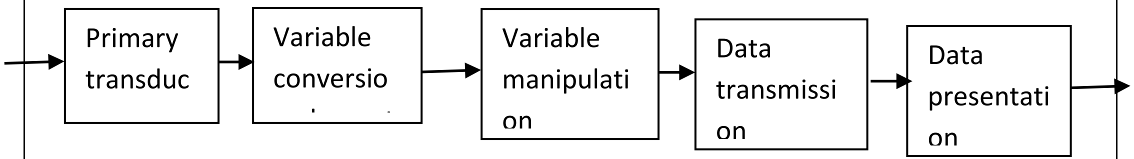
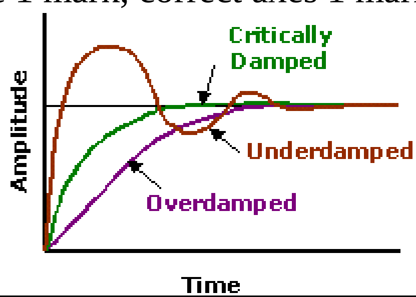
Important Instructions to examiners:

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 tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given moreImportance. (Not applicable for subject English and Communication Skills.)
4) While assessing figures, examiner may give credit for principal components indicated in thefigure. 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 constantvalues 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
1.	**Attempt any TEN of the following**		**20**
a.	**Explain hysteresis effect in instrument**	2	
Answer	Phenomena which depicts different output effects when loading and unloading an instrument by any form of energy. It is due to the fact that all the energy put into the stressed parts when loading is not recoverable upon unloading.		
b.	**Explain repeatability and reproducibility of instruments**	**2**	
Answer	**Repeatability:** closeness of agreement among a no. of consecutive measurement of output for the same value of input under the same operating conditions for full-range traverse. **Reproducibility:** closeness of agreement among a no .of repeated measurements of output for the same value of input under the same operating conditions over a period of time.		
c.	**Define range and span of instruments**	**2**	
Answer	**Range:** Range is the maximum value we can measure with any measuring instrument. It is the region between the limits within which a quantity is measured, received or transmitted. It is expressed by stating the lower and upper range values. **Span**: The algebric difference between the upper and lower range values expressed in the same units as the range.		
d.	**Define dead zone.**	**2**	
Answer	Dead zone is the largest range of value of measured variable to which instrument does not respond. It is mainly due to friction in the instrument.		
e.	**Explain need of calibration of any instrument.**	**2**	
Answer	Calibration is the comparison between measurements: between a standard known		

	value and the unknown value. There are three main reasons for having instruments calibrated: 1. To ensure readings from an instrument are consistent with other measurements. 2. To determine the accuracy of the instrument readings. 3. To establish the reliability of the instrument i.e. that it can be trusted.			
f.	**Explain what is meant by dynamic error in instruments.**	**2**		
Answer	It is one of the dynamic characteristics of a measurement system. It is the difference between the set point and the measured value of the dynamic variable.			
g.	**Define transducer.**	**2**		
Answer	Device which converts one form of energy to another form. Or, the device which converts nonelectrical energy to electrical energy.			
h.	**Define stress and strain.**	**2**		
Answer	Stress: Force experienced per unit area Strain: Ratio of change in length to original length Or the effect of applied force is referred to as Stress, and the resulting deformation is the Strain.			
i.	**State name of instrument used for measurement of speed.**	**2**		
Answer	AC Tachometer, DC Tachometer, rotary encoder, magnetic pick up			
j.	**Explain why filters are used in signal conditioning.**	**2**		
Answer	The Hall effect is the production of a voltage difference (the Hall voltage) across an electrical conductor, transverse to an electric current in the conductor and a magnetic field perpendicular to the current. The Hall effect is due to the nature of the current in a conductor			
k.	**Explain why filters are used in signal conditioning.**	**2**		
Answer	To eliminate unwanted noise signals from measurements, it is necessary to use circuits that block certain frequencies or band of frequencies. These circuits are called filters. Filter is a special tuned circuit that passes frequencies in a certain band and rejects all others.			
l.	**Define CMRR in operational amplifiers.**	**2**		
Answer	CMRR is the ratio of differential gain to the common mode gain of the op amp. CMR(Common mode rejection) is the property of a differential amplifier to reject input signals that are common to both inputs. CMRR= Av(d)/Av(com) CMRR=20 $\log_{10}$ (CMRR)			
2.	**Attempt any FOUR of the following**		**16**	
a.	**Draw and explain general block diagram of instrumentation.**	4		

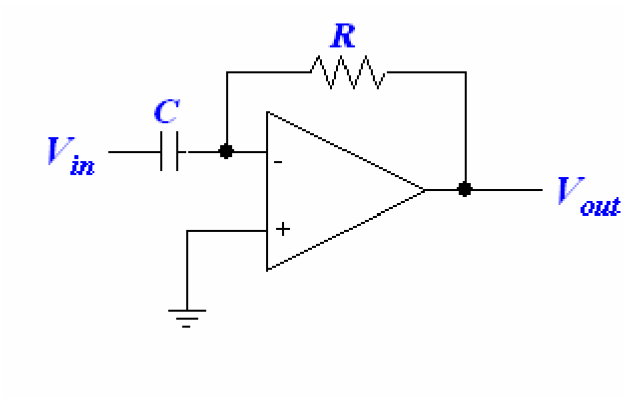
Answer	(diagram 2 marks, explanation 2 marks)  **Primary transducer**: The sensor which comes in contact with the measurement medium to sense the quantity. **Variable conversion element**: the transducer which converts the sensor output from nonelectrical to electrical form. **Variable manipulation element**: This is mainly signal conditioning element which modifies the signal to the desired form suitable for the transmission /presentation. It can be amplification, ADC,DAC, filtering etc. **Data transmission and data presentation element**: The modified signal is transmitted through suitable transmission medium to the operator or presented with the help of indicators.	**02Marks** for diagram **and 02 Marks** for suitable explaination		
b.	**Draw a response curve for step curve for second order system under overdamped, critically damped condition.**	4		
Answer	(each response 1 mark, correct axes 1 mark)  	01Mark for each Response curve and 01 Mark for correct axes		
c.	**Explain working of thermistor. State any two applications of thermistor.**	4		
Answer	Thermistor is a temperature sensor for electrical measurement of temperature. Its principle is based on the variation of semiconductor resistance with temperature. It is made up of semiconductor materials. Oxides of metals such as manganese, cobalt, magnesium etc are used for thermistor manufacturing. As the temperature increases, the resistance decreases for thermistor due to semiconductor property. It's response between resistance and temperature is nonlinear. Negative Temperature Coefficient (NTC) thermistor exhibit a decrease in electrical resistance when subjected to an increase in body temperature and Positive Temperature Coefficient (PTC) thermistor exhibit an increase in electrical resistance when subjected to an increase in body temperature. **Applications:**	**02 Marks for Explanation and 02 Mark for application any 02**		

	1. As current-limiting devices for circuit protection, as replacements for fuses. 2. As resistance thermometers in low-temperature measurements 3. Thermistor can be used to monitor the temperature of an incubator 4. Thermistors are also commonly used in modern digital thermostat 5. Consumer Appliance industry for measuring and controlling the temperature such as Toasters, coffee makers, refrigerators, freezers etc			
d.	**Classify transducer. Write one sentence about each of them.**	4		
Answer	(any 4 classifications,1 mark each) 1. **Active and passive**: Active transducer does not need external power supply. Ex. Thermocouple Passive transducer needs external power supply. Ex. RTD 2. **Primary and secondary**: Primary transducers are the sensors which comes in contact with the measurement medium, senses it and gives the output in nonelectrical form. Secondary transducers converts the nonelectrical output of primary transducer to electrical form. 3. **Analog and digital**: Analog transducers give the output in analog form. Ex. LVDT. Digital transducer gives the output in digital form. Ex. Rotary encoder 4. **Based on transduction principle**: It can be resistive, capacitive, inductive, thermoelectric, mechanical etc. 5. **Transducers and inverse transducers**: Transducers convert non electrical energy to electrical form. Inverse transducers convert electrical energy to nonelectrical form. Ex. Piezoelecric transducer	**any 4 classifications,1 mark each**		
e.	**State types of filters. Define each of them.**	4		
Answer	a. Low pass b. High pass c. Band pass d. All pass e. Active and passive f. Linear and nonlinear a. Low pass filter: A low-pass filter is a filter that passes low-frequency signals and attenuates (reduces the amplitude of) signals with frequencies higher than the cutoff frequency. b. High-pass filter: It passes high-frequency signals but attenuates (reduces the amplitude of) signals with frequencies lower than the cutoff frequency c. Band pass filter: It is a combination of a low-pass and a high-pass filters. It passes frequencies within a range and rejects frequencies outside that	**Type 01Mark and 03 Marks for Brief Expaina tion**		

<table>
<tr><td></td><td>range.

d. All pass filter: An all-pass filter passes all frequencies equally in gain, but changes the phase relationship between various frequencies. It does this by varying its phase shift as a function of frequency.

e. Active and passive filters:
Passive implementations of linear filters are based on combinations of resistors (R), inductors (L) and capacitors (C). These types are collectively known as passive filters, because they do not depend upon an external power supply and/or they do not contain active components such as transistors.
Active filter design contains active components such as transistors and op amp.
f. Linear filters process time-varying input signals to produce output signals, giving linear response. Non linear filters process time-varying input signals to produce output signals, giving non linear response</td><td></td><td></td></tr>
<tr><td>f.</td><td>Draw diagram of each of following operational amplifiers
i)differentiator
ii)integrator
iii)inverter
iv)adder</td><td>4</td><td></td></tr>
<tr><td>Answer</td><td>(1 mark each)

Differentiator:


