D.C Tachogenerator is kept in the permanent magnetic field. The armature of the tachogenerator is coupled to the machine whose speed is to be measured. When the shaft of the machine revolves, the armature of the tachogenerator revolves in

		the magnetic field producing e.m.f. which is proportional to the product of the flux and speed to be measured. Now as the field of the permanent field is fixed, the e.m.f generated is proportional to the speed directly. The e.m.f induced is measured using moving coil voltmeter with uniform scale calibrated in speed directly. The series resistance is used to limit the current under output short circuit condition. The polarity of output voltage indicates the direction of rotation. The commutator collects current from armature conductors and converts internally induced a.c e.m.f into d.c (unidirectional) e.m.f. while the brushes are used to collect current from commutator and make it available to external circuitry of the d.c tachogenerator.	
	d)	**Discuss any 4 points to be considered while selecting a transducer for its intended applications.**	**4M**
	Ans:	**(Any Four Points)** 1. Operating range 2. Operating principle 3. Sensitivity 4. Accuracy 5. Frequency response and resonant frequency 6. Errors 7. Environmental compatibility 8. Usage and ruggedness. 9. Electrical aspect. 10. Stability and Reliability 11. Loading effect 12. Static characteristics 13. General selection criteria	**1M Any Four Points**
	e)	**What is Hall effect ? State its applicability in parameter measurement.**	**4M**
	Ans:	**<u>Principle:</u>** The principle of working of a Hall Effect Transducer is that if a strip of conducting material carries' a current in the presence of a transverse magnetic field, a difference of potential is produced between the opposite edges of the conductor. The magnitude of the voltage depends upon the current, the strength of magnetic field and the property of the conductor called Hall Effect.	**4M**

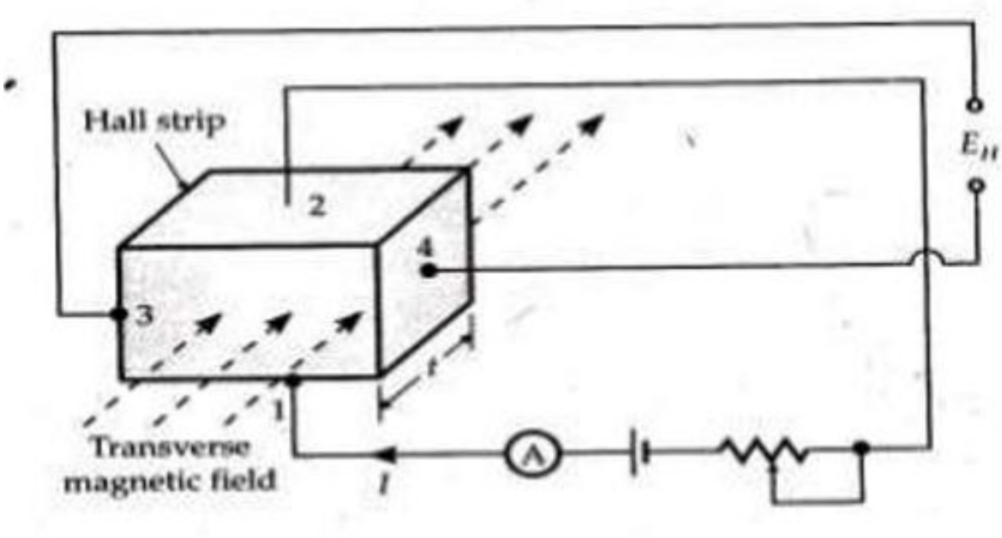


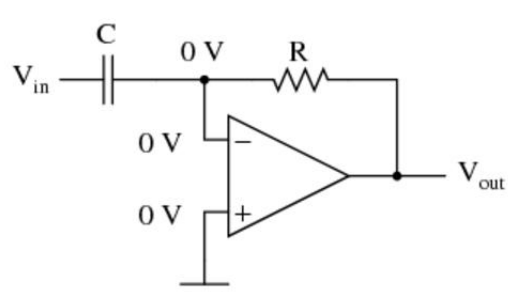
Fig Hall Effect Element.

Current is passed through leads 1 and 2 of the strip. The output leads connected to edges 3 and 4 are at the same potential when there is no transverse magnetic field passing through the strip. When a transverse magnetic field passes through the strip, an output voltage appears across the output leads.

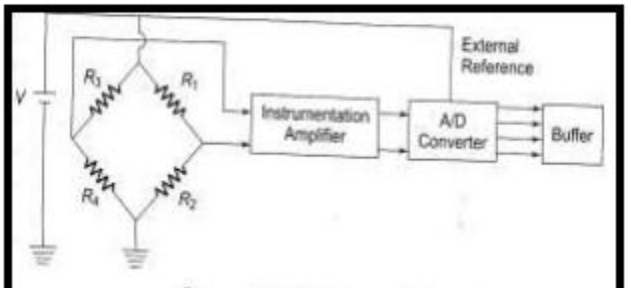
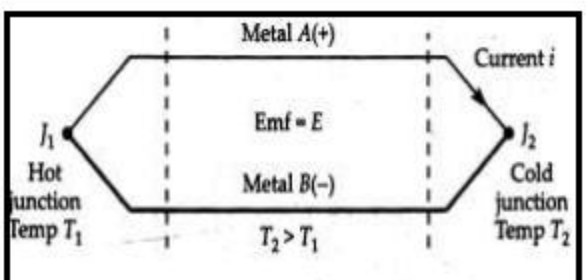
This voltage is proportional to the current and the field strength. The output voltage is,
EH = KH IB / t
where KH = Hall effect coefficient ;   V - m /A- Wb m-2
t = thickness of strip; m, and I and B are respectively the current in ampere and flux density in Wb/m2.
Thus the voltage produced may be used for measurement of either the current I or the magnetic field strength B.

f)	**Draw circuit diagram of Op-Amp as differentiator with inverting configuration. State its output equation.**	**4M**
Ans:	**<u>Diagram :</u>**	**2M**

Differentiator



Voltage output for the differentiator is as follows:

