MODEL ANSWER

WINTER– 18 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.

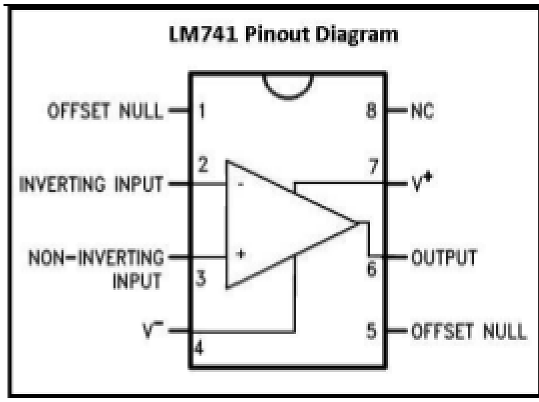
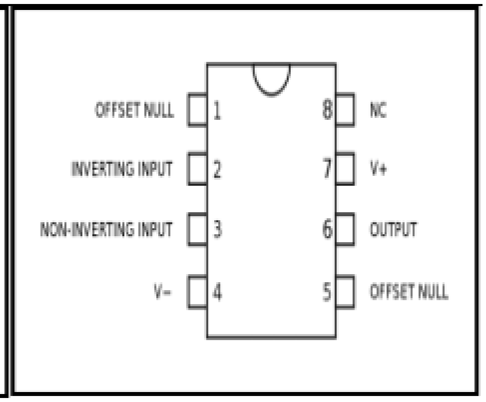
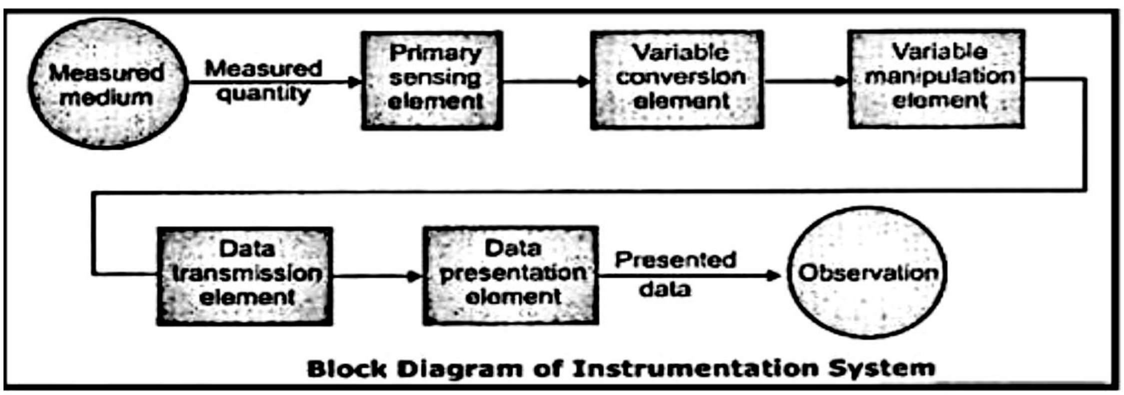
Q. No.	Sub Q.N.	Answer	Marking Scheme
Q.1		**Attempt any TEN of the following :**	**20-Total Marks**
	a)	**Define:** **i) Range ii) Span of instruments**	**2M**
	Ans:	i) **Range:** It is defined as the difference between Greatest and Smallest value of the data or reading of the instrument. ii) **Span:** It is defined as the algebraic difference between the upper and lower range values	**1M each**
	b)	**Define:** **i) Sensitivity ii) Linearity**	**2M**
	Ans:	i) **Sensitivity:** It is the ratio of magnitude of output signal to the magnitude of input signal. ii) **Linearity** is defined as the ability to reproduce the input characteristics symmetrically and this can be expressed by the equation y= mx+c where 'y' is the output, 'x' is the input, 'm' is the slope and 'c' is the intercept.	**1M each**
	c)	**Define:** i) **Calibration ii) Traceability**	**2M**
	Ans:	i) **Calibration:** Comparison of an unknown quantity to a known standard quantity. i) **Traceability:** It is defined as an unbroken chain of comparisons relating an	**1M each**

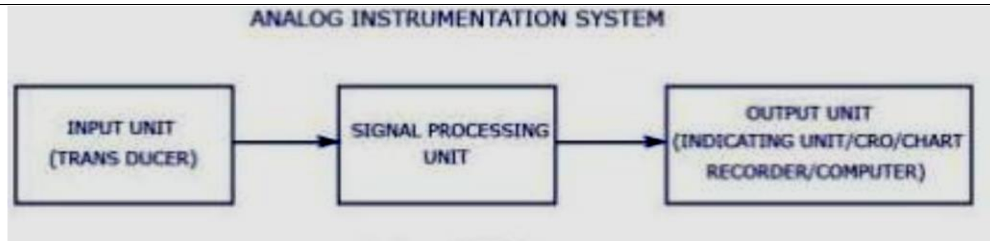
		instrument's measurements to a known standard. Calibration to a traceable standard can be used to determine an instrument's bias, precision, and accuracy.	
	d)	**Difference between repeatability and reproducibility (any two points)**	**2M**
	Ans:	(see table below)	**1 M each**

Repeatability	**Reproducibility**
It is the degree of closeness with which a given input value is repeatedly measured.	It is the degree of closeness with which a given input value is repeatedly measured .
It is the variation of scale reading	It is specified in terms of scale reading over a given period of time
It is random in nature	It is not random in nature

	e)	**Define the static characteristics:** **i) Resolution ii) Drift.**	**2M**
	Ans:	i) **Resolution:** It is the smallest increment in the input which can be detected by the instrument or the smallest measurable input change**.** ii) **Drift:** The gradual shift in the indication or record of the instrument over an extended period of time, during which the true value of the variable does not change is referred to as drift.	**1 M each**
	f)	**State the effect of dead zone on instruments.**	**2M**
	Ans:	It is the largest change in input during which the output remains constant**.** So during dead zone**,** even if input changes, output remains the same.	**2M**
	g)	**Define transducers. Give their two examples.**	**2M**
	Ans:	Transducer is a device which converts one form of energy to another form. Ex. 1. Potentiometer 2. RTD 3. LVDT 4. strain gauge	**1M** **1M (any 2 ex.)**
	h)	**Differentiate between active and passive transducers (any two points)**	**2M**
	Ans:	Active transducers: Active transducers are also known as self-generating type transducers. They do not require external power source to produce the output. They work under energy conversion principle. Active transducers develop their own voltage or current. The energy	**2M**

		required for the production of the output signal is obtained from the physical phenomenon being measured. Ex: piezoelectric transducer, thermocouple. Passive transducers: Passive transducers are also known as externally powered transducers. They require external power source to produce the output. They work under energy controlling principle. Ex: resistive, capacitive, inductive transducer.	
	i)	**Define :** **i) Strain gauge ii) Gauge factor**	**2M**
	Ans:	**i)** **Strain gauge** is a **resistance transducer** whose resistance varies with applied force; It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured. **ii)** **Gauge factor** is defined as the ratio of per unit change in resistance to per unit change in length	**1M each**
	j)	**List two advantages of platinum resistance thermometer.**	**2M**
	Ans:	1. The platinum resistance thermometer is stable 2. It is resistant to corrosion 3. It is resistant to oxidation	**2M for any 2**
	k)	**Define :** **(i) CMMR ii) Slew rate**	**2M**
	Ans:	**(i) 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= A_{DM}/A_{CM} **ii) Slew rate:** The slew rate of an op amp or any amplifier circuit is the rate of change in the output voltage caused by a step change on the input. OR -The maximum rate at which an amplifier can respond to an abrupt change of input level It is measured as a voltage change in a given time.	**1M each**