Integrator:</td><td>1 mark each</td><td></td></tr>
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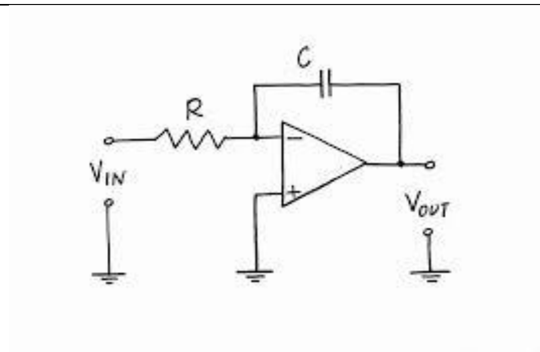
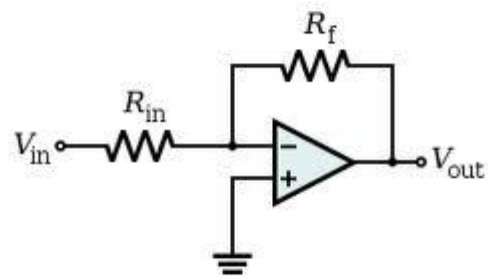
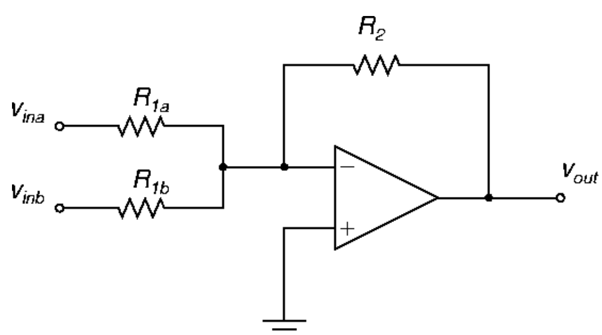
	 Inverter:  Adder: 		
3.	**Attempt any four:**		**16**
a.	**Explain each of following w.r.t instruments settling time, linearity.**	**4**	
Answer	**Settling time** Settling time is the time taken by a system to be within a close range of its steady-state value. If it is an indicating instrument, one may be interested in knowing the time taken by the pointer to reach a value within ±1% of the final indication and this time interval is reckoned as its settling time. A smaller settling time indicates higher speed of response. Settling time is also dependent on the parameters of the system and varies with the conditions under which the system operates. The settling time of second-order instruments is affected by the degree of damping provided for the instrument.	**2 Marks** for each revelent Explanation.	

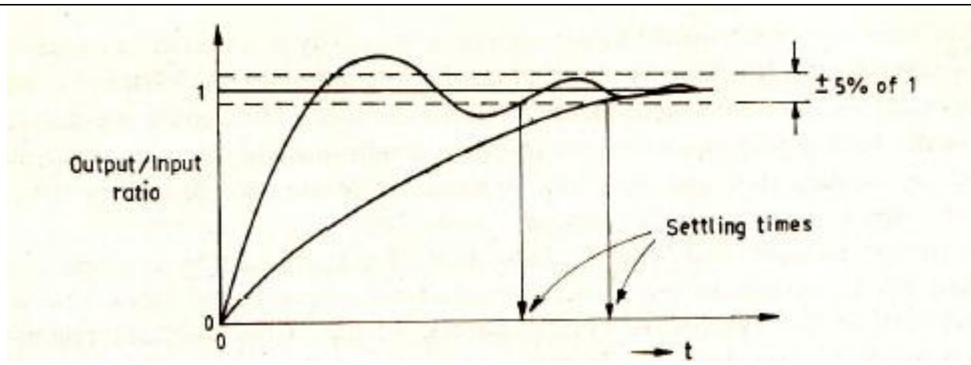


Fig. shows the effect of damping on the settling time.

Linearity :

It is defined as maximum deviation of calibration curve from a straight line drawn between no load and full load output, expressed as percentage of full scale output and measured on increasing load only.

$$\%linearity = \frac{\text{Maximum deviation}}{\text{Full scale reading}} * 100$$

Linearity may be expressed as percent of actual reading or a percent of full scale reading or combination of the two.

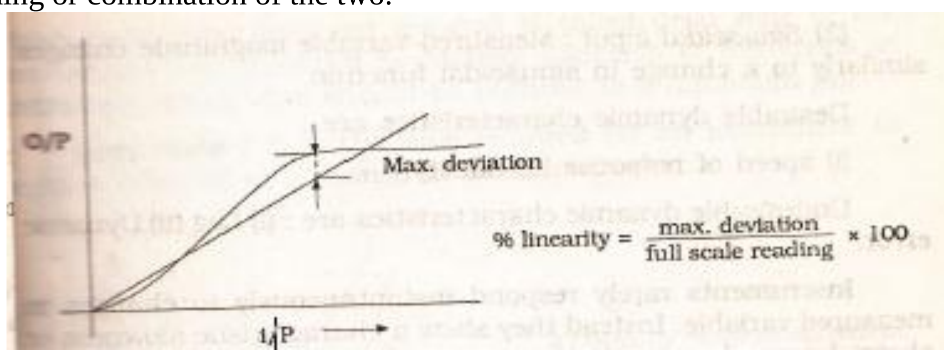
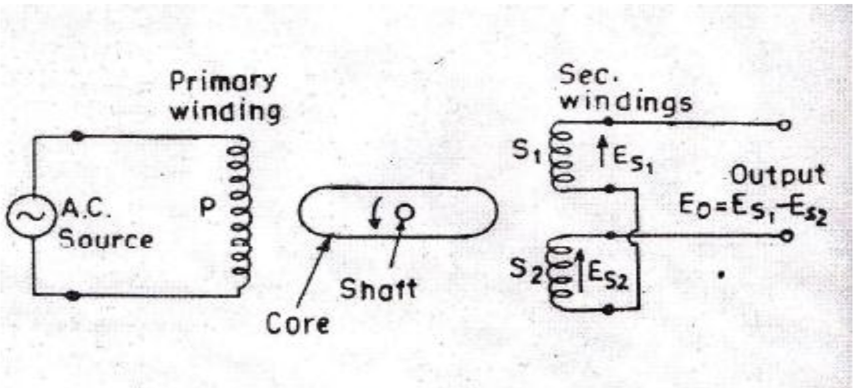
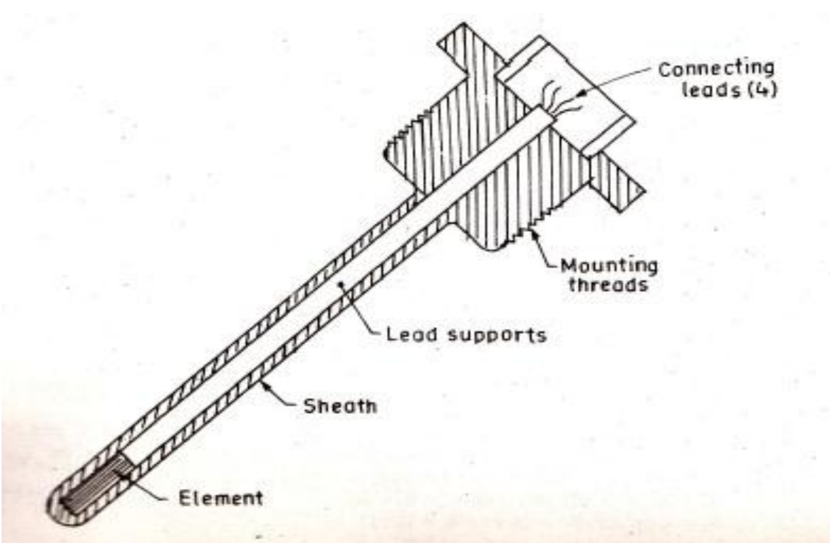
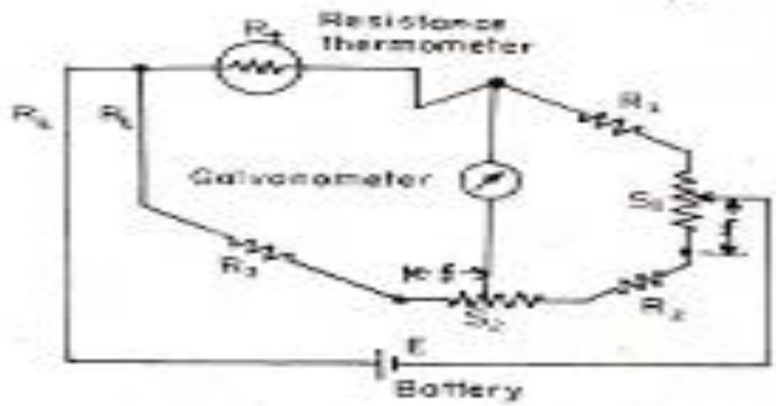


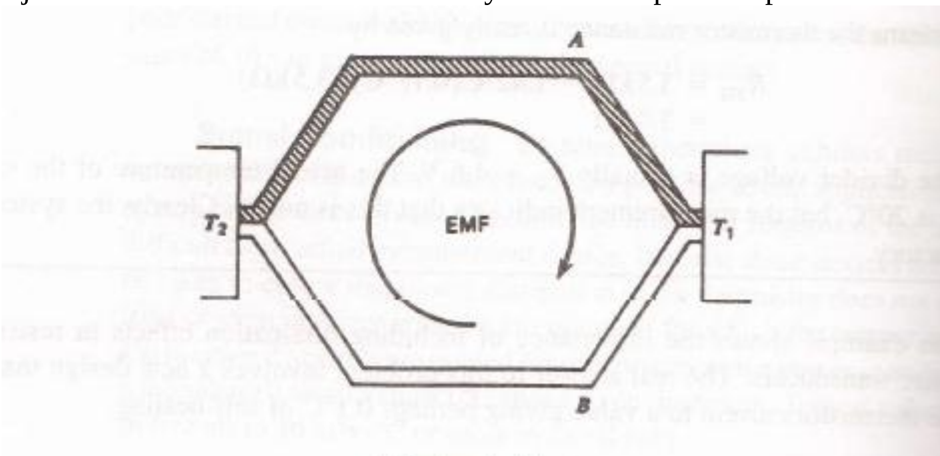
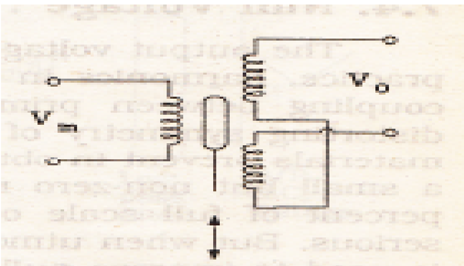
Fig. shows maximum deviation from straight line.