		Equation : $$V_{out} = -RC \frac{dv_{in}}{dt}$$	**2M**
Q. 3		**Attempt anyFour:**	**16M**
	a)	**Describe ratio metric conversion in brief.**	**4M**
	Ans:	**Diagram:**  Fig. Ratiometric conversion	**2M**
		Discription: It is a signal conditioning method applicable with DAS. It includes an analog voltage divider to which an excitation voltage is given as the input. The output of it is given to an instrumentation amplifier and then to A to D converter. The output voltage of the divider is the ratio of the amplifier output voltage and the excitation voltage. Thus by this method the output of the signal amplifier will be a voltage proportional to the input parameter only and independent of the input excitation voltage. Hence the system accuracy improves since variation in the excitation voltage does not affect the sensitivity of the system	**2M**
	b)	**State the principle of working for Thermocouple. Why cold junction compensation is required in Thermocouple?**	**4M**
	Ans:	**Diagram:**  Basic circuit of thermocouple.	**1M**

Principle of Working:

When heat is applied to junction (hot junction) of the two dissimilar metals, an emf is generated which can be measured at the other junction (cold junction). 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. **1M**

Reason why cold junction compensation is required: **2M**

- Temperature should be measured with the cold junction at 0°C or 32°F, when a thermocouple or its extension wires are connected to the terminals of a device like a thermocouple transmitter the cold junction is at the room temperature T1°C.
- If both temperatures of the hot and the cold junctions are above 0°C, the device receives a lower emf than when the cold junction temperature is 0°C.
- In order to measure the temperature accurately, we need to add the emf value which corresponds to T1 to the measured emf. It is called cold junction compensation.

c) **State advantages of active filter over passive filter. Hence draw frequency response of major active filters.** **4M**

Ans: **Advantages of active filter**:- **(Any four)** **2 M**

1. Produces high gain
2. Easier to design
3. High input impedance and low output impedance for minimal loading
4. No inductors
5. Easier to tune
6. Small in size and weight

Diagram : **2M**

Frequency response for active filters:

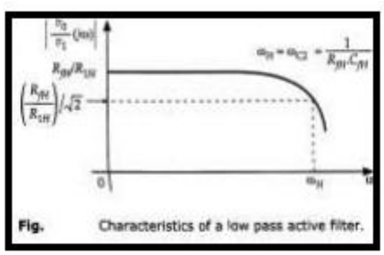


Figure 1:- Frequency response of low pass active filter

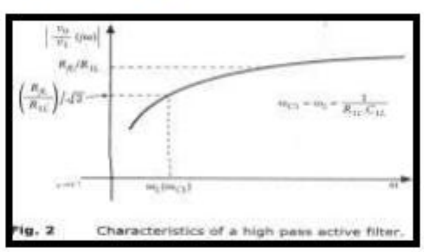


Figure 2:- Frequency response of high pass active filter

d) **Explain the working of diaphragm for pressure measurement.** **4M**

Ans: **Diagram:** **2M**

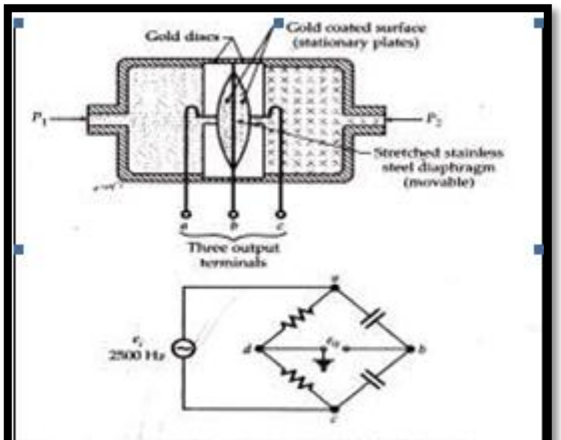
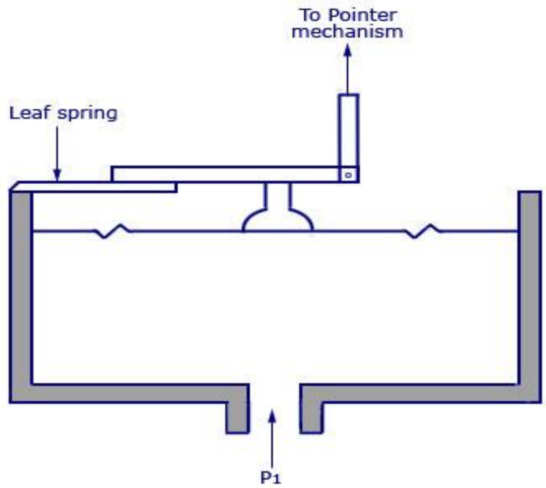


Fig. Capacitive transducer and bridge circuit.

Explanation: **2M**

- Capacitive transducers are used for the measurement of pressure by converting the pressure into a displacement.
- The displacement is sensed by a capacitive transducer using a differential arrangement. A thin stainless steel diaphragm which act as the moveable plate is clamped between the discs which is the stationary plates
- With equal pressures applied (*i.e.*, P1=P2) the diaphragm is in neutral position and the bridge is balanced.
- The output voltage e0, is zero under the conditions. If one pressure is made greater than the other, the diaphragm deflects in proportion to the differential pressure, giving an output voltage, e0 from the bridge terminal.
- This output voltage is proportional to the differential pressure. For an opposite pressure difference, the output voltage shows a 180^0 phase shift.
- This voltage may be amplified by an emitter follower amplifier.

OR



Diaphragm Gauge

Explanation:

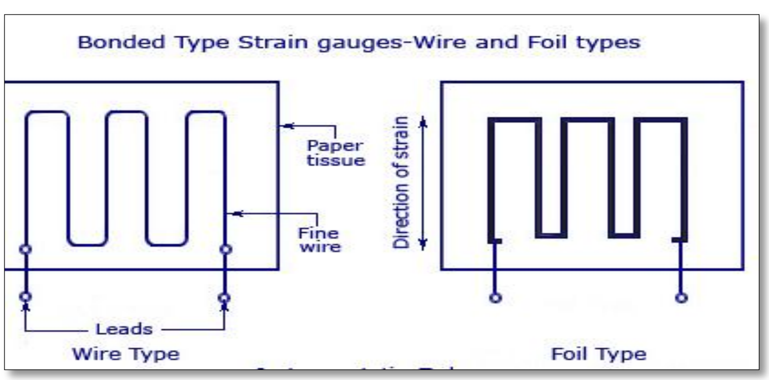
- A diaphragm pressure transducer is used for low pressure measurement. They are commercially available in two types – metallic and non-metallic.
- The diagram of a diaphragm pressure gauge is shown above. When a force acts against a thin stretched diaphragm, it causes a deflection of the diaphragm with its centre deflecting the most.
- Its motion is transmitted through the diaphragm, sealed link and pointer drive to the pointer. Then pointer moves over calibrated scale of pressure.