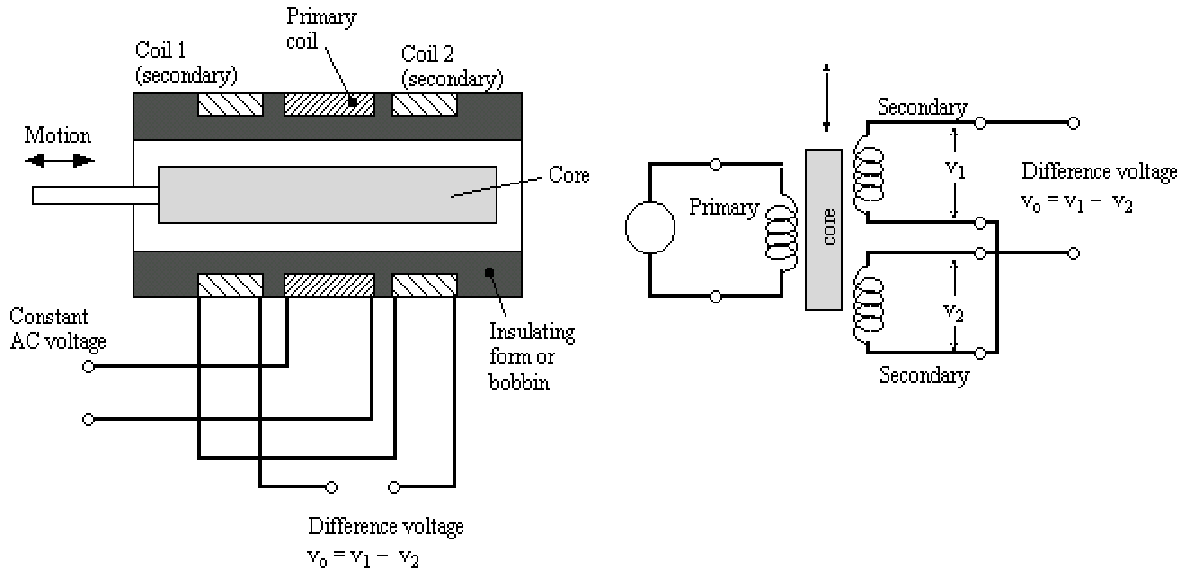
	l)	**Draw the pin diagram of IC 741 OpAmp.**	**2M**
	Ans:		**2M**
Q 2		**Attempt any FOUR of the following:**	**16-Total Marks**
	a)	**Explain in brief generalized instrumentation system operation with the block diagram.**	**4M**
	Ans:	**Fig. Block diagram of instrumentation system**	**2M**
		Primary Sensing Element: primary sensing element of system is that which first receives energy from the measured medium and produces an output depending in some way on the value of measured quantity. **Variable Conversion Element**: A variable conversion element merely converts the output signal of the primary sensing element into a more suitable variable or condition useful to the function of the instruments. **Variable Manipulation Element**: It manipulates the signal represented by some physical variable, to perform the intended task of an instrument. In the manipulation process, the physical nature of the signal is preserved. **Data Transmission Element**: It transmits the data from one element to other element. **Data presentation Element**: It performs the translation function, such as the simple indication of a pointer moving over a scale or recording of a pen moving over a chart. OR	**2M**

		 **The Primary Element/Transducer**: The input receives the quantity whose value is to be measured and is converted into its proportional incremental electrical signal such as voltage, current, resistance change, inductance or even capacitance. Thus, the changed variable contains the information of the measured variable. Such a functional element or device is called a transducer. **The Secondary Element/Signal Processing Unit** :The output of the transducer is provided to the input of the signal processing unit. This unit amplifies the weak transducer output and is filtered and modified to a form that is acceptable by the output unit. Thus this unit may have devices like: amplifiers, filters, analog to digital converters, and so on. The **Final Element/Output Unit**: The output from the signal processing unit is fed to the input of the output unit. The output unit measures the signal and indicates the value to the reader. The indication may be either through: an indicating instrument, a CRO, digital computer, and so on	
	b)	**Define:** **i) Accuracy** **ii) Precision** **iii) Measurement uncertainty** **iv) Tolerance.**	**4M**
	Ans:	**1) Accuracy:** The degree of exactness (closeness) of a measurement compared to the expected (desired) value. **OR** Closeness with which the instrument reading approaches the true value of the quantity being measured is known as accuracy **2) Precision:** It is the measure of consistency or reproducibility of measurements. OR The closeness with which the individual measurements are departed or distributed about the average of number of measured value. **3) Measurement uncertainty:** it is the parameter, associated with the result of a measurement that characterizes the dispersion of the values that could be attributed to the measured. It is the standard deviation of the probability distribution over the possible values that could be attributed to a measured quantity **4) Tolerance**: Ability of an item or system to withstand high levels of stress or overloading without suffering irreparable harm. 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 OR Allowable variation in actual measured value and desire value	**1M each**

c) **Draw and explain the working principle of LVDT. List its applications.** **4M**

Ans:

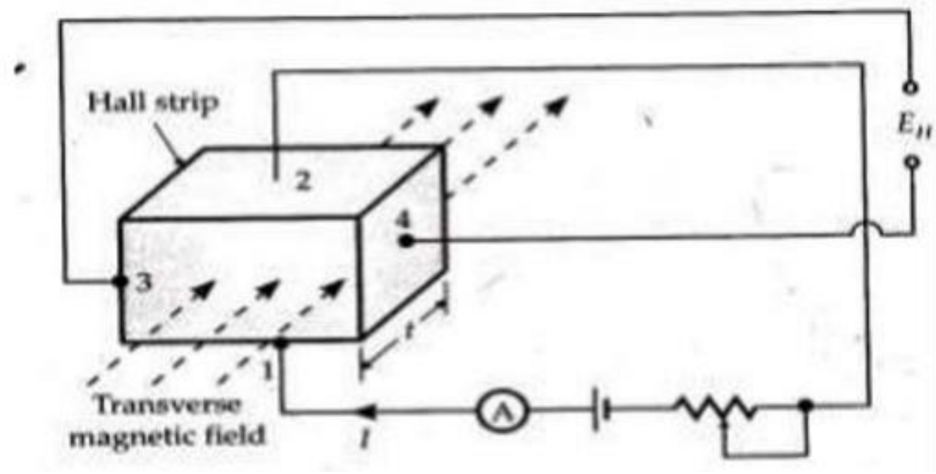
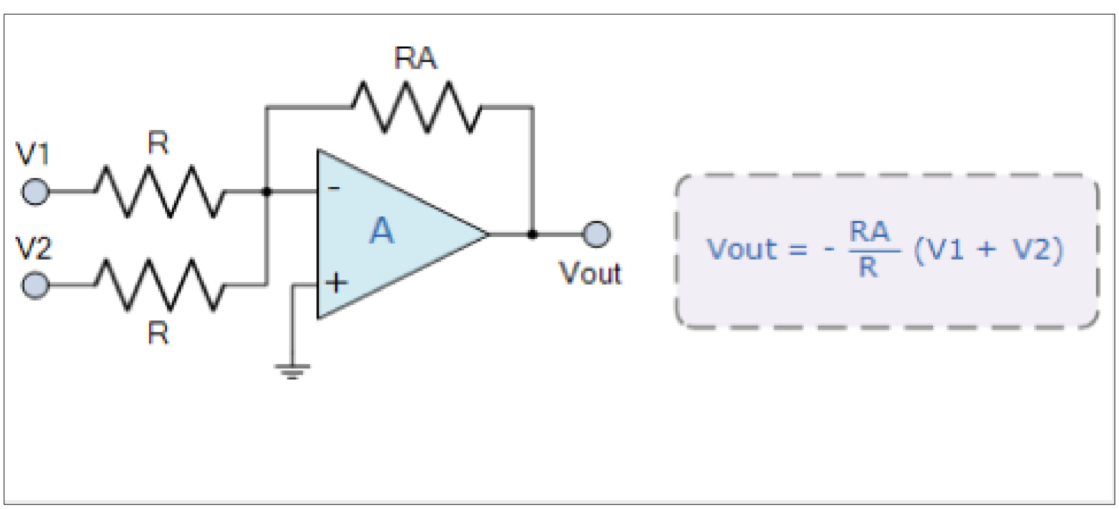
Diagram: **2M**