b.	**Explain working of resistance strain gauge**	**4**	
Answer	**Principle working:** Strain gauge is a passive, versatile transducer and it is often used for measuring weight, pressure, force and displacement .They sense the strain produced in a wire due to applied force. The strain changes resistance of wire. By measuring this resistance variation strain in a material is calculated. At constant temperature, R= ρ*L/A. when tensile force is applied to a wire it increases it length and reduces cross-sectional area. Hence resistance of wire changes. Gauge factor of a strain gauge is called strain sensitivity factor. Thus knowing gauge factor, original resistance and change of resistance strain can be calculated. The resistive strain gauge element is one such device that plays the role of a secondary transducer in sensing the tensile or compressive strain in a particular-direction at point on the surface of a body or structure. If the modulus of elasticity (Young's modulus) E of the material of the body is known, the stress can be	**04 marks** for suitable explanation	

	calculated and utilized to identify the magnitude of quantities affecting the stress. Strain gauge pressure transducers and strain-gauge accelerometers are such transducer systems employing the strain gauges as the secondary electrical transducer along with a suitable primary mechanical transducer for converting the basic quantity under measurement into stress. In certain cases, the strain—gauge element may be stressed directly, allowing the strain measured to be related to the applied stress and hence the force applied.		
c.	**Explain how rotary motion can be measured**	**4**	
Answer	 Rotary variable differential transformer (RVDT). LVDTs are also made in rotary models . Its core has specially shaped iron from it is shown in fig linear output is possible for only +/- 40 degree. Thus angular displacement can be measured. It has sensitivity of 10 to 20 mv per degree. The operation of RVDT is similar to that of an LVDT. At the null position of the core, output voltage of secondary winding S1 and S2 are equal and in opposite thus net output is zero. Any rotary motion from null position will result in differential voltage output .The greater this angular or rotary displacement, greater will be differential output hence response of transducer is linear. Clockwise rotation produces an increasing voltage of secondary voltage of one phase while counterclockwise rotation produces an increasing voltage of opposite phase hence the amount of angular displacement and its direction may be ascertained from the magnitude and phase of output voltage of transducer.	**2 Mark** for Dia. & **2 Mark** for suitable Explanation.	
d.	**Define each of following terms of operational amplifiers** **i) Slew rate** **ii) Input offset voltage** **iii) Voltage gain** **iv) Input capacitance**	**4**	
Answer	i) Slew rate:- Maximum rate of change of o/p voltage per unit of time. It is express in volt/µsec. ii) Input offset voltage:- The voltage that must be applied between two i/p terminal of an op-amp to learn the o/p.	01 Mark for each correct definition	

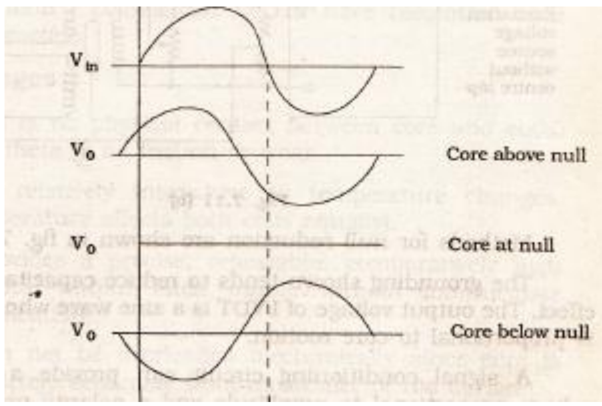
	iii) Voltage gain:- Voltage gain is the ratio of o/p voltage to i/p voltage. iv) Input capacitance:- This is equivalent capacitance that can be measured at either be inverting or non-inverting terminal with other terminal connected to ground.			
e.	**Select suitable transducer for each of following** **i) Humidity in substation** **ii) Thickness of magnetic material** **iii) Transformer winding temperature** **iv) Oil level in transformer**	**4**		
Answer	i) Hygrometer ii) Reluctance variation transducer iii) Thermistor. iv) Conductive type .(sight Glass) **Note: any suitable transducer may be considered**	**1 Marks** For each correct answer.		
f)	Explain working of instrumentation system for temperature measurement by RTD	04	**12**	1
Answer	 (This diagram is optional)			

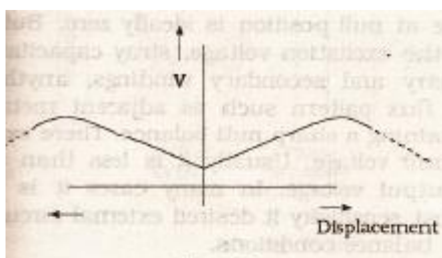
	 . Measurement of temperature with double slide wire bridge and resistance thermometer. Resistance thermometer are primary electrical tranducers enabling mesurement of temperature changes in terms of resistance changes .The resistive element is usally made of a solid material, metallic alloy or a semiconductor compound. The resistivity of metals increases with temperature, while that of semiconductors and insulators generally decreases. The wire wound elements employ considerable lengh of wire and if free to expand the length also increases with incerease in temperature hence as temperature changes the changes in resstance will be due to changes in both length and resistivity. The materical used for resistance thermomerters have temperature coefficient of resistance α ,is given by $\alpha = 1/\Delta t\ \Delta\beta/\beta_0 = 1/\Delta t\ (\Delta R/R0)$ Where Δt =changes in temperature c $\Delta\beta/\beta_0$=fractional changes in resistivity $\Delta R/R0$= fractional change in resistance β_0,R0= resistivity and resistance repctively at 0c The resistance R_T at any others temperature T deg.C is given by $R_T = R_0 (1+ \alpha \Delta T) = R0(1+ \alpha T)$ Each metal or metallic alloy obeys the relaionship over a range of temperatures and each resistance is generally limited to measure temperature within ranges. Nonlinearity sets in at higesr temperature and in such cases the relationship is modified as $Rt = R0 (1+ \alpha_1 T + \alpha_2 t^2 \ldots \quad + \alpha_n T^n)$ Where $\alpha_1, \alpha_2 \ldots\ldots \alpha_n$ are constants applicable for each metal.	**2 Mark** for Dia. & **2 Mark** for suitable Explanation.	
4	**Attempt any four**		**16**
a)	Explain seeback effect	**4**	
Answer	**Seeback Effect:-** If close circuit is formed of two dissimilar metal and two junctions of metal are at different temperature, an electrical current will flow around the circuit.Current flow from hot to cold junction in a loop. The total seebeck emf produced is thus partly due to peltier effect and partly due	**01 mark** for statement	

	to Thomson effect .The peltier emfs are assumed proportional to the temperature of the junction while Thomson emfs is very low as compared to peltier emf .  a) Seeback effect Figure shows (a) a pictorial representation of this effect, called the Seeback effect, in which two different metals, A and B are used to close the loop with the connecting junctions at temperature T1 and T2. We could not close the loop with the same metal because the potential differences across each leg would be the same, and thus no net emf would be present. The emf produced is proportional to the difference in temperature between the two junctions. Theoretical treatments of this problem involve the thermal activities of the two metals. Using seeback and peltier effects refer to the relation between emf and temperature in a two-wire system. $\mathcal{E}= \int T1.(Q_A – Q_B) D_t$ Where $\mathcal{E}$= emf produced in volts T1,T2 = junction temperature in K Q_A, Q_B= thermal transport constants of the two metals This equation, which describes the seeback effect shows that the emf produced is proportional to the difference in temperature .	**&** **3Marks** for explanation.		
b)	**Explain working of LVDT**			
Answer	**Working principle:-**  Fig (a) When primary winding is excited by suitable a.c. source.It tries to produces magnetic flux. This mutual flux link with two secondary winding and as flux linkages change emf is induced in both secondaries. When core is centrally located, equal voltage is induced in both secondaries. But when core is displaced	**2 Mark** for Dia. & **2 Mark** for suitable Explanation.		

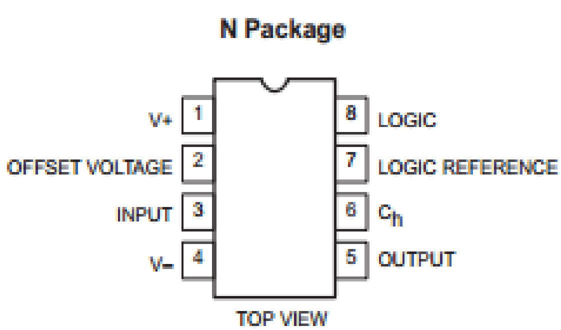
flux linkages changes and hence more voltage is induced in on secondary than the other one. The variation of o/p voltage with core position is shown fig. (a) when core is centrally located, net o/p voltage Vo is zero (theoretically). This core position is called as null position.

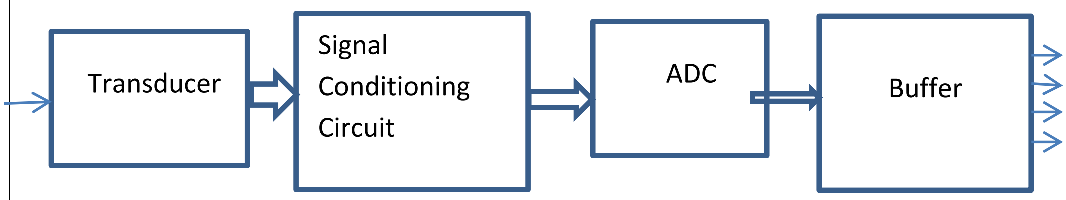
As core moves on either side from null positon, output voltage increases primarily dependent upon length of secondary coils. Beyond proportionality limit o/p increases at a decreasing rate until it reaches a maximum from which it drops again to the balnced condition when the core is removed. There is a phase shift as core moves both to and from from central position, so that phase measurement can be related to the direction of core motion voltage variation with core is shown fig (b).