e)	**Define gauge factor. Describe bonded metal for strain gauge.**	**4M**
Ans:	Define Gauge Factor:	**1M**

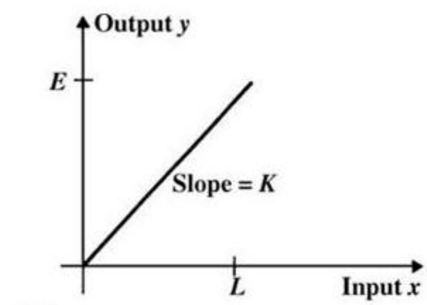
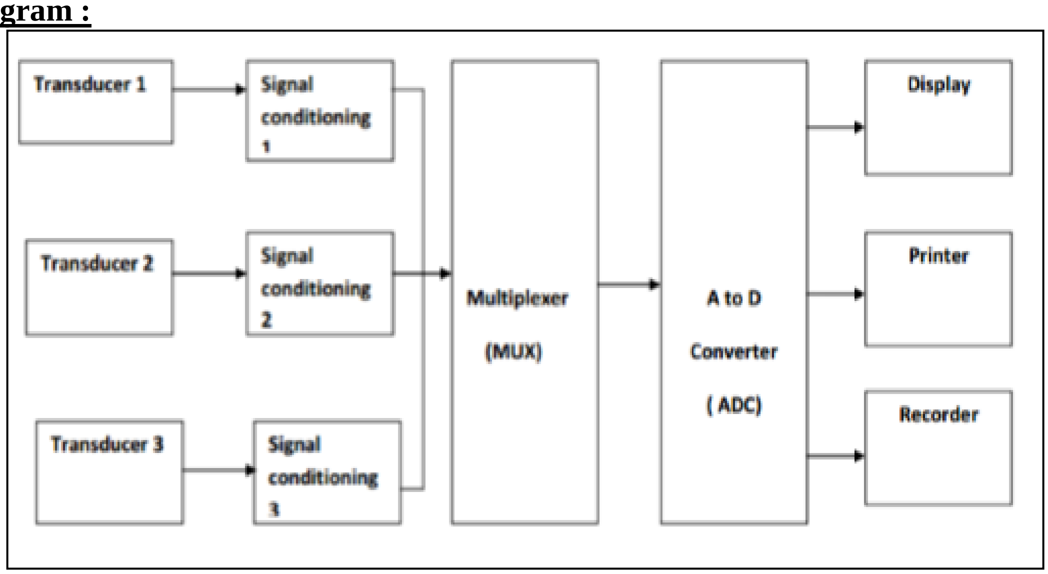
Gauge factor is defined as the ratio of per unit change in resistance to per unit change in length

$$G_f = \frac{\Delta R/R}{\Delta L/L}$$

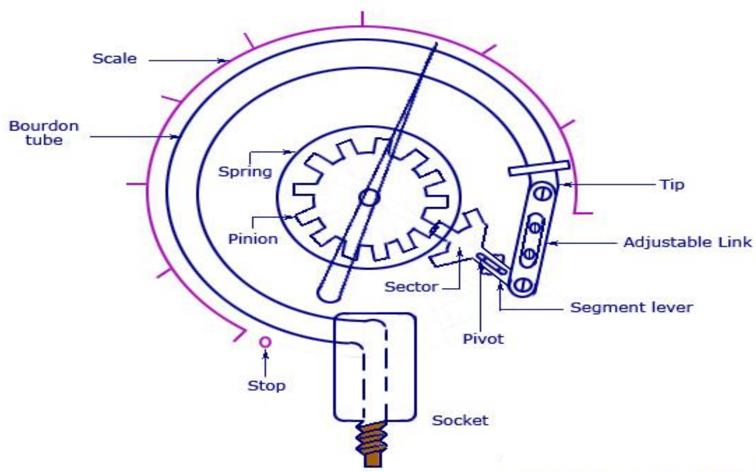
Diagram: **1.5M**

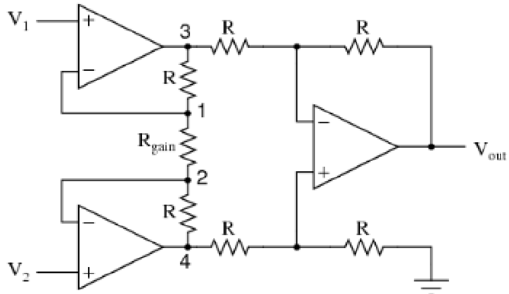
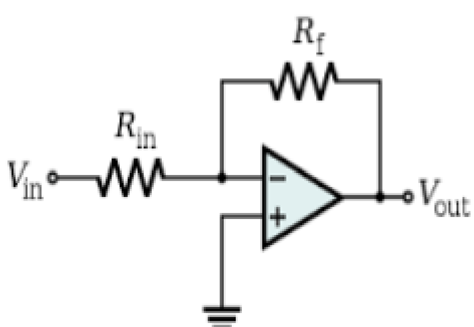