A Linear Variable Differential Transformer (~~R~~LVDT) is an electromechanical transducer that provides a variable alternating current (AC) output voltage that is linearly proportional to the linear displacement of its input shaft.
LVDT is a passive inductive transducer to translate the linear motion into electrical signals. **1M**
It consists of a single primary winding and two secondary windings. Secondary windings have equal number of turns and are identically placed on either side the primary winding.
The primary winding is connected to an A.C. source.
A movable **iron core** is placed inside the winding.
The displacement to be measured is applied to the arm attached to the soft iron core.
Since the primary coil is excited by an A.C. source, it produces an alternating magnetic field, which in turn induces alternating current or voltage in the two secondary windings.
Two secondary windings are connected in series opposition to get differential output voltage. When displacement is applied to the core, inductance of one secondary winding increase and other decreases, giving differential output.
The Differential output voltage= V_1-V_2

Applications of LVDT: **1M**

- Measurement of displacement
- Measurement of weight or pressure exerted by liquid in a tank.
- Measurement and control of thickness of a meat sheet being rolled.
- Acting as a secondary transducer it can be used as device to measure force, weight and pressure

	d)	**Draw and explain the Hall effect transducer.**	**4M**
	Ans:	 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. 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.	**2M** **2M**
	e)	**Draw the Op-Amp based circuit diagram of Adder and explain its operation.**	**4M**
	Ans:		**2M**

Explanation : **2M**

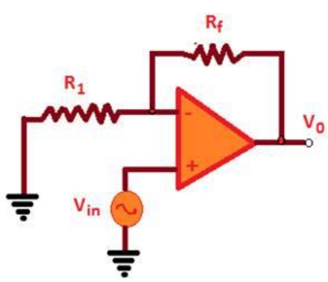
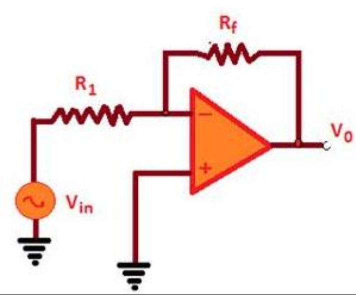
The Adder, also called a summing amplifier, produces an inverted output voltage which is proportional to the sum of the input voltages V1 and V2. More inputs can be summed. If the input resistors are equal in value (R1 = R2 = R) then the summed output voltage is as given and the gain is $\frac{RA}{R}$. If the input resistors are unequal then the output voltage is a weighted sum and becomes:

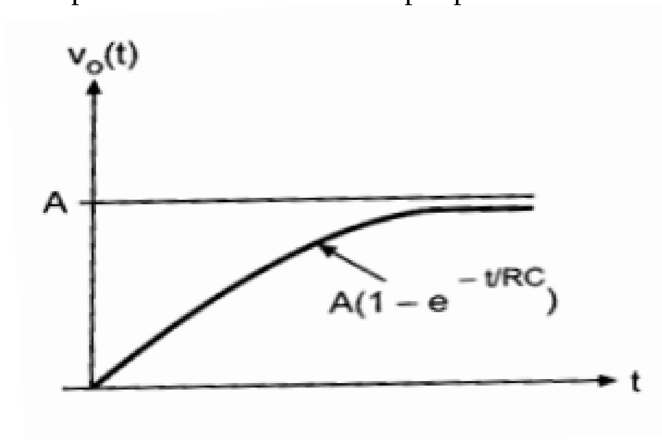
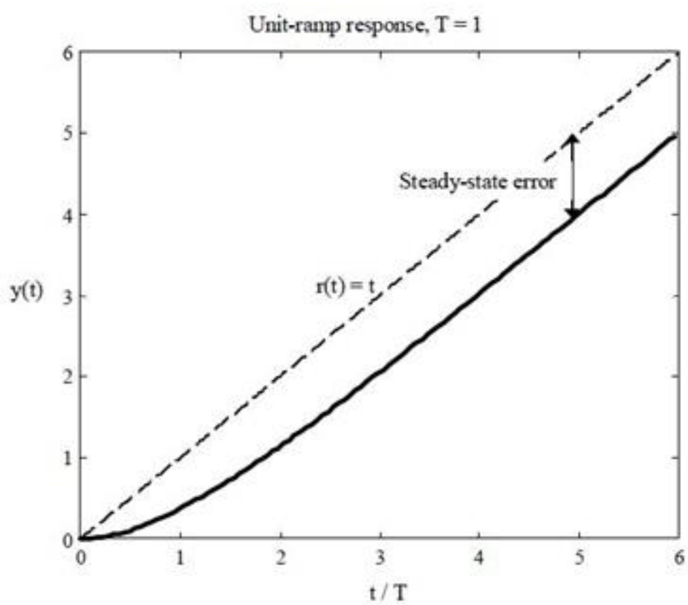
Vout= $-(V1(\frac{RA}{R1}) + V2(\frac{RA}{R2}))$

f) Compare between inverting and non-inverting closed loop Op-Amp ckts. **4M**

Ans:

Any 4 points IM each

Parameter	**Non-inverting amplifier**	**Inverting amplifier**
Type of feedback	Negative, Voltage series feedback	Negative, Voltage shunt feedback
Gain of the feedback circuit (B)	B = 1+ $\frac{R1}{R1+Rf}$	B = 1+ $\frac{R1}{R1+Rf}$
Closed loop voltage gain	AVF = $\left[1+\frac{Rf}{Ri}\right]$ (ideal) Or = $\frac{Av}{1+Av\beta}$ (Exact)	AVF = $\frac{-Rf}{R1}$ Or = $\frac{-AvK}{1+Av\beta}$ (Exact)
Value of closed loop voltage gain	AVF Always greater than or equal to 1.	AVF can be greater than or less than 1.
Input Resistance	RiF = (1+Avβ)Ri Input resistance increases due to the negative feedback.	RiF = R1 (Ideal) Input resistance decreases due to the negative feedback.
Phase relation	Input and output voltages are in phase.	Input and output voltages are 180^{o} out of phase.
Configuration		

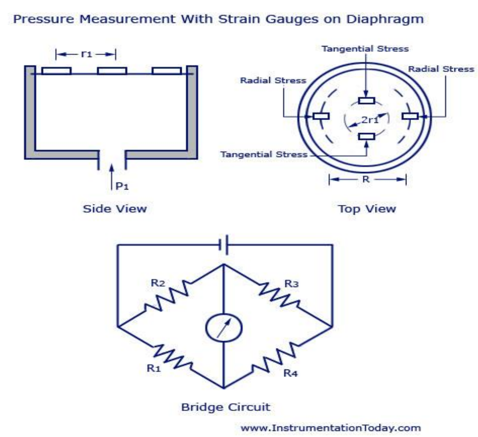
Q.3		**Attempt any Four of the following:**	**16-Total Marks**
	a)	**Draw and explain the responses of first order instruments to step and ramp inputs.**	**4M**
	Ans:	The response of first order for step input:  Response is exponential and reaching the set point exponentially. Output $y(t) = 1 - e^{-t/T}$  Response is exponential with a permanent steady state error. Output $y(t) = t - T + T e^{-t/T}$	
	b)	**Explain in brief self-heating effect and list the electrical transducers in which this effect is occurred.**	**4M**
	Ans:	**Self Heating Effect: 2M** Self-heating refers to the thermal energy originating at a current-carrying element. The local temperature rise depends upon the thermal dissipation path(s) away from the element. The model for thermal conduction uses an electrical equivalent – heat flows through a "thermal resistance", which is characteristic of the materials surrounding the source.	