Fig(b)

c)	Draw a pin diagram IC LF398.Write function of each pin		
Answer		**2 Mark** for PIN Dia. & **2 Mark**	

<table>
<tr><td></td><td>Function of Each Pin:
1. Bipolar input stage is used to achieve low offset voltage & wide bandwidth.
2. V^+ & V^- : +/- 5 V to $\pm$ 18 V supply voltage
3. Input signal equal to supply voltage .
4. Logic i/p are fully differential with low i/p current, allowing direct connection to TTL , CMOS & PMOS Differential Threshold is 1.4 V.
5. Ch: hold capacitor 0.5 mV typical hold step at Ch=0..01 µF</td><td>for suitable Explanation</td><td></td><td></td></tr>
<tr><td>**d)**</td><td>**Draw and explain block diagram of general Data Acquisition System.**</td><td></td><td>**04**</td><td></td></tr>
<tr><td>**Answer**</td><td>

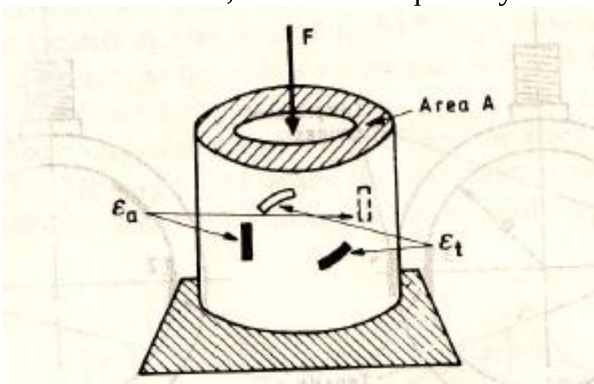
General Block diagram of Data Acquisition System

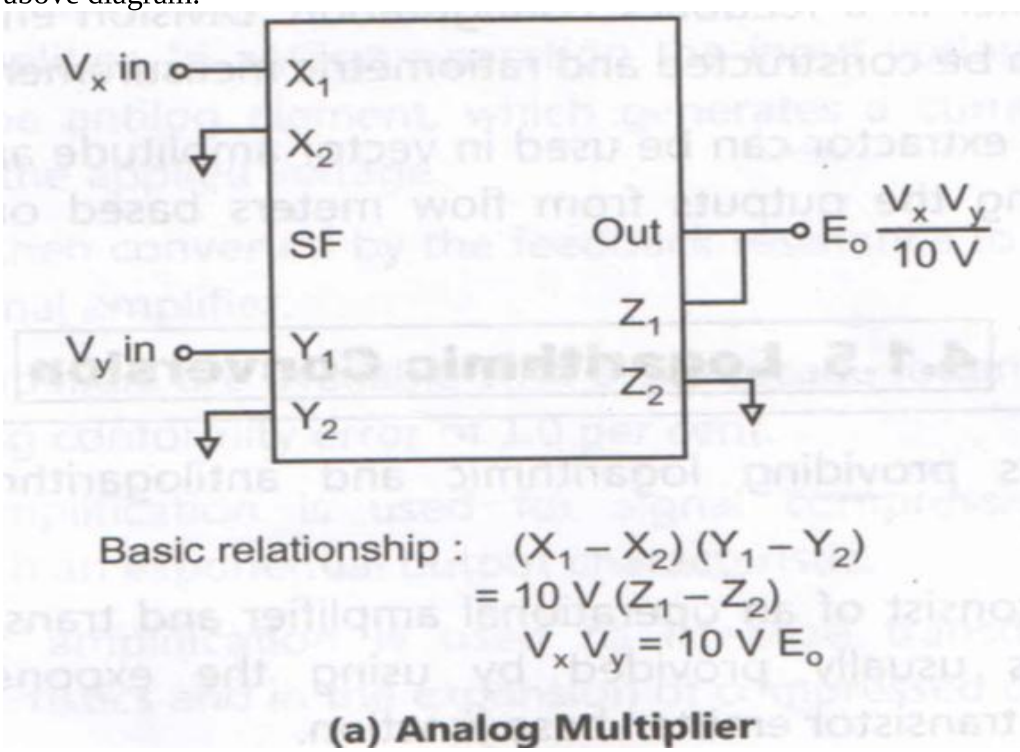
Block Description:
Basic elements required for Data acquisition System are
(1) Transducer.
(2) Amplifiers or signal conditioners.
(3) Multiplexers.
(4) Sample and Hold circuit .
(5) Analog to Digital converters.

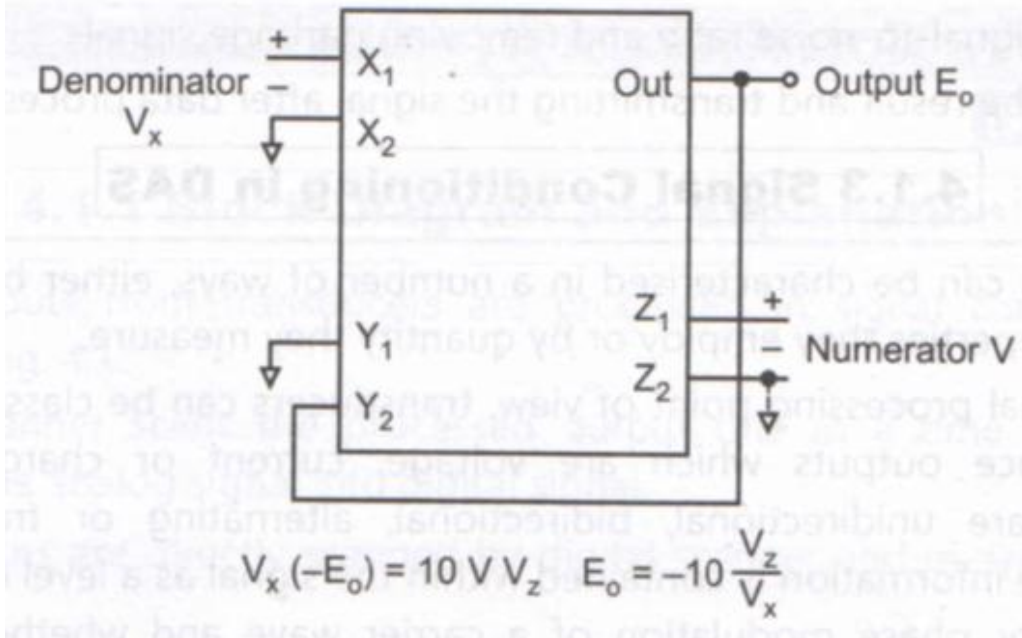
(1)Transducer-
It is desirable that an emf obtained from transducer is proportional to quantity being measured, is used as input to the data acquisition system thus transducers such as thermocouple, strain gauges and piezoelectric devices etc. are used.
An exception to this usual function of transducer ,some sensor produces frequency which can be counted with electronic counter to obtain integral of measured quantity.
(2) Amplifiers or signal conditioning Equipment-
Signal conditioning Equipment includes any equipment that assists in transforming the output of transducer to the desired magnitude or form required by next stage of the DAS.
It produces the required conditions in the transducers so that they work properly.
Signal conditioners may include devices for amplifying, refining, or selecting certain positions of these signals.
Examples of signal conditioning equipment include known constant voltage sources for strain gauge bridges, zero bridge balance devices for strain gauge circuits, temperature control devices for thermocouple junctions, voltage amplifiers and servo-systems.
(3)Multiplexers.
Multiplexing is the process of sharing a single channel with more than one output. multiplexer accepts multiple analog inputs and connects them sequentially to one measuring input. Multiplexing is a means of using the same transmission channel for transmitting</td><td>**1mark for Dia.**

&

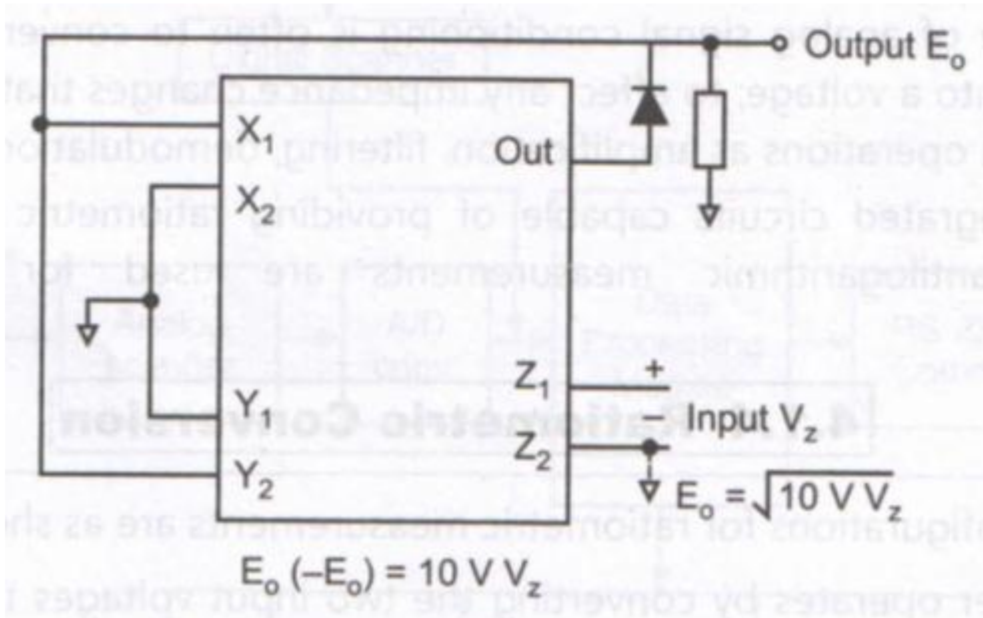
3 Mark for suitable Explanation</td><td></td><td></td></tr>
</table>