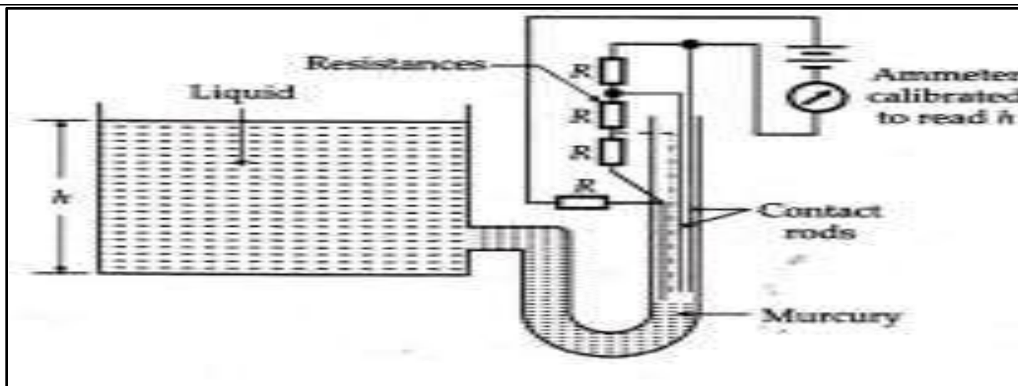
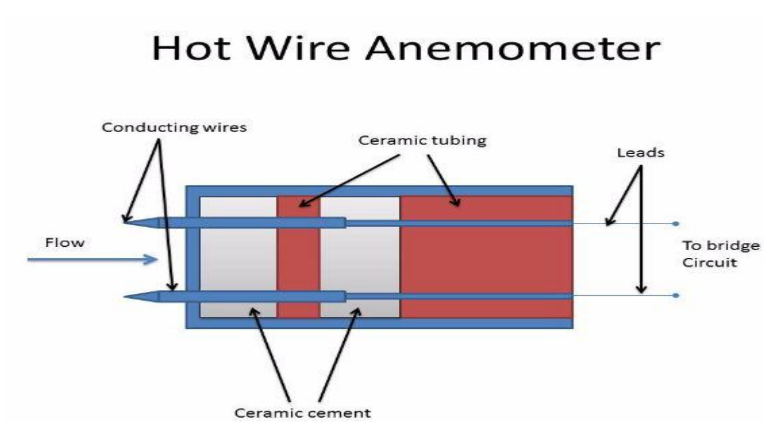
Explanation: **1.5M**

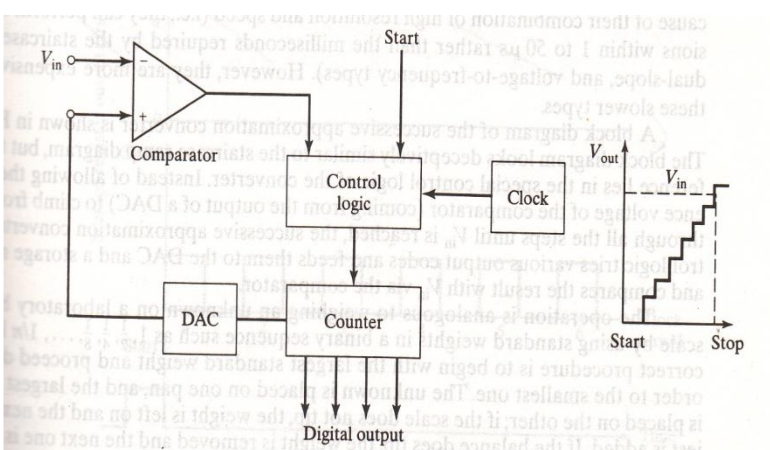
		In this type, the spreading of wire permits a uniform distribution of stress over the grid. The carrier is bonded with an adhesive material to file specimen under study. This permits a good transfer of strain from carrier to grid of wires. The wires cannot buckle as they are embedded in a matrix of cement and hence faithfully follow both the tensile and compressive strains of the specimen. Foil type gauges have a much greater heat dissipation capacity as compared with wire wound strain gauges on account of their greater surface area for the same volume. For this reason, they can be used for higher operating temperature range.	
	f)	**With the help of mathematical expression describe dynamic response of zero order instrument**.	**4M**
	Ans:	Mathematical expression: Output/Input= constant $$\frac{Y(t)}{X(t)} = K$$ Example: potentiometer Dyanmic response:  	**2 M** **2 M**
Q. 4	**A)**	**Attempt any FOUR:**	**16 M**
	a)	**Draw generalized block diagram of data acquisition system and explain it.**	**4M**
	Ans:	**<u>Diagram :</u>**  	**2M**

		Explanation: • A data acquisition (DAQ) system is used for the measurement and processing of plant signal data before it is displayed on the operator desk or permanently recorded. A block diagram of a PC (computer) based data acquisition is shown in figure . It consists of individual transducers (sensors) for measurement of physical plant parameters (such as temperature, pressure, flow, etc.). After measurement, the transducer data is fed to the signal conditioning device to bring the signal level up to a sufficient value to make it useful for conversion, processing, indicating and recording. Signal conditioner is used to amplify, modify or select certain portion of signals. • The output of the signal conditioner is fed to the multiplexing (telemetry) device. With the help of multiplexing all individual signal data (called lower bandwidth communication channels) are combined and transmitted over a higher bandwidth channel. At the receiving end, de-multiplexing recovers the original lower bandwidth channels. It scans across a number of analog signals and time-sharing them sequentially into a single analog output channel. The multiplexed data is converted into digital signal with the help of analog-to-digital converter. The converted digital signals are fed to the computer for further processing, mathematical computation, storage, etc. The final and processed data is either displayed on electronic digital display panel or recorded on magnetic media and/or chart recorders.	**2M**
	b)	**Explain force measurement using lead cell.**	**4M**
	Ans:	**Load Cell** : Load Cell is a specific type of transducer or sensor capable of transforming force (load) into a measurable electrical output. Load cells measure tension, compression, or shear. A typical load cell device comprises of four strain gauges in a Wheatstone bridge configuration. **Working**: Force conversion into an electrical signal by a load cell is usually carried out indirectly and in two stages. The first stage conversion is done through a mechanical arrangement in which the force being sensed deforms the strain gauge. This strain gauge then converts the deformation (strain) to electrical signals. One can also get load cells with one or two strain gauges. The electrical signal generated by strain gauge is in the order of a few millivolts which needs further amplification by an instrumentation amplifier. The output of the transducer is fed to an algorithm calculator to calculate the force applied to the transducer. Diagram	**2M** **2M**
	c)	**List any 4 advantages of platinum resistance Thermometer.**	**4M**
	Ans:	**Advantages :** 1. Highly accurate measurement. 2. Linear characteristics. 3. Wide range of measurement.	**1M each.**