List of transducers: any two -2M
RTD
Ultrasonic transducer
thermistor

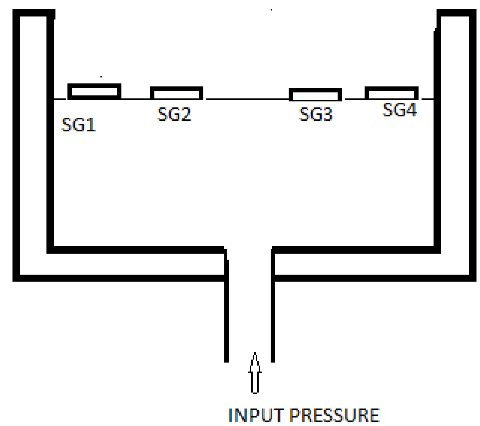
c) **Draw and explain the operation of four resistance strain gauges, based diaphragm type presssure transducer.** **4M**

Ans:

Diagram:2M



OR



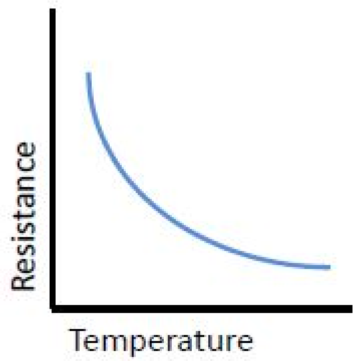
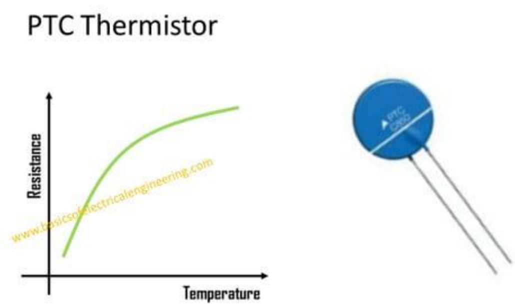
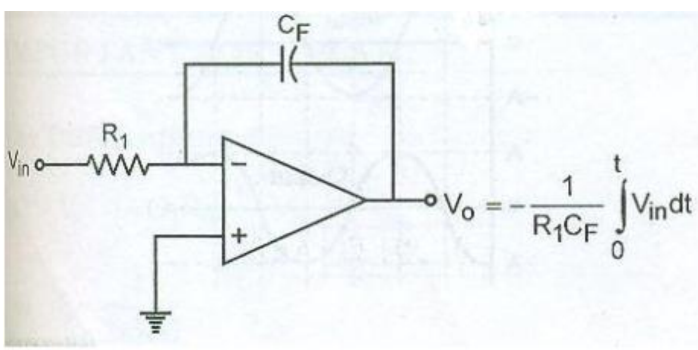
Explanation: 2M

- The sensing element is typically a diaphragm or tube whose internal volume contains the applied pressure.
- The pressure causes the element to deflect in a predictable manner causing surface strains as well as an applied force.
- Depending on design, the strain gages can be bonded to the non-pressurized face of the sensing element and respond to the surface strains.
- The strain gages can be bonded to a separate structure, usually a cantilever beam, driven by the force input of the diaphragm.
- In this case the strain gages respond to the surface strains of the beam.
- The strain gages change resistance in response to the surface strains they sense.
- The relationship between strain and resistance is expressed by the gage factor (G.F.) of the strain gage foil

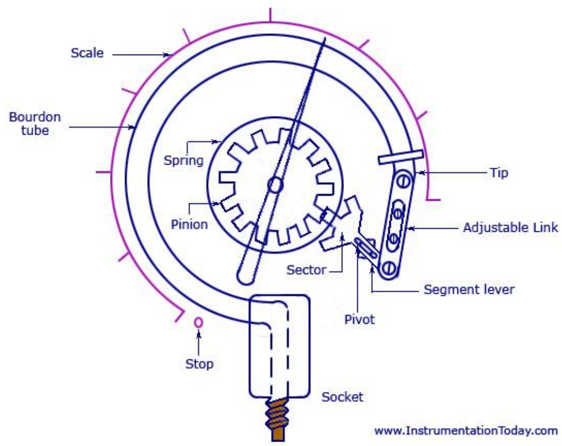
d) **Draw and explain the temperature resistance characteristics of NTC-type and PTC-TYPE thermistors.** **4M**

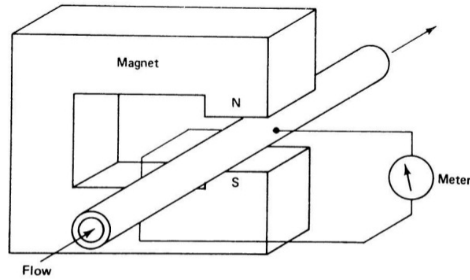
Ans: **2M**

NTC: The NTC thermistors are ceramic semiconductors that have a high Negative Temperature Coefficient of resistance. NTC thermistors decrease in resistance as the temperature increases.

		 **PTC: PTC thermistors are Positive Temperature Coefficient resistors generally made of polycrystalline ceramic materials that have a high positive temperature coefficient, which increases in resistance as the temperature increases.**  	**2M**
	e)	**With the help of circuit diagram, explain the working of Op-Amp based intergator. State its output voltage equation.**	
	Ans:	**Diagram:**  **Fig.OP-AMP as integrator** **Working of Op-Amp based intergator** 1. When Vin is firstly applied to the input of an integrating amplifier, the uncharged capacitor C has very little resistance and acts a bit like a short circuit allowing maximum current to flow via the input resistor, Rin as potential difference exists between the two plates. No current flows into the amplifiers input and point X is a virtual earth resulting in zero output. 2. As the impedance of the capacitor at this point is very low, the gain ratio of X_C/R_{IN} is also very small giving an overall voltage gain of less than one, (voltage follower circuit).	**1M** **2M**

		3. As the feedback capacitor, C begins to charge up due to the influence of the input voltage, its impedance Xc slowly increase in proportion to its rate of charge. 4. The capacitor charges up at a rate determined by the RC time constant, (τ) of the series RC network. Negative feedback forces the op-amp to produce an output voltage that maintains a virtual earth at the op-amp's inverting input. The integrator Op-amp produces an output voltage that is both proportional to the amplitude and duration of the input signal. **Output Equation:** $$v_0 = -\frac{1}{RC}\int v_1 \, dt$$	**1M**
	f)	**Explain in brief the selection criteria of transducers for particular application (any four points).**	**4M**
	Ans:	Transducer is a device which transforms energy from one form to another. The following points should be considered while selecting a transducer for particular application. 1. Operating range: The range of transducer should be appropriate for measurement to get a good resolution. 2. Operating principle: The transducers are selected on the basis of operating principle it may be resistive, inductive, capacitive, optical etc. 3. Sensitivity: The transducer should be more sensitive to produce the output or sensitivity should be as per requirement. 4. Accuracy: The accuracy should be as high as possible or as per the measurement. 5. Frequency response and resonant frequency 6. Errors: The error produced by the transducer should be low as possible. 7. Environmental compatibility: The transducer should maintain input and output characteristic for the selected environmental condition. 8. Usage and ruggedness.:it should be rugged in construction 9. Electrical aspect. 10. Stability and Reliability: Transducer should produce stable and accurate output in any environmental condition. 11. Loading effect: The transducer's input impedance should be high and output impedance should be low to avoid loading effect.	**Any four - 4M**

Q.4	**A)**	**Attempt any FOUR of the following :**	**16-Total Marks**
	a)	**Draw and explain 'C' type Bourdon tube.**	**4M**
	Ans:	**Diagram**  **Working-** • 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 the fig. 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 figure. • 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.	**2M**

	b)	**Draw and explain the working principle of electromagnetic flow meter and state its applications.**	**4M**
	Ans:	**Diagram:**  **Fig: Electromagnetic Flow meter**	**1.5M**
		Working Principle: Principle of Magnetic Flow Meter Based on Faraday's Law. Magnetic flow meters works based on Faraday's Law of Electromagnetic Induction. According to this principle, when a conductive medium passes through a magnetic field B, a voltage E is generated which is proportional to the velocity v of the medium, The density of the magnetic field and the length of the conductor. In a magnetic flow meter, a current is applied to wire coils mounted within or outside The meter body to generate a magnetic field. The liquid flowing through the pipe acts as the conductor and this induces a voltage which is proportional to the average flow velocity. This voltage is detected by sensing electrodes mounted in the Magnetic flow meter body and sent to a transmitter which calculates the volumetric flow rate based on the pipe dimensions. The induced voltage E=B L V Where B=flax density wb/m^2 L=length of Conductor **i.e diameter of pipe in meter** **v= velocity of Conductor i.e flow m/sec.**	**1.5M**
		Application: 1. Waste water application 2. They are useful at petroleum plants to measure the flow rate of combustible fuels. 3. They are useful in measuring displacement of explosive liquids, paints, and abrasives	**1M any one application.**

c) **Draw the circuit diagram of instrumentation amplifier (using 3 Op-Amps). State its two advantages over conventional amplifier.** **4M**