	more than one quantity. Multiplexing becomes necessary in measurement systems when the distance between transmitting and receiving point is large and many quantities are to be transmitted. If a separate channel is used for each quantity, the cost of installation, maintenance, and periodic replacement becomes prohibitively large and therefore a single channel is used which is shared by the various quantities. Multiplexing is commonly accomplished by either time or frequency sharing of the transmission channel between the individual quantities. **(4)A/D Converters** A/D converter based on dual slope techniques are useful of low frequency data, such as from thermocouples or analog devices.			
e)	**Explain how force is measured using load cell**	04		
Answer	Load cell are primarily intended for measurement of weight of bodies such as slowly moving vehicles. Load cell utilize an elastic member as primary transducer and strain gauges as secondary transducer. They are as well designed for various applications where concentrated forces can be conveyed to the load cells through mechanical linkages.Those cells meant for weighing are provided with supports for hanging the body to be weighted A column type load cell primarily consists of either slender rod, robust column of rectangular or circular cross-section, or even the square cylinder shown in figure  Fig. A column type load cell These columns of regular configurations enable the measurements of deformations with reasonable accuracy, though ultimately they are calibrated against standard weights. It is essential to recognize the importance of transmitting the force uniformly over the entire cross-section A of this load cell. it is also essential to recognize that there is no other force working on the column apart from the one under measurement, acting along the axis of the column. Due to the stress F/A, the surface of the column undergoes compressional Ɛa strain along its axis and tensile strain along its circumference Ɛt. These strains are measured conveniently by the resistance type strain gauges, by locating them suitably on the outside surfaces. The strains are given by $\varepsilon_a = F/AE = \varepsilon_1 = \varepsilon_3$ $\varepsilon_t = -\mu F/AE = \varepsilon_2 = \varepsilon_4$. The size of the column permits the attachment or bonding of the strain gauges as shown and so utilization of the axial displacement is not considered any more	**1mark for Dia.** **&** **3 Mark** for suitable Explanation		

	efficient. The column is held rigidly in vertical position on a vibration-free mounting and the force is transmitted through a piston or any other means, to the entire sectional area of the column. They are designed to measure up to 2000 T. Distributing the four strain gauges around the periphery such that the tensile and compressional strain gauges are alternated. it is possible to achieve both temperature compensation and immunity to bending stress due to forces inadvertently applied at an angle to the axis of the column. Some-times, the column is held vertically by guard plates so as to increase its stiffness in the radial direction. **Note: Load cell with general explanation for force measurement can be considered**		
f)	**Explain ratio metric conversion in DAS**		
Answer	In DAS integrated circuits capable of providing ratiometric measurements logarithmic and antilogarithmic measurement are used for non-liner signal processing Different configurations for ratiometric measurements are as shown in above diagram. (a) Analog Multiplier	**2mark for Dia.** **&** **2 Mark** for suitable Explanation (Any two)	



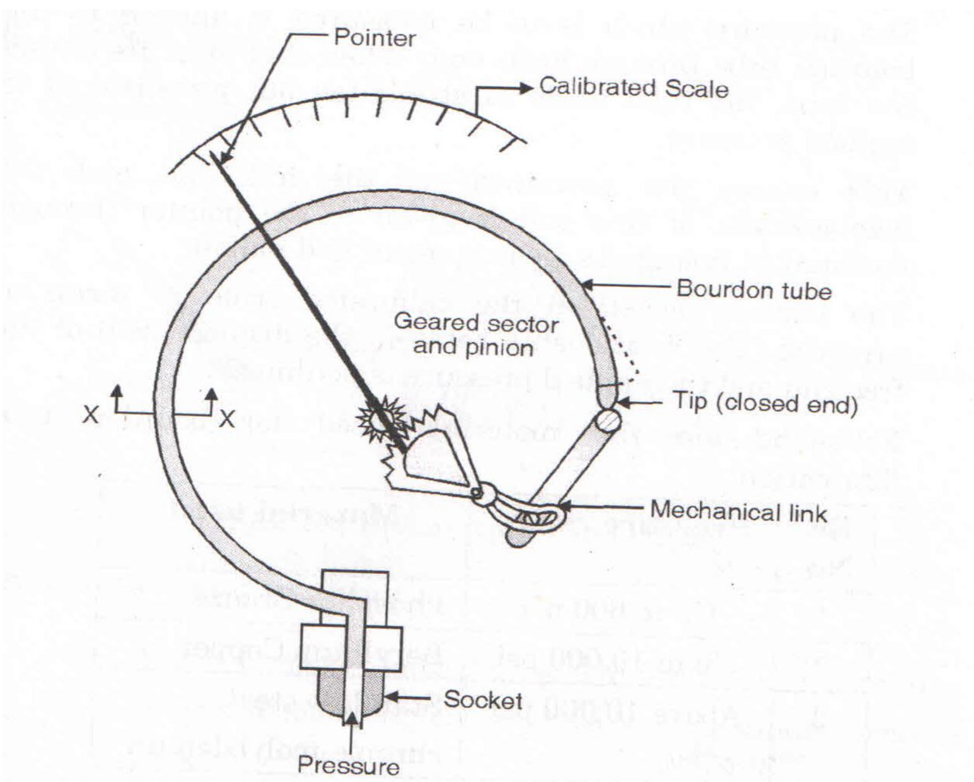
(b) Analog Divider



(c) Analog Square Root Extractor

The multiplier operate by converting the two input voltages to be multiplied into current and operates by converting the two input voltages to be multiplied into currents and generating an output current which is the ratio of the product of the two input current to a reference current .The multiplier can be used as modulator and demodulators as gain control element and in power measurement.

The multiplier can also be used to provide division and square rooting. The divider

	uses the multiplier in feedback configuration division enable fixed or variable gain element to be constructed and ratiometric measurement to be made. The square root extractor can be used in vector amplitude and r.m.s computations and in linearizing the output from flow meters based on differential pressure devices.		
5.	**Attempt any FOUR of the following:**		**16**
a)	**Explain how pressure can be measured using Bourdon Tube.**	**04**	
Answer	 (a) C type bourdon tube (a) C type bourdon tube (b) Section XX of bourdon tube	**02 Marks** for diagram & **02 Marks** for Explanation	

	C type bourdon tube is made up of an elliptically flattened tube bent in such a way as to produce the 'C' shape as shown in Fig. 2.9(a). One end (free end) of this tube is closed or sealed and the other end (fixed end) opened for the pressure to enter. The free end connected to the pointer with the help of geared sector and pinion. Calibrated scale and pointer is provided to indicate the pressure. The cross section view of 'C' type bourdon tube under normal condition and pressurized condition is as shown in Fig. 2.9(b). The pressure which is to be measured is applied to the bourdon tube through open end. When this pressure enters the tube, the tube tends to straighten out proportional to applied pressure. This causes the movement of the free end and the displacement of this end is given to the pointer through mechanical linkage i.e. geared sector and pinion. The pointer moves on the calibrated scale in terms of pressure. The relationship between the displacement of the free end and the applied pressure is nonlinear.		
b)	**Explain electromagnetic flow meter**	**04**	
Answer	Electromagnetic flow meter consists of the following : **(1) Electrodes :** These are platinum or stainless steel electrodes located diametrically opposite to each other with their axis perpendicular to both magnetic fields and tube axis. **(2) Flow tube :** It is made up of non-conductive non-magnetic alloys. It is insulated by glass lining from flowing liquid so as to prevent e.m.f. short circuiting of e.m.f. between electrodes. • This flow meters on the principle of electromagnetic induction i.e. when conductor cuts the magnetic field, an e.m.f. gets induced in it. • The basic arrangement for electromagnetic flow meter is shown in Fig. 2.48. • The pipe carrying liquid is placed in the gap of 'C' shaped iron core. A coil is wound on the core. When coil is excited, a magnetic field is produced. The pipe is placed such that liquid flow is in perpendicular direction to magnetic field.	**02 Marks** for diagram & **02 Marks** for suitable Explanation	

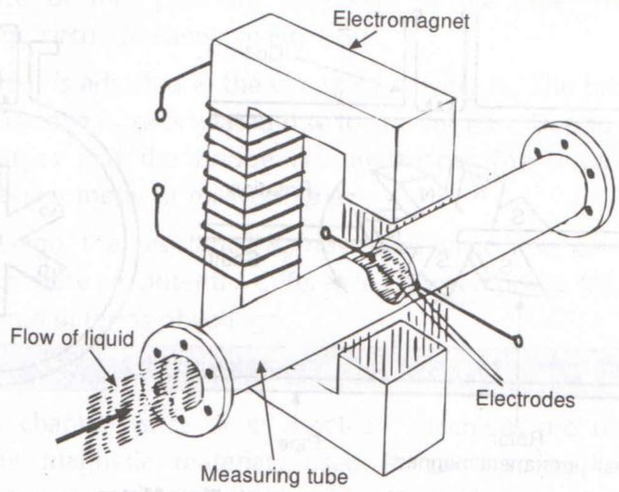


Fig. 2.48 : Principle of Electromagnetic Flow Meter

- Thus, conductor (liquid in motion) cuts the magnetic field, hence e.m.f. is induced in the liquid. This e.m.f. is collected by the two electrodes. This e.m.f. is proportional to the flow rate of liquid i.e. rate of cut of flux.
- Any liquid which separates into ions has sufficient conductivity. So flow of solutions of acids, alkalis even water flow can be measured with this flow meter.
- Petroleum products do not conduct electricity, hence flow of these liquids cannot be measured with this device.