		4. Greater Stability and repeatability over measurement.	
	d)	**State types of Bourdon tubes. Describe 'C' type bourdon tube.**	**4M**
	Ans:	**<u>There are 3 types ofBourdon tube:</u>** i)C-shaped Bourdon tube , ii)Spiral shaped bourdon tube, iii) helical shaped bourdon tube **<u>Diagram:</u>**  Bourdon Tube Pressure Gauge **<u>Explanation :</u>** • The C-shaped Bourdon tube has a hollow, elliptical cross section. • It is closed at one end and is connected to the fluid pressure at the other end. • When pressure is applied, its cross section becomes more circular, causing the tube to straighten out, like a garden hose when the water is first turned on, until the force of the fluid pressure is balanced by the elastic resistance of the tube material. • Since the open end of the tubes anchored in a fixed position, changes in pressure move the closed end. • A pointer is attached to the closed end of the tube through a linkage arm and gear and pinion assembly, which rotates the pointer around a graduated scale. • Bourdon-tube pressure gauges are often classified as simplex or duplex, depending upon whether they measure one pressure or two pressures. • A simplex gauge has only one Bourdon tube and measures only one pressure. The pressure gauge shown in above diagram is a simple gauge. • A red hand is available on some gauges. This hand is manually positioned at the maximum operating pressure of the system or portion of the system in which the gauge is installed.	**1M** **1M** **2M**
	e)	**Explain instrumentation amplifier using three Op-Amp. State its applications.**	**4M**
	Ans:	**<u>Diagram :</u>**	**2M**

		 **Fig. Instrumentation amplifier using 3 OP-AMP** **<u>Application:</u>** 1. In Data acquisition from low output transducers such as strain gauges, Thermocouples, Wheatstone bridge measurements e.t.c 2. In Medical instrumentation, Navigation, Radar instrumentation e.t.c 3. In Audio applications involving low amplitude audio signals in noisy environments to improve the signal to noise ratio; 4. High-speed signal conditioning for video data acquisition and imaging **5.** High frequency signal amplification in cable RF systems	**2M** **(Any two)**
	f)	**Explain the concept of virtual ground in op-amp.**	**4M**
	Ans:	In ideal op-amp gain(a) is infinity... a=Vo/Vi, which means Vo/Vi=infinity then Vi=0, as V1-V2=0 in an op-amp V1=V2(V1 is grounded).so, V1=0 (actual ground) n V2=0 (virtual ground). When one terminal is grounded the other terminal is assumed to be at ground potential that is virtual ground concept of op-amp. **<u>Diagram :</u>**  	**4M**
Q.5		**Attempt any FOUR:**	**16M**
	a)	**Describe how liquid level is measured by resistive sensor.**	**4M**
	Ans:	**<u>Diagram:</u>**	**2M**

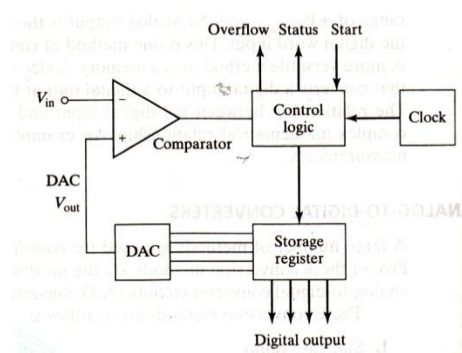
		 Fig. Measurement of level of liquids by resistive method. **<u>Explanation:-</u>** This method uses mercury as a conductor. A number of conduct rods are placed at various liquid levels. As head h increases, the rising level of mercury above the datum shorts successive resistors R and increases the value of h directly.	**02M**
	b)	**Select a suitable transducer for following application.** **i) Measurement of Air pressure inside car tyre.** **ii) Measurement of Room Temperature.** **iii) Measurement of Force** **iv) Measurement of Rotary motion.**	**4M**
	Ans:	i) Measurement of Air pressure inside car tyre. - Bourdon tube ii) Measurement of Room Temperature. - Thermistor or RTD iii) Measurement of Force –Load cell **iv)** Measurement of Rotary motion. –Optical encoder, RVDT	**1M each**
	c)	**Explain working of 'hot wire anemometer with the help of diagram.**	**4M**
	Ans:	**<u>Diagram :</u>**  **<u>Working:</u>** The hot-wire anemometer is a fine resistance wire heated by a current passing through it. If a cooler fluid flows past the wire, heat is removed from it by the fluid. The rate of heat transfer varies with the type of fluid, but it also tends to vary as the square root of velocity at which the fluid flows past the wire. If the current in the wire is	**2M** **2M**

		kept constant, the change in resistance due to the cooling will yield a voltage signal. It is very sensitive and responsive to high-frequency change in flow rate. One of its main application is aerodynamic research.	
	d)	**List any 4 factors that decide the configuration of DAS.**	**4M**
	Ans:	The factors that decide the configuration of DAS are as follows: • Resolution and accuracy • The number of channels to be monitored • Sampling rate per channel • Signal conditioning requirement of each channel • cost	**1M each**
	e)	**List the different types of ADC. Explain anyone in detail.**	**4M**
	Ans:	**Different Types of ADC-** • Staircase ramp • Successive approximation • Dual slope • Voltage to frequency • Parallel (or flash) **Staircase ramp:** The simplest A/D converters are staircase ramp converters. A block diagram of their operation is shown in Fig. When a Start command is issued to the control logic, the analog input voltage is compared to a voltage output of a digital-to-analog converter (DAC). The output of the DAC begins at zero and is increased by one LSB increment with each pulse of the clock, as shown in Fig. As long as V_{in} is greater than the output voltage of the DAC, the comparator produces an output signal that continues to allow the clock pulses to be fed to the counter. When the output voltage of the DAC exceeds V_{in} however, the comparator output changes and this action stops the clock pulses from reaching the counter. The counter state at the time represents the value of V_{in} digital form. **Diagram :**  **OR**	**1M** **2M** **1M**

Successive approximation :

A block diagram of the successive approximation converter is shown in Fig.
The block diagram looks deceptively similar to the staircase ramp diagram, but the difference lies in the special control logic of the converter.
Instead of allowing the reference voltage of the comparator (coming from the output of a DAC) to climb from zero through all the steps until V_{in} is reached, the successive approximation converter
Control logic tries various output codes and feeds them to the DAC and a storage and compares the result with V_{in} via the comparator.
The operation is analogous to weighing an unknown on a laboratory balance scale by using standard weights in a binary sequence such as $1, 1/2, 1/4, 1/8, \ldots, 1/n$ kg. the correct procedure is to begin with the largest standard weight and proceed down order to the smallest one. The unknown is placed on one pan, and the largest is placed on the other; if the scale does not tip, the weight is left on and the next heaviest is added.
If the-balance does tip, the weight is removed and the next one is The same procedure is used for the next largest weight and so on down to the smallest.