Ans:

Diagram **2M**

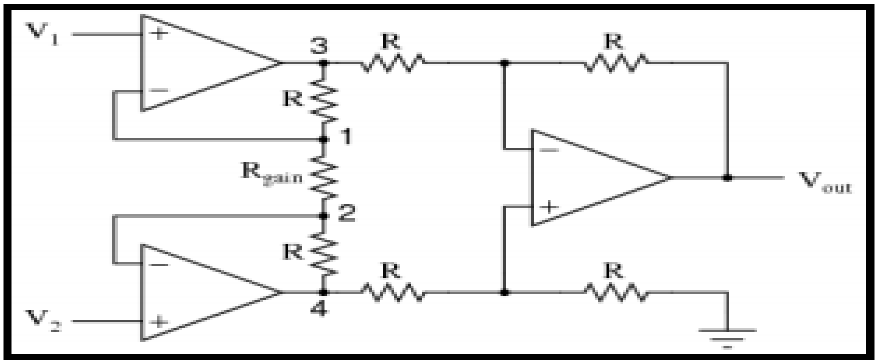


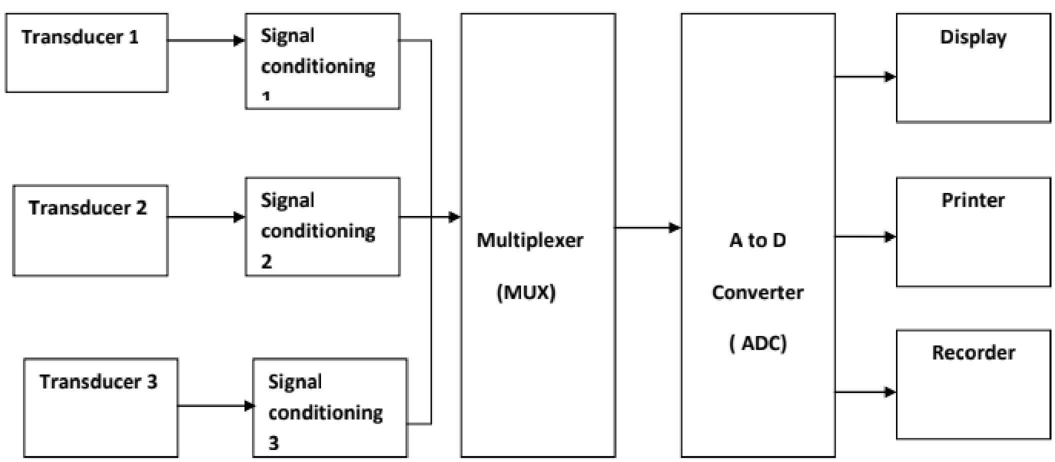
Figure:- Instrumentation amplifier

Advantages: **2M**

1. **The gain of amplifier is adjusted only by varying the Rgain resistors.**
2. **For unity gain all resistors values need not be same.**
3. **Input Impedance is higher than normal op-amp.**

d) **Draw and explain the block diagram of generalized Data Acquisition System (DAS).** **4M**

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



Working: **2M**

1. Transducer:-

A transducer is used to convert the physical parameters corning from the field into electrical signals or it is used to measure directly the electrical quantities such as resistance, voltage, frequency, etc.

2. Signal Conditioner:-

Usually the output signals of the transducer will be of very low level (weak) signals

which cannot be used for further processing. In order to make the signals strong enough to drive the other
elements signal conditioners are used such as amplifiers, modifiers, filters etc.
3. Multiplexer:-
The function of the multiplexer is to accept multiple analog inputs (after signal conditioning) and provide a single output sequentially according to the requirements.
4. A/D Converter:-
The analog-to-digital (A/D) converter is generally used to convert the analog data into digital form. The digital data is used for the purpose of easy processing, transmission, digital display and storage. Processing involves various operations on data such as comparison, mathematical manipulations, data is collected, converted into useful form and utilized for various
purposes like for control operation and display etc.
The transmission of data in digital form is possible over short distances as well as long distances of and has advantages over transmission in analog form. The data can be stored permanently or temporarily and can be displayed on a CRT or digital panel.
5. Recorders and Display Devices:-
In display devices the data is displayed in a suitable form in order to monitor the input signals. Examples of display devices are oscilloscopes, numerical displays, panel meters, etc.

e) **Compare between single-channel DAS and Multi-Channel DAS.** **4M**

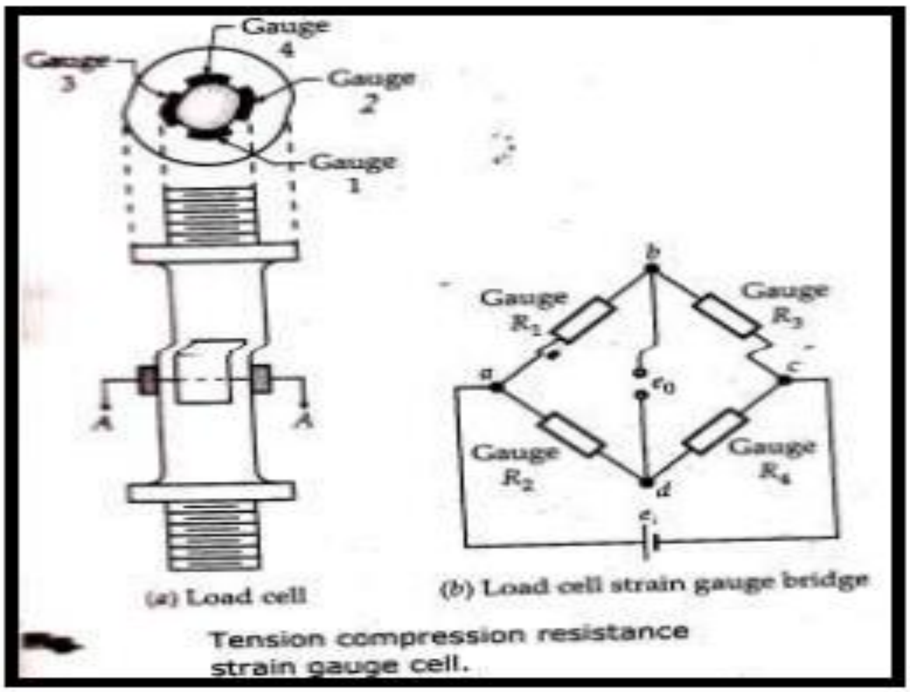
Ans:

Differences:

Each point 1 mark

Note:- (Diagram of both DAS can be considered.)