Advantages of Electromagnetic Flow Meter :

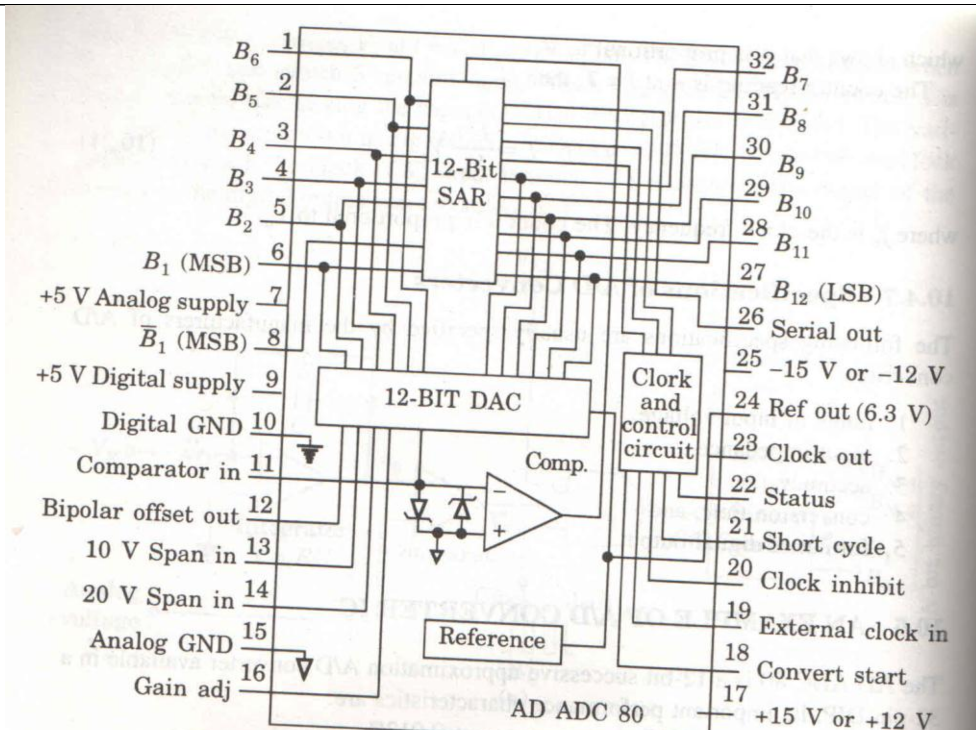
(i) There is no obstruction in the flow of liquid.
(ii) Calibration is not affected due to change in viscosity of liquid.
(iii) Flow in reverse direction can be measured with ease.
(iv) Its linear range is wide.
(v) The flow rate of corrosive liquids can be measured by making proper arrangement of electrodes.

Note :Adv.are optional

c)	**State any two application of each of following i) Comparator ii) Zero Crossing Comparator**	**04**	
Answer	**Application of Comparator:** **1. Null detectors:** A null detector is one that functions to identify when a given value is zero. Comparators can be a type of amplifier distinctively for null comparison measurements. It is the equivalent to a very high gain amplifier with well-balanced inputs and controlled output limits. The circuit compares the two input voltages, determining the larger. The inputs are an unknown voltage and a reference voltage,		

	usually referred to as v_u and v_r **2. Zero-crossing detectors:** For this type of detector, a comparator detects each time an ac pulse changes polarity. The output of the comparator changes state each time the pulse changes its polarity, that is the output is HI (high) for a positive pulse and LO (low) for a negative pulse squares the input signal. **3. Relaxation oscillator:** A comparator can be used to build a relaxation oscillator. It uses both positive and negative feedback. The positive feedback is a Schmitt trigger configuration. Alone, the trigger is a bistable multivibrator. However, the slow negative feedback added to the trigger by the RC circuit causes the circuit to oscillate automatically. That is, the addition of the RC circuit turns the hysteretic bistable multivibrator into an astable multivibrator. **4. Level shifter:** This circuit requires only a single comparator with an open-drain output as in the LM393, TLV3011 or MAX9028. The circuit provides great flexibility in choosing the voltages to be translated by using a suitable pull up voltage. It also allows the translation of bipolar ±5 V logic to unipolar 3 V logic by using a comparator like the MAX972. **5. Analog-to-digital converters:** When a comparator performs the function of telling if an input voltage is above or below a given threshold, it is essentially performing a 1-bit quantization. This function is used in nearly all analog to digital converters (such as flash, pipeline, successive approximation, delta-sigma modulation, folding, interpolating, dual-slope and others) in combination with other devices to achieve a multi-bit quantization. **6. Window detectors:** Comparators can also be used as window detectors. In a window detector, a comparator used to compare two voltages and determine whether a given input voltage is under voltage or over voltage. **Application of Zero Crossing Detector:** 1.It is particularly important in magnetic digital recordings. These are recorded as "transitions" from one polarity of magnetization to another, each transition	**02 Marks** for 2 comparator application &	

	representing a "bit". The location of these transitions is used to decode the recording. Since the transition goes from a positive value to a negative value (or vice versa) the zero crossing identifies the location of the transition. 2.Zero crossing detectors are used in frequency counters. 3.Zero crossing detectors are used in time interval meters. 4.Another application is in electrical power control switching circuits. These circuits control power by interrupting the current flow for a number of AC cycles. Voltage spike and electrical noise are minimized if the switching occurs at the beginning or end of cycles, at the point where the voltage is momentarily zero. A zero-crossing detector controls the switching so that it occurs at close to zero voltage of the cycle.	**02 Marks** for 2 Zero crossing detector application	
d)	**Draw a block diagram of practical analog to digital converter**	**04**	
Answer	The AD ADC 80 is a 12-bit successive-approximation A/D converter available in a 32-pin DIP. Its important performance characteristics are: Linearity error at + 25°C : ± 0.012% Maximum gain temperature Coefficient : 30 ppm/°C Power dissipation : 800 mW Maximum conversion time : 25 μs Digital output format : Unipolar and bipolar; parallel and serial Output drive : 2 TTL loads Analog voltage ranges : ± 2.5 V, ± 5 V, ± 10 V (bipolar) or 0 to 5 V, 0 to 10 V (unipolar) The functional block diagram of ADC 80 is shown in Fig. 10.26. When a convert start command is received, it converts the voltage at its analog input to an equivalent 12-bit binary number. The status flag is set during the time conversion is in progress. The status flag is reset after the conversion is over and the parallel output data becomes available. Serial data can be transferred by clocking it into a shift register bit by bit, starting from the decision taken about each bit. The digital data is available in parallel as well as serial form. The parallel 12-bit data is available at pins marked B_1 through B_{12}, where B_1 is MSB and B_{12} is LSB. For unipolar input ranges, the output is in complementary straight binary code (CSB), whereas for bipolar input ranges the output is either in complementary offset	**02 Marks for** suitable explanation **02 Marks** for Diagram	

	 **Fig. 10.26** Functional block diagram of AD ADC 80. binary (COB) or complementary 2's complement binary (CTC) code depending on whether B_1 (pin 6) or $\overline{B}_1$ (pin 8) is used as the MSB. Serial data coding is in CSB for unipolar input ranges and COB for bipolar input ranges. The MSB is the first bit at the serial output pin and LSB is the last. The circuit can be used for 12-, 10-, or 8-bit resolution by connecting the short-cycle terminal (pin 21) to pin 9, 28, or 30, respectively. The maximum conversion time is reduced to 21 and 17 μs for 10-bit and 8-bit resolutions, respectively.		
e)	**Explain how pressure can be measured using diaphragm**	**04**	
Answer	The working principle of diaphragm is similar to bellows. Diaphragm is merely a thin film of metal. The pressure is applied to one side of diaphragm. The pressure causes stretching of diaphragm along periphery, the displacement thus occurs. (Refer Fig. 2.45)	**02 Marks** for diagram & **02 Marks** for Explanation	

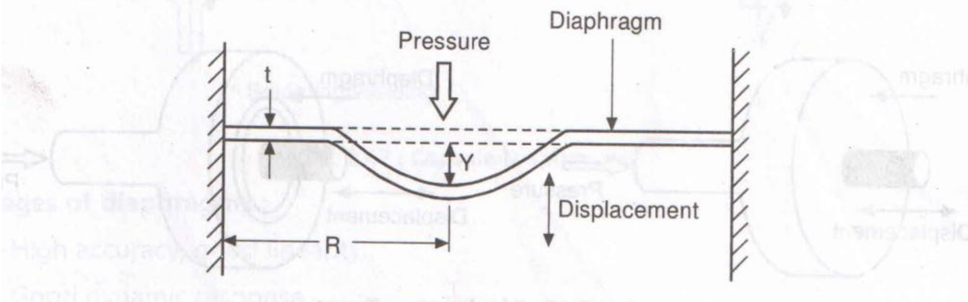


Fig. 2.45 : Diaphragm details

The deflection (y) is given by the following expression :

$$y = \frac{3}{16}\frac{(1-\mu^2)}{Et^3}R^4P$$

where, μ = Poisson's ratio

E = Modulus of elasticity

t = Thickness of diaphragm

R = Radius of diaphragm

P = Pressure to be measured

The displacement of diaphragm thus depends on its thickness and radius.

The materials used for diaphragms are mainly elastic metal alloys such as bronze, phosphor bronze, beryllium copper, stainless steel, ferrous nickel alloy etc.

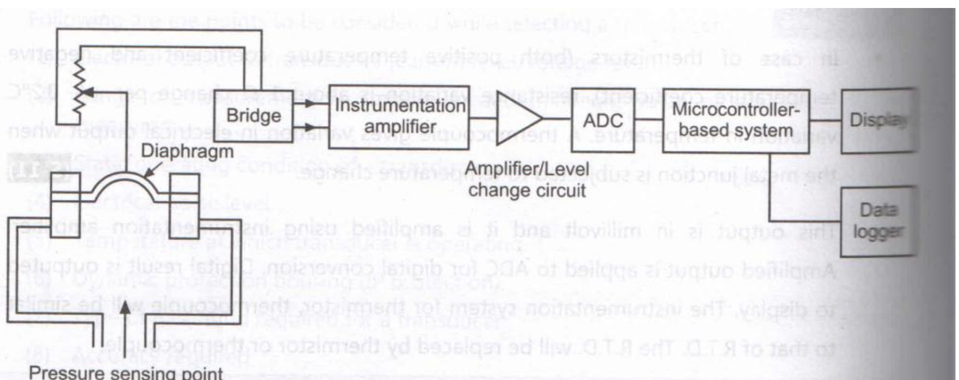


Fig. 5.3 : Diaphragm based Pressure Measurement System

These gauges use flexible membrane which produces deflection when pressure is applied.