Diagram :



s

OR

Dual slope :

the dc voltage to be converted by the dual-slope converter, V_{in}, is fed to an integrator, which produces a ramp waveform output, The ramp signal starts at zero and creases for a fixed time interval, T_1 equal to the maximum count of the multiplied by the clock frequency. An 8-bit counter operating at 1 MHz would there by cause T_1 to be 8 µs. The slope of the ramp is proportional to the magnitude of V_{in}. the end of the interval, T_1 the carry-out (CO) bit of the ripple counter causes the switch to move to the - V_{REF} position. In this position, a constant current (- *VREFI R)* begins to discharge capacitor C. The ripple counter is reset to zero there is a Co. The count continues until the zero crossing detector switches state as result of capacitor C being discharged. The counter is stopped by the zero crossing detector, and the resultant count is proportional to the input voltage. In the following rivation it is important to observe that t, is independent of the value of Rand C.

$$V_{\text{charging}} = V_{\text{discharging}}$$

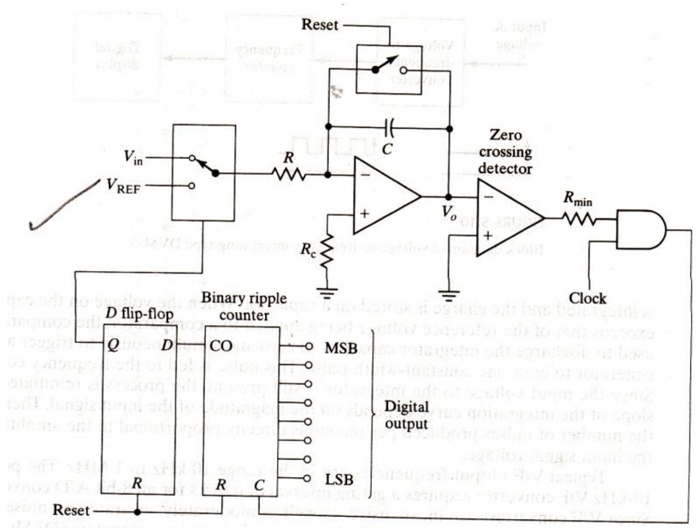
$$\frac{i_{\text{charging}} T_1}{C} = \frac{i_{\text{discharging}} t_r}{C}$$

$$\frac{V_{\text{input}}}{R} T_1 = \frac{V_{\text{REF}}}{R} t_r$$

$$V_{\text{input}} = V_{\text{REF}} \frac{t_r}{T_1}$$

.

Diagram :

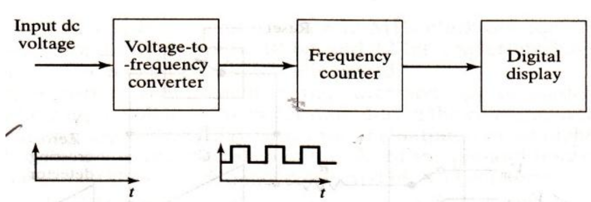


OR

Voltage to frequency :

Voltage-to-frequency converter In these types of AID converters, the voltage is converted (by a voltage-to-frequency converter) into a set of pulses repetition rate (or frequency) is proportional to the magnitude of the input. The pulses are counted by an electronic counter similar to the way the number of wavelengths was counted by the time-interval counter in the ramp-type DVM

Diagram :



OR

Parallel(or flash) :

Parallel converters perform the fastest AID versions. In this technique (by way of example, a 3-bit parallel converter, is shown Fig. 5.11) the input voltage is fed simultaneously to one input of each of *P* comparator The other input of each comparator is a reference voltage. As shown in Fig. comparator receives a different reference voltage value, starting at V_{Rmax} By using voltage-divider principle and equal values of.R, the voltage reference value V_R at comparator will be given by

$$V_{R_p} = V_{R_{\max}} \frac{P}{Q}$$

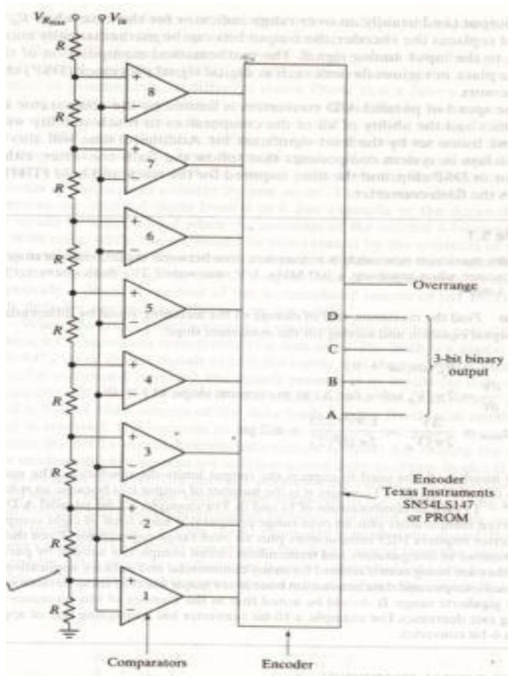
where

$p =$ comparator number(l to P)

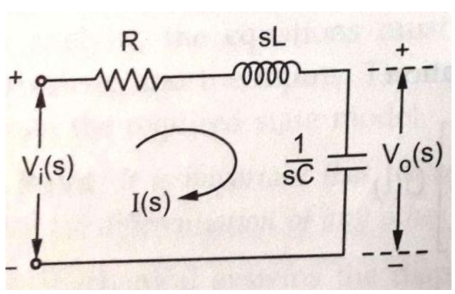
$P =$ total number of comparators 1 ''\

Q = total number of resistors $= P + 1$

Diagram :



	f)	**Describe dynamic response of second order system for step input.**	**4M**
	Ans:	**Diagram :**	



To obtain the dynamic response, assume that the input to the system is unit step input u(t) where u(t) = 1 for t ≥ 0.