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

	f)	**Draw and explain the either circuit diagram or block diagram of instrumentation system used for force measurement using load cell.**	**4M**
	Ans:	**Diagram:** 	**2M**
		Working: 1. Load cells utilize an elastic member as the primary transducer and strain gauges as secondary transducers. 2. Strain gauges may be attached to any elastic member, on which there exists a, suitable plane area to accommodate them. 3. This arrangement may then be used to measure loads applied to deform or deflect the member, provided that the resultant strain is large enough to produce detectible outputs. 4. When the strain gauge –elastic member combination is used for weighing it is called a load-cell.	**2M**
Q.5		**Attempt any FOUR of the following :**	**16-Total Marks**
	a)	**State the setback and peltier effects.**	**4M**
	Ans:	**Seeback effect :** Seeback effect state that whenever two dissimilar metals are connected together to form two junctions, out of which, one junction is subjected to high temperature and another junction is subjected to low temperature then emf is induced proportional to the temperature difference between two junctions. **Peltier effect :** The Peltier effect is a temperature difference created by applying a voltage between two	**2 M each**

electrodes connected to a sample of semiconductor material. This phenomenon can be useful when it is necessary to transfer heat from one medium to another on a small scale.

b) **Draw and explain the working of liquid measurement process using capacitive type level transducer.** **4M**

Ans:

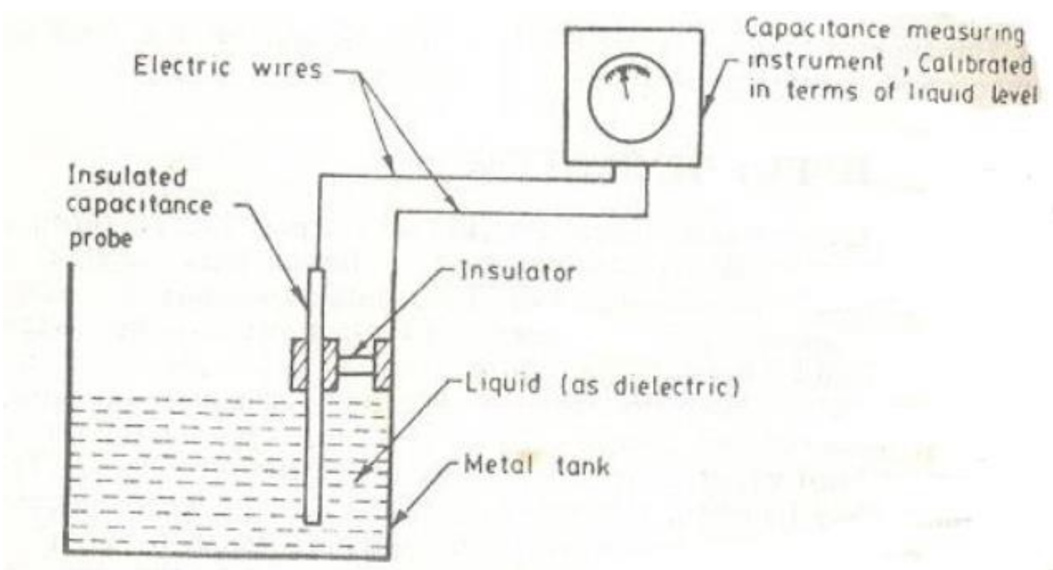


Diagram 2M

Working :

The capacitive level detector operates on the equation of parallel plate capacitor, i.e. $C = \varepsilon A/d$. It consist of an insulated capacitance probe (which is a metal electrode) firmly fixed near and parallel to the metal wall of the tank. If liquid in the tank is non-inductive, the capacitance probe and the tank wall form the plates of a parallel plate capacitor and liquid in between them acts as the dielectric. If liquid is conductive, the capacitance probe and liquid form the plates of the capacitor and insulation of the probe acts as the dielectric. A capacitance measuring device is connected with the probe and the tank wall, which is calibrated in terms of the level of liquid in the tank. When the level of liquid in the tank rises, the capacitance increases. When liquid level in the tank decreases, the capacitance also decreases. This increase and decrease in the capacitance is measured and is displayed on the indicator calibrated in terms of liquid level.

Explanation 2M

c) **Compare between active and passive filters (any four points).** **4M**

Ans:

Parameters	**Active**	**Passive**
Definition	Based on the electrical phenomenon or parameter that may be changed due to the whole process. Some of the most commonly electrical quantities in a transducer are Voltage or current	Based on the electrical phenomenon or parameter that may be changed due to the whole process. Some of the most commonly electrical quantities in a transducer are resistance, capacitance
Example	Thermocouple, Piezoelectrical	LDR, thermister

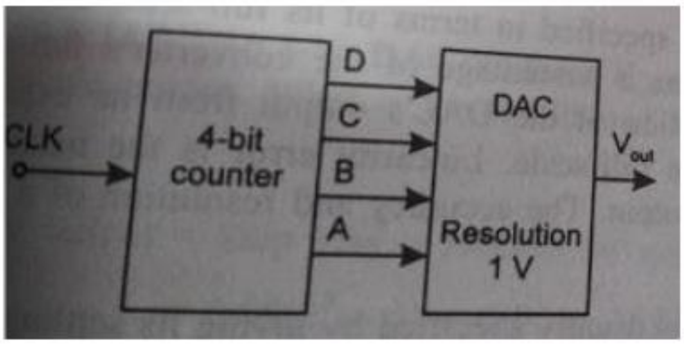
1 M each

Circuit	simple	Complicated
Active Bridge	Not Require	Require

d) **Draw and explain the working principle of Digital to Analog Converter (DAC).** **4M**

Ans: **(Any appropriate circuit and explanation may be considered.)**

Digital-to-Analog Converters:



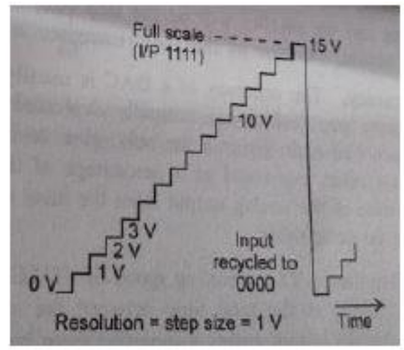


Diagram 2M

DAC fed by a binary counter Output waveform of a DAC

D/A conversion is the process of converting a value represented in digital code such as binary or BCD into a voltage or current which is proportional to the digital value.

Fig represents the symbol of a typical 4 bit D/a converter.

Each of the digital inputs A,B,C and D can assume a value 0 or 1, therefore there are2_4 = 16 possible combination of inputs. For each input number, D/A converter outputs a unique value of voltage.

The analog output voltage V_{out} is proportional to the input binary number.

So, Analog output = (K *digital input) where K is proportionality factor and is constant for a given DAC.

Explanation2 M

(OR)

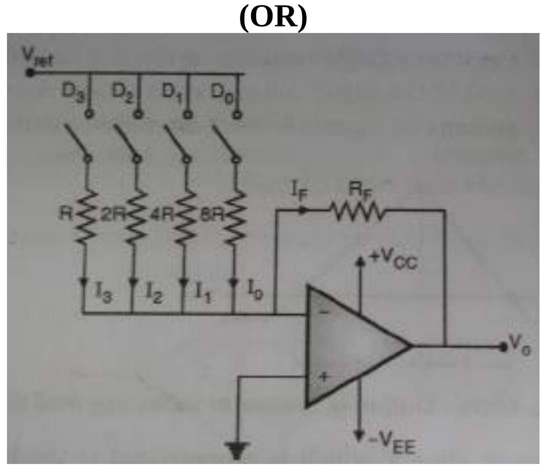


Figure above represents a DAC using op-amp. The summing amplifier has four input resistances corresponding to four binary inputs D0,D1,D2 and D3.Switches are provided with each input. If a switch is open ,it indicates ‘0’ And for closed switch it Indicates‘1’.

The output of the 4 bit DAC is : Iin= (Vref/R)(D3+2-1D2+2-2D1+2-3D0).

So the total voltage available at the output of the op-amp is the total of input voltage levels which represents the equivalent analog signals of the 4-bit digital input.