This deflection can be calibrated and a linear potentiometer is connected to convert motion into resistance variation.

f)	**Explain how flow can be measured using turbine flow meter**	**04**	

<table>
<tr>
<td>Answer</td>
<td>
This flow meter consists of a rotor pivoted along the axis of the pipe and it is designed in such a way that rate of rotation of rotor is proportional to the rate of flow of liquid through the pipe. Refer Fig. 2.49.

The rotor consists of small permanent magnets. When rotor rotates, this magnetic field also rotates, so it is a rotating magnetic field. There is a coil fitted at the surface of pipe. The coil is stationary and the magnetic field is rotating. So flux linking with the coil changes and an e.m.f. is induced in the coil.

The amount of e.m.f. induced depends upon flow rate. Thus, electrical voltage proportional to flow rate is obtained.

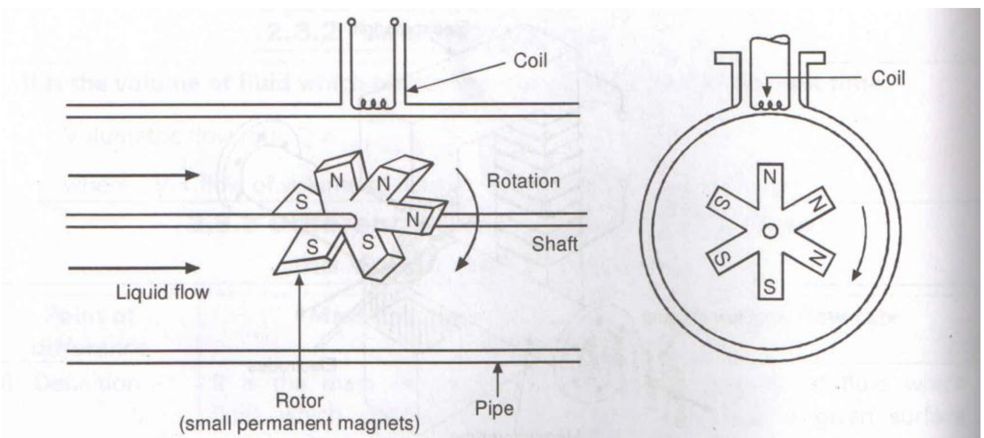


Fig. 2.49 : Electromagnetic Flow Meter
</td>
<td>02 Marks for diagram & 02 Marks for Explanation</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Attempt any FOUR of the following :</td>
<td></td>
<td>16</td>
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<tr>
<td>a)</td>
<td>Explain how current can be measured using hall effect.</td>
<td>04</td>
<td></td>
</tr>
<tr>
<td>Answer</td>
<td>
The circuit arrangement for measuring a.c. current is shown in Fig. 2.52.

An iron core of suitable dimensions as per design is constructed. A small cut is made or the slot is made in one of its limbs to place the Hall effect sensor.

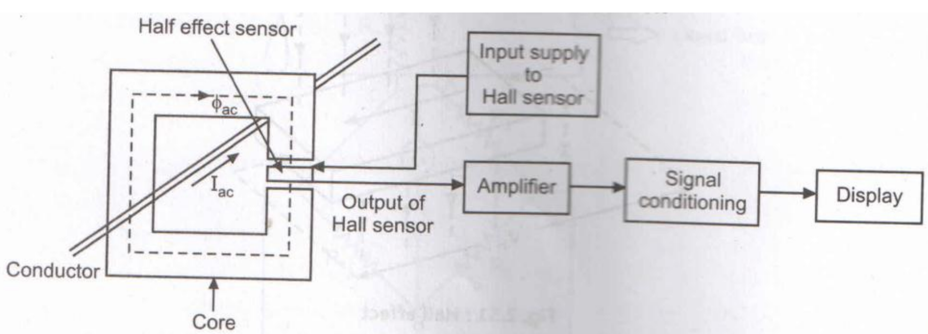

Fig. 2.52 : Measurement of a.c. current using Hall effect transducer

The conductor carries a.c. current which is to be measured. This conductor is placed in the core as shown.
</td>
<td>02 Marks for diagram & 02 Marks for Explanation</td>
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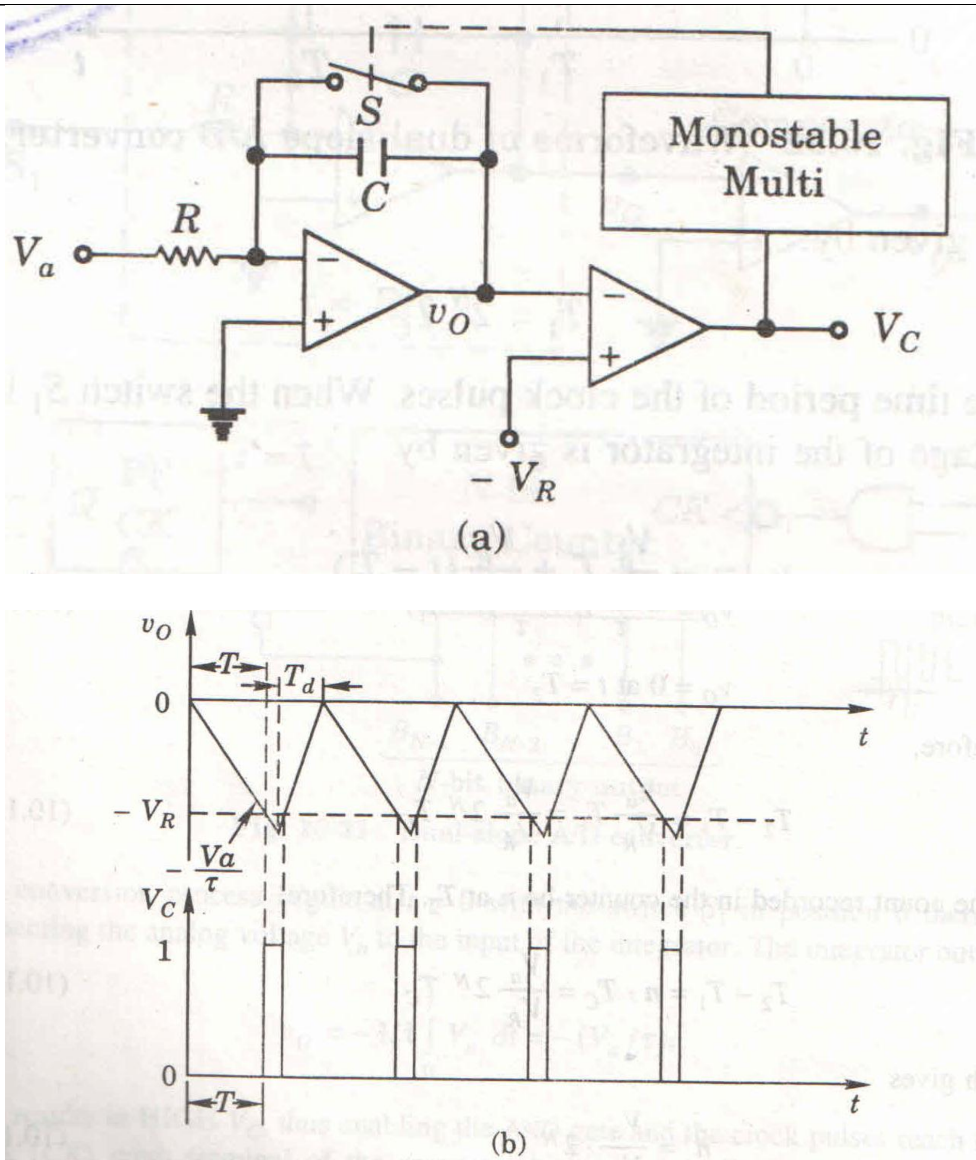
	I_{ac} produces magnetic flux (ϕ_{ac}) in the core. This flux passes through the core and the air gap in which the Hall effect sensor is placed. The Hall effect sensor produces output V_H, which is proportional to the flux density in the air gap. The flux density is produced due to I_{ac}, hence $V_H \propto B \propto I_{ac}$ So we can measure I_{ac} in terms of V_H. The output voltage V_H is amplified using amplifier circuit. In signal conditioning the scaling of signal is done such that display shows the value of I_{ac} directly.		
b)	**Explain how transducer can be selected for application.**	**04**	
Answer	Following points should be considered while selecting a transducer 1. Electrical output of transducer (Current/voltage level) 2. Range of measurement i.e maximum and minimum values of parameter to be measured. 3. Static operating condition of a transducer. 4. Electrical Noise level. 5. Temperature at which transducer is operating. 6. Dynamic protection housing (IP Protection) 7. Type of mounting required for transducer. 8. Accuracy required. 9. Operating principle suited for application. 10. Sensitivity of transducer. 11. Loading effect. 12. Stability & Reliability of transducer 13. Cost and availability.	**04 Marks** for any 8 points	
c)	**Explain voltage to frequency converter method of analog to digital converter.**	**04**	
Answer	An analog voltage can be converted into digital form, by producing pulses whose frequency is proportional to the analog voltage. These pulses are counted by a counter for a fixed duration and the reading of the counter will be proportional to the frequency of the pulses, and hence, to the analog voltage. A voltage-to-frequency converter is shown in Fig. 10.23*a*. The analog voltage V_a is applied to an integrator whose output is applied at the inverting input terminal of a comparator. The non-inverting input terminal of the comparator is connected to a reference voltage $-V_R$. Initially, the switch *S* is open and the voltage v_O decreases linearly with time ($v_O = -V_a t/\tau$), which is shown in Fig. 10.23*b*. When the decreas-	**02 mark** for diagrams & **02 Marks** for explanation	

	 **Fig. 10.23** Voltage-to-frequency converter (a) schematic circuit, and (b) waveforms.		

ing v_O reaches $-V_R$ at $t = T$, the comparator output V_C goes HIGH. This is used to close the switch S through a monostable multivibrator. When the switch S is closed, the capacitor C discharges, thereby returning the integrator output v_O to 0. Since the pulse width of the waveform V_C is very small, a monostable multivibrator is used to keep the switch S closed for a sufficient time to discharge the capacitor completely. The rate at which the capacitor discharges depends upon the resistance of the switch.