$\therefore\ v_i(t) = u(t)$ hence

$$V_i(s) = L[u(t)] = \frac{1}{s}$$

Hence, $V_o(s) = V_i(s)\left[\dfrac{1/LC}{s^2+\dfrac{R}{L}s+\dfrac{1}{LC}}\right] = \dfrac{\dfrac{1}{LC}}{s\left(s^2+\dfrac{R}{L}s+\dfrac{1}{LC}\right)}$

By partial fractions, $V_o(s) = \dfrac{A}{s} + \dfrac{Bs+C}{s^2+\dfrac{R}{L}s+\dfrac{1}{LC}}$

The dynamic response is obtained by taking inverse Laplace transform of $V_o(s)$.

$$\therefore \quad v_o(t) = L^{-1}[V_o(s)] = L^{-1}\left\{\frac{A}{s}+\frac{Bs+C}{s^2+\frac{R}{L}s+\frac{1}{LC}}\right\}$$

The dynamic response depends on the nature of roots of the equation $s^2+\frac{R}{L}s+\frac{1}{LC}=0$. This is the characteristic equation of the network. The roots of this equation are,

$$s_{1,2} = -\frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2-\frac{1}{LC}}$$

The dynamic response depends on the nature of the roots of this equation which ultimately depends on the values of R, L and C of the network.

If both the **roots are real, unequal and negative** say $-a$ and $-b$ then the dynamic response becomes,

$$v_o(t) = A + B e^{-at} + C e^{-bt}$$

This is **purely exponential.**

If both the roots are **real, equal and negative** say $-a$ and $-a$ then the dynamic response becomes,

$$v_o(t) = A + B t e^{-at} + C e^{-at}$$

This is **exponential and fastest** of all the exponential responses.

If both the roots are **complex conjugates with negative real part** as $-a \pm jb$ then the dynamic response becomes,

$$v_o(t) = A + B e^{-at}\sin(bt+\theta)$$

This is **damped oscillatory response.**

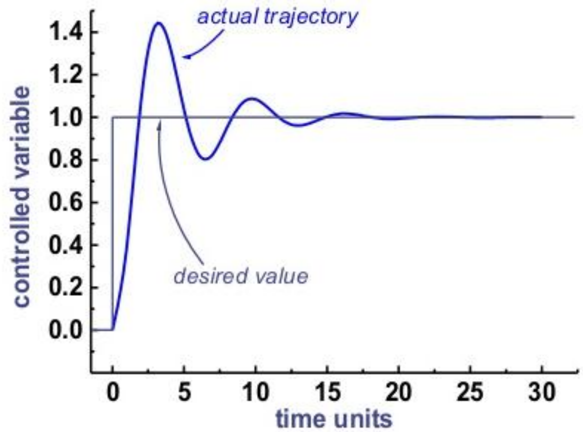
If both the roots are **purely imaginary** as $0 \pm jb$ then the dynamic response becomes,

$$v_o(t) = A + B\sin(bt)$$

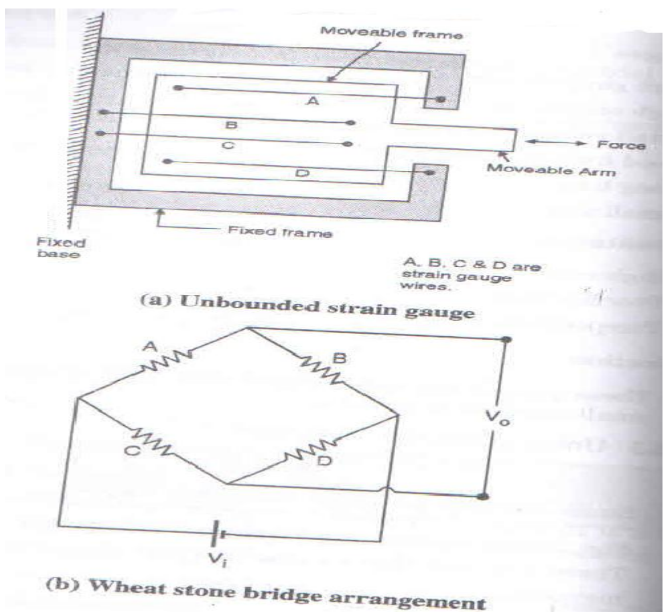
This is **purely sinusoidal** in nature.

3M

Waveforn : — 1M



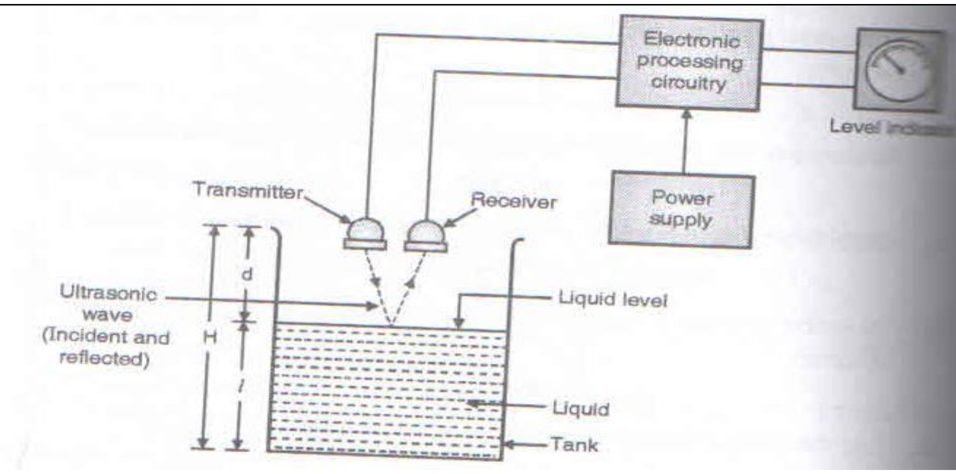
Q.6		**Attempt any FOUR:**	**16M**
	a)	**Describe the working of strain gauge using Wheatstone configuration.**	**4M**
	Ans:	**Diagram:**	**2M**



Working: — **2M**

- Four strain gauges are connected as four arms in Wheatstone's bridge.
- Two stain gauges will be under tension and two under compression.
- When mechanical deformation is applied, the strain gauges will get compressed or expanded and the bridge becomes unbalanced. Thus the electrical output is obtained.

	b)	**Describe with neat labeled diagram measurement of level using ultrasonic radiations.**	**4M**
	Ans:	**Diagram:**	**2M**



Description:

It operates by generating an ultrasonic wave or pulse and measuring a time it takes for the echo to return. There are two way of measurement of liquid level:

- Doppler Type
- Time difference type

The ultrasonic waves are generated by transmitter and directed towards the liquid surface in the tank which is to be measured. These waves get reflected from the surface of the liquid and are received by the receiver. The time take by the wave is a measure of the distance travelled by the wave. Therefore the time ‘t’ between transmitting and receiving a wave is proportional to the distance ‘d’ between ultrasonic set and surface of the liquid in the tank. As the distance ‘H’ between ultrasonic set and the bottom of the tank is fixed, time ‘t’ is the measure of level ‘l’

2M

c) Compare RTD and Thermistor (any four points). **4M**

Ans:

Sr. No	RTD	Thermistor
1	RTD is made up of metals.	Thermistor is made up of semiconductor Materials
2	Metals have Positive Temperature Coefficient (PTC) of resistance. Hence the resistance of RTD increases with an increase in temperature and decreases with a decrease in temperature	Semiconductor materials have Negative Temperature Coefficient (NTC) of resistance. Hence, the resistance of a thermistor decreases with an increase in temperature and increases with a decrease in temperature.
3	The resistance temperature characteristics of RTD's are linear.	The resistance temperature characteristics of thermistor are highly nonlinear.
4	It is less sensitive to temperature compared to thermistor.	It has large temperature coefficient of resistance i.e. thermistor highly sensitive to temperature compared to RTD.
5	It has-a wide operating temperature range i.e.,	It has low operating temperature range compared to RTD i.e., minus 100 to plus

Any four points 1M each

	minus 200 to plus 650°C.	300°C.
6	RTD's provide high degree of accuracy and long term stability.	Thermistors provide less degree of accuracy and short term stability.
7	They have low self-resistance.	They have high self-resistance. Thus, they require shielding cables to minimize interference problems.
8	RTD's are relatively larger in size. They are costlier as compared to thermistor.	Size of thermistors is small. They are not costlier as compared to RTD.

d) **Define:**
i) **Absolute pressure ii)Gauge pressure**
iii) Differential pressure iv) Pressure **4M**

Ans: **<u>Absolute pressure:</u>** **1M each**

Absolute pressure is defined as actual total pressure including atmospheric pressure acting on a surface.

$P_{Absolute} = P_{Atmospheric} + P_{Gauge}$

<u>Gauge pressure :</u>

Gauge pressure is defined as the difference between actual pressure and atmospheric pressure.

Gauge pressure= $P_{absolute} - P_{atmospheric}$

<u>Differential pressure:</u>

Differential pressure is a pressure that is measured relative to the pressure in the atmosphere around it. It shows the difference between two pressures of the same unit.

<u>Pressure:</u>

Pressure is defined as force acting (perpendicular) on unit surface area.

$$P = F/A$$

e) **Describe the operation of turbine flow meter.** **4M**

Ans: **<u>Diagram:</u>-** **2M**

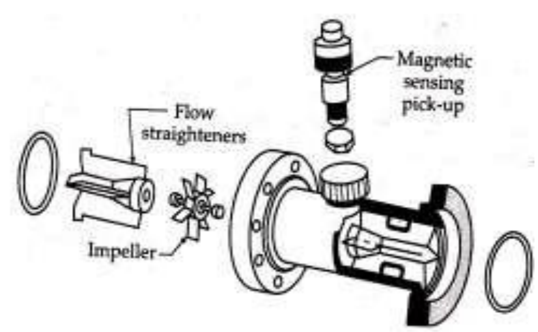
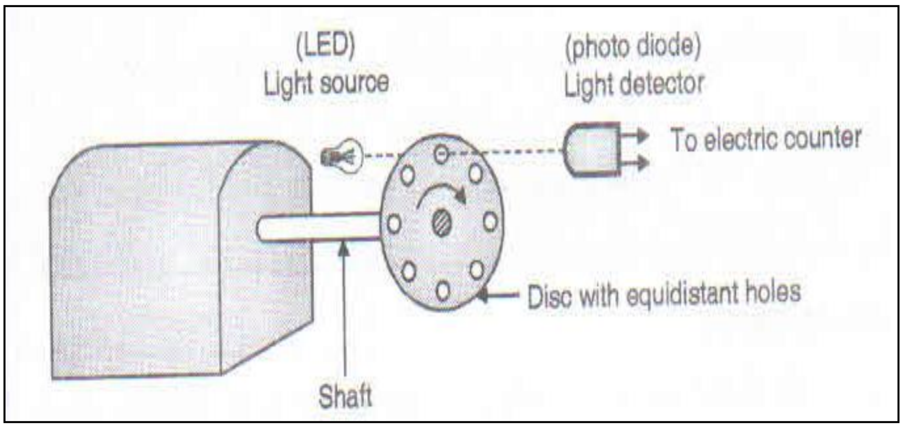


Fig. Turbine flow meter.

		Explanation: - Turbine flow meters are volumetric flow meters and are available in wide ranges. The output is usually in the form of a digital electrical signal whose frequency is directly proportional to flow rate and whose total count is proportional to flow rate and whose total quantity, as each pulse represents a discrete volume. A feature of this turbine meter is a hydraulically supported turbine rotor. A permanent magnet sealed inside the rotor body is polarized at 900 to the axis of the rotation. As the rotor rotates so does the magnet and therefore rotating magnetic field is produced. This produces an a.c voltage pulse in the pick-up coil located external to the meter housing. The frequency of this voltage is directly proportional to the rate of flow. The pulse can be totalized by a counter to give the value of total flow over a particular interval of time.	**2M**
	f)	**Describe instrumentation system for speed measurement using non-contact type transducer.**	**4M**
	Ans:	***Note: Any one type can be considered*.** There are two types of non-contact types of tachometer **i) Photoelectric Tachometer:** **Constructional Diagram:** **Diagram :**  **Working:** • 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	**2M** **2M**

the disc and its speed of rotation. Hence the speed is given by

$N=f/H_S$

N=speed

f=frequency

H_s=holes on the disc

OR

ii) Toothed rotor variable reluctance Tachometer (Magnetic Pick up)

It consists of a housing containing a small permanent magnet with a coil wound round it. When rotor rotates, the reluctance of the air gap between pickup and the toothed rotor changes giving rise to the induced e.m.f in the pickup coil. This output is in the form of pulses, with variety of wave shapes.

The frequency of the pulses of induce voltage will depend upon the number of teeth of the rotor and speed of rotation.

Number of pulses per revolution= T

Thus, Speed = $\frac{pulses\ per\ second}{number\ of\ teeth}=\frac{P}{T}$ rps.

Diagram :