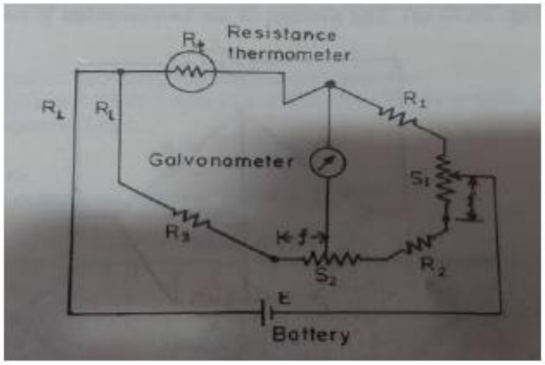
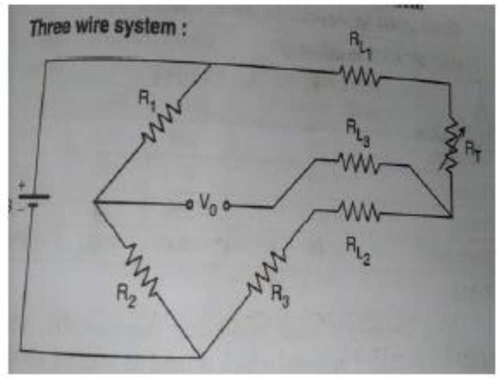
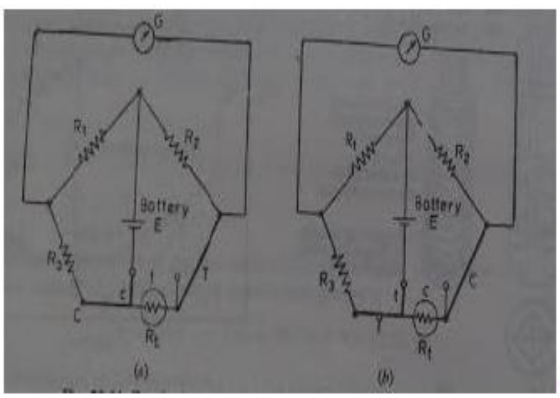
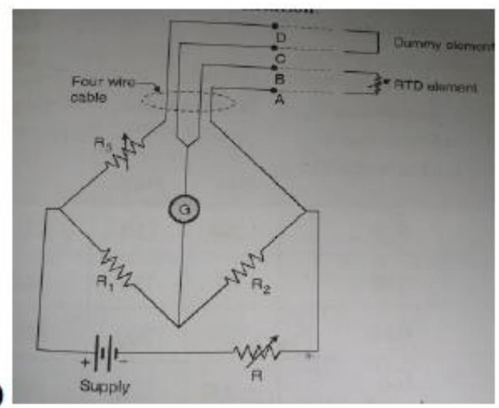
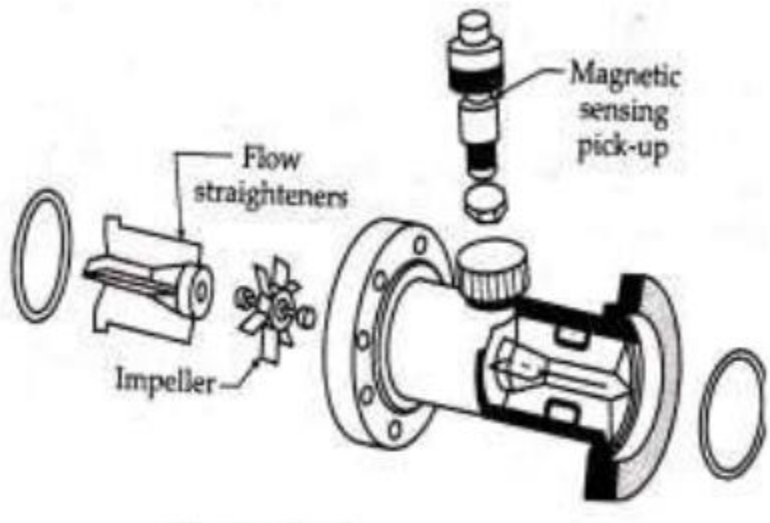
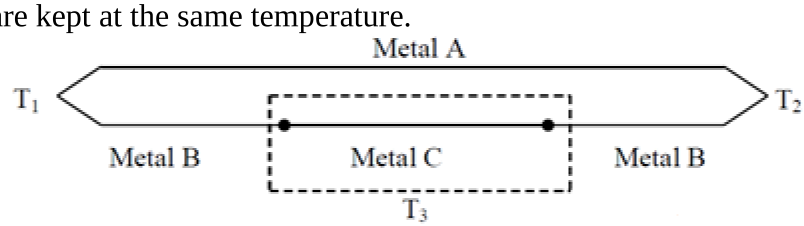
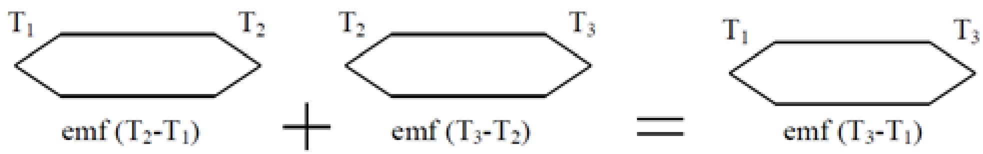
	e)	**Draw the three-wire and four-wire configurations of RTDs.**	**4M**
	Ans:	**3-wire RTD measurement configuration:**  **(or)**  **4-wire RTD measurement configuration:**  **(OR)** 	**2 M each**
	f)	**Draw and explain the working of turbine flow meter.**	**4M**
	Ans:	**Principle:** The flowing fluid impinges on the turbine blades (rotor), imparting a force to the blade surface which causes the rotation of the rotor. The speed of the rotation is directly proportional to the fluid velocity. The rotor consists of small permanent magnets. When rotar rotates this magnetic field also rotates. The speed of rotation monitored in most of the meters by magnetic pickup coil, which generates pulses. Total number of pulses gives the total flow. So the amount of emf induced depends upon the flow rate.	**Explan ation 2M**

		Diagram: 	**Diagram 2M**
Q.6		**Attempt any FOUR:**	**16- Total Marks**
	a)	**Draw and explain the thermocouples laws of intermediates metals and temperature.**	**4M**
	Ans:	**The Laws of Thermocouples.** **Law of intermediate metals** The law of intermediate metals states that a third metal may be inserted into a thermocouple system without affecting the emf generated, if, and only if, the junctions with the third metal are kept at the same temperature.  Law of Intermediate Metals When thermocouples are used, it is usually necessary to introduce additional metals into the circuit This happens when an instrument is used to measure the emf, and when the junction is soldered or welded. It would seem that the introduction of other metals would modify the emf developed by the thermocouple and destroy its calibration. However, the law of intermediate metals states that the introduction of a third metal into the circuit will have no effect upon the emf generated so long as the junctions of the third metal are at the same temperature, as shown in Above Figure **Law of intermediate temperatures** The law of intermediate temperatures states that the sum of the emf developed by a thermocouple with its junctions at temperatures T1 and T2, and with its junctions at temperatures T2 and T3, will be the same as the emf developed if the thermocouple junctions are at temperatures T1 and T3.	**1M** **1M**



Law of Intermediate Temperatures

This law, illustrated in above Figure, is useful in practice because it helps in giving a suitable correction in case a reference junction temperature other than 0 °C is employed. For example, if a thermocouple is calibrated for a reference junction temperature of 0 °C and used with a junction temperature of 20 °C, then the correction required for the observation would be the emf produced by the thermocouple between 0 °C and 20 °C.

b) **State the advantages and disadvantages of LVDT (2 points each).** **4M**

Ans: **Advantages :-**

Very basic transducer which is always useful in the field of instrumentation,
Infinite resolution is present in LVDT

- High output
- LVDT gives High sensitivity
- Very good linearity
- Ruggedness
- LVDT Provides Less friction
- Low hysteresis
- LVDT gives Low power consumption

(any two) 1 M each

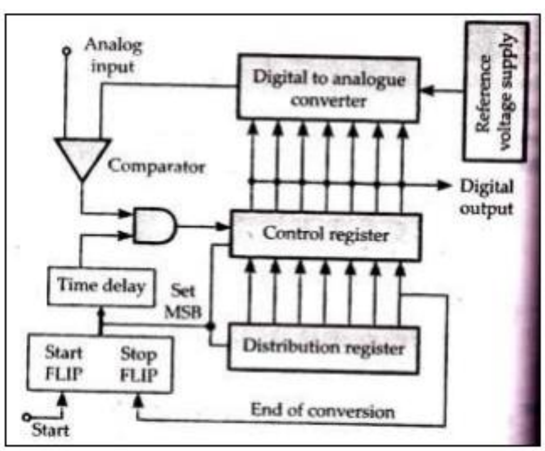
Disadvantages :-

- It has large primary voltage produce distortion in output.
- Temperature affects the performance.
- Sensitive to stray magnetic field.