Let the pulse width of the monostable multivibrator be T_d. Therefore, the switch S remains closed for T_d after which it opens and v_O starts decreasing again.

If the integration time $T >> T_d$, the frequency of the waveforms v_O and V_C is given by

$$f = \frac{1}{T + T_d} \approx \frac{1}{T} = \frac{1}{\tau}\frac{V_a}{V_R} \qquad (10.18)$$

Thus, we obtain an output waveform whose frequency is proportional to the analog input voltage.

An A/D converter using the voltage-to-frequency (V/F) converter is shown in Fig. 10.24. The output of the V/F converter is applied at the clock (CK) input of a counter through an AND gate. The AND gate is enabled for a fixed time interval T_1. The reading of the counter at $t = T_1$ is given by

$$n = fT_1 = \frac{1}{\tau}\frac{V_a}{V_R}T_1 \qquad (10.19)$$

which is proportional to V_a.

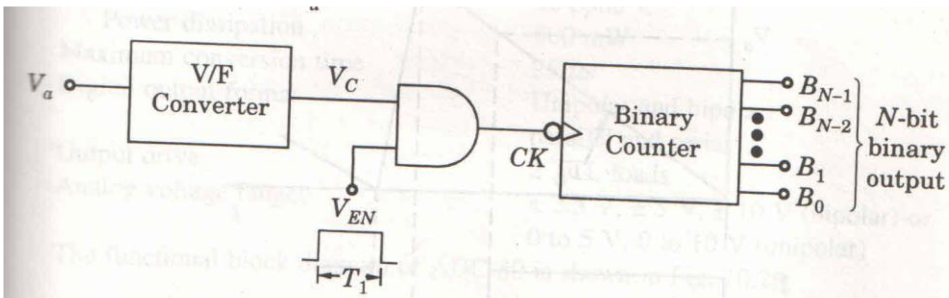
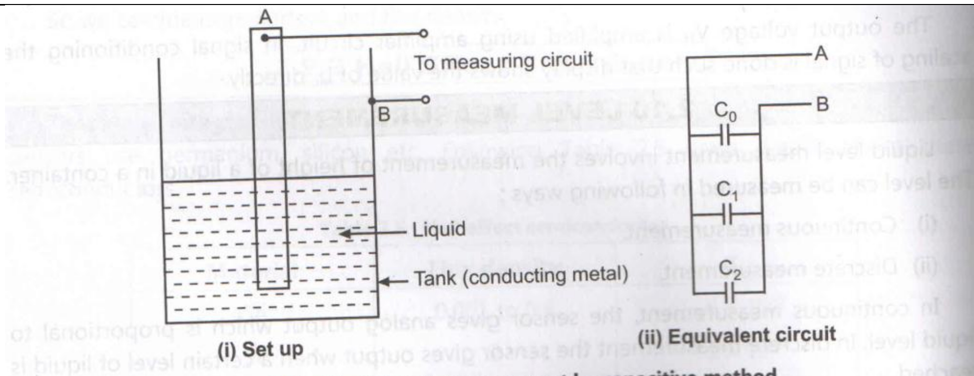
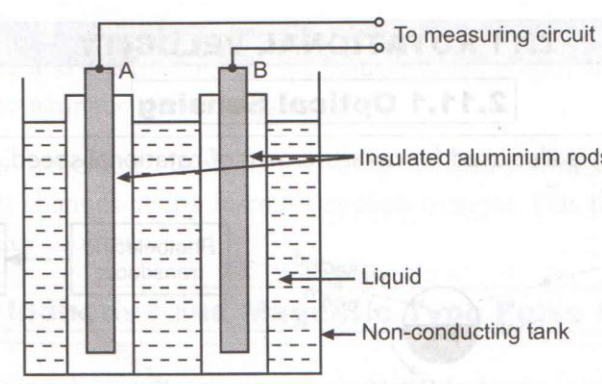
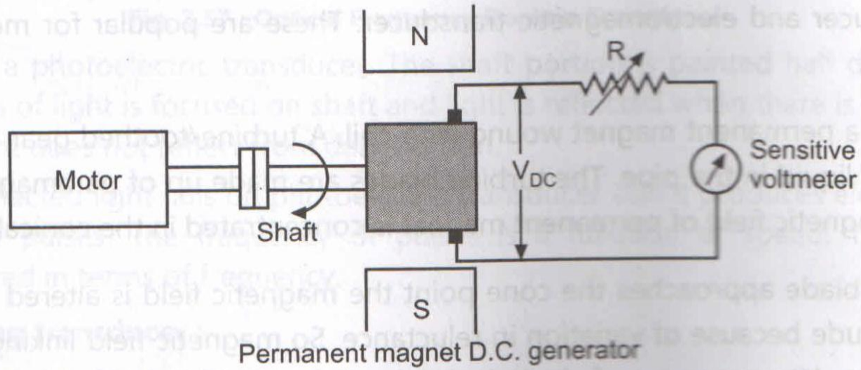
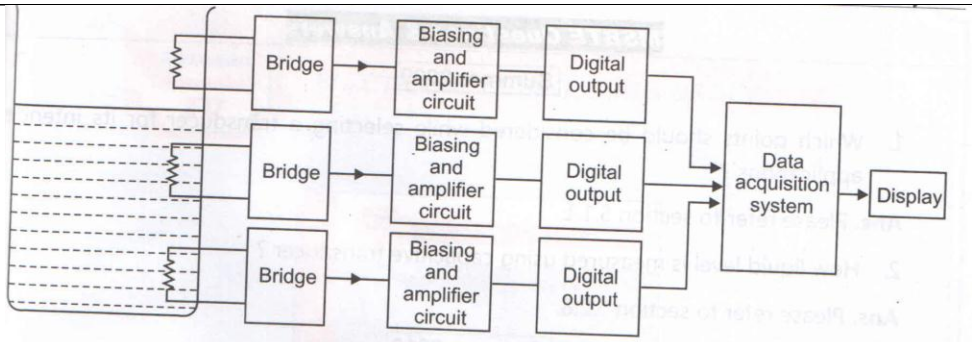


Fig. 10.24 An A/D converter using a V/F converter.

d)	**Explain how level can be measured using capacitive method.**	**04**	
Answer	The capacitance effect can be used for liquid level measurement. The arrangement for liquid level measurement by capacitive method is shown in Fig. 2.54.	**02 Marks**	

	 **Fig. 2.54 : Liquid level measurement by capacitive method** An insulated metal rod (A) is kept in the liquid container. The tank is made of conducting material. A capacitance is formed between rod (A) and the tank face (B). The liquid between these two act as a dielectric medium. Three different capacitances are formed C_0 = Capacitance between A and B with dielectric medium as air only C_1 = Capacitance between A and B with dielectric medium as air + liquid C_2 = Capacitance between A and B with dielectric medium as liquid only The values of C_1 and C_2 change as per the liquid level. If liquid level is high capacitance between A and B is high and if liquid level is low, capacitance between A and B is low. The capacitance and level can be measured by suitable measurement system. If liquid is conducting in nature, a resistance is connected between A and B. When the tank is madeup of non-conducting material, following arrangement is made. Two rods or plates (A and B) madeup of aluminum are placed in the tank. These rods are electrically insulated. A capacitance is formed between A and B with liquid as a dielectric medium. The capacitance between A and B changes as per the liquid level. It is high if liquid level is high and it is low if liquid level is low.  **Fig. 2.55 : Liquid level measurement by capacitive method**	for diagram & **02 Marks** for Explanation	

e)	**Explain how speed can be measured using dc tachogenerator**	**04**	
Answer	The construction is same as that of D.C. generator. It is a small permanent magnet D.C. generator connected to the shaft of motor whose speed is to be measured.  **Fig. 2.60 : D.C. tachometer or D.C. tachogenerator** When the motor rotates, D.C. generator also rotates and produces D.C. output voltage (V_{DC}). This D.C. output voltage is proportional to the speed. The voltage can be measured by a voltmeter whose scale is directly calibrated to measure speed. Resistance 'R' is protective resistance. If any short circuit occurs at output terminals of D.C. generator, the short-circuit current will be limited by this resistance. If motor rotates in reverse direction the polarity of output voltage changes. Thus the direction of rotation can also be determined. **Advantages :** (i) Simple to construct and operate. (ii) The output voltage can be measured with normal voltmeter of low ranges. (iii) The direction of rotation can be determined from polarity of output voltage. **Disadvantages :** (i) Commutator brush arrangement needs regular maintenance. (ii) The brush contact resistance produces error in measurement. (iii) Voltmeter with high resistance is needed.	**02 Marks** for diagram & **02 Marks** for Explanation **Adv.& Disadv. are optional**	
f)	**Explain liquid level can be measured using resistive sensor.**	**04**	
Answer	Resistive electrodes are located at known height intervals. The heat transfer coefficient at surface of resistance element changes when dipped in liquid. This change in resistance is sensed and a digital output (1 or 0) of + 5V or 0 volt is generated.	**02 Marks** for diagram &	

	 **Fig. 5.9 : Resistive Transducer for Liquid Level Measurement** This digital signal representing liquid level is given to microcontroller based system for processing and output is displayed on display device.	**02 Marks** for Explaination	