(any two) 1 M each

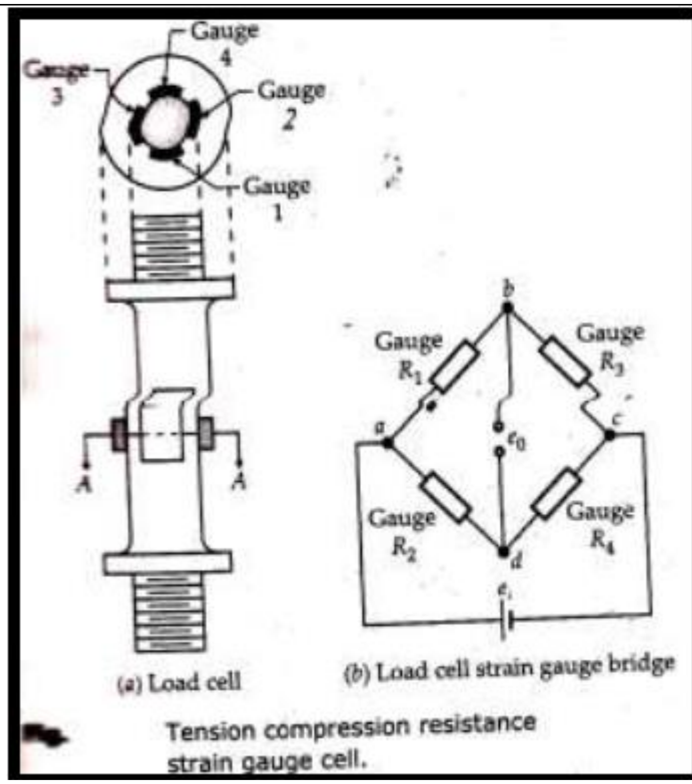
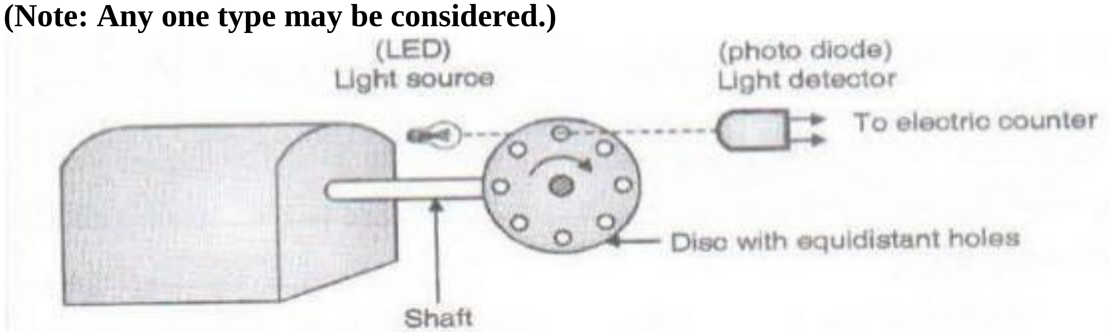
c) **Draw and explain the operation of any technique of Analog to Digital Converters (ADCs).** **4M**

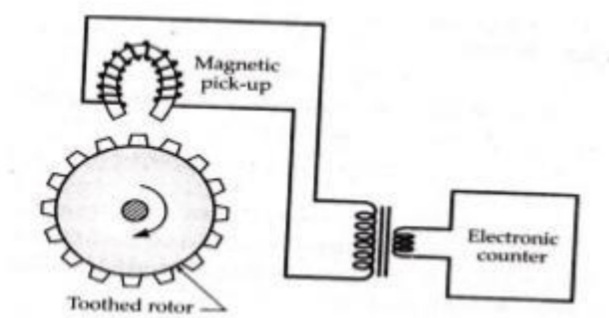
Ans:

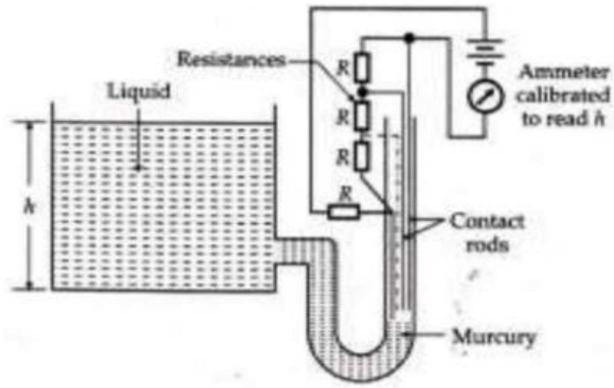


2M Diagram

		Explanation: A generalized block diagram of a basic successive approximation converter is shown in figure. The converter uses a digital control register with gateable binary inputs of 1 and 0, a D/A converter with a reference voltage supply, a comparison circuit, a control timing loop, and a distribution register. At the start of conversion cycle, both the control register and distribution register are set with a 1 in the MSB and a 0 in all bits of less significance. Thus the distribution register shows that the cycle has started and the process is in the first phase. The control register shows 1000, and this causes an output voltage at D/A converter section of one half of reference supply. At the same time, a pulse enters the time delay circuitry. By the time that the D/A converter and the comparator have settled, this delayed pulse is gated with the comparator output. When the next MSB is set in control register by the action of timing circuit, the MSB remains in a one state or it is reset to 0 depending upon the comparator output. The single 1 in the distribution register is shifted to the next position and keeps track of the comparison made. The procedure repeats itself following the diagram of fig until the final approximation has been corrected and the distribution register indicates the end of the conversion. ***Any other Technique Marks to be given***	**Explanation 2M**
	d)	**List the types of load cells. Explain any one type with neat diagram.**	**4M**
	Ans:	**Types of Load Cells** The Load Cell Types are classified based on three criteria. They are ▪ Working principle of a load cell ▪ Construction of Load Cell ▪ Electrical Properties of the load cell **Based on the Working Principle of the Load Cell** ▪ Compression Principle ▪ Tensile based Working ▪ Universal ▪ Hollow ▪ Shear Based Based on the Construction of the Load Cell ▪ S type Construction load cell ▪ Load Button types ▪ Single ended shear beam ▪ Double ended shear beam Load cell ▪ Single column and Multi Column load cell ▪ Pancake Load cell ▪ Diaphragm/membrane ▪ Torsion Ring Load cell Based on the Electrical Properties of the Load cell ▪ Analog and Digital property based load cell ▪ Resistance and Capacitance Based ▪ Piezoelectric and Wireless Based Load cell	**Types 1 mark** **Diagram 1M** **Explanation 2M**

		 **Explanation:-** Load cells utilize an elastic member as the primary transducer and strain gauges as secondary transducers .Strain gauges may be attached to any elastic member , on which there exists a, suitable plane area to accommodate them. This arrangement may then be used to measure loads applied to deform or deflect the member , provided that the resultant strain is large enough to produce detectible outputs. When the strain gauge –elastic member combination is used for weighing it is called a load-cell. ***Any other type Diagram and Explanation marks to be given.***	
	e)	**Draw and explain the operation of speed measurement using non-contact type transducer**	**4M**
	Ans:	**(Note: Any one type may be considered.)**  **i)Photoelectric Tachometer:** This method of measuring speed consists of mounting 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. On other side of the disc, and on the line of the light source, a light sensor like phototube or some photosensitive semi-conducting device is placed. When the opaque portion of the disc is between the light source and the light sensor,	**Diagram 2M**

		the light sensor is not illuminated and it does not produce any output. When a hole appears between two, the light falling upon the sensor produces an output pulse. The frequency at which the pulses are produced depends on the number of holes in the disc and its speed of rotation. As the number of holes is fixed, the pulse rate is a function of speed of rotation. The pulse rate is measured by an electronic counter which is directly calibrated in terms of speed. **(OR)** **ii)Toothed rotor variable reluctance Tachometer (Magnetic Pick up) :**  This tachometer consists of a metallic toothed rotor mounted on the shaft whose speed is to be measured. The magnetic pickup consists of a housing containing a small permanent magnet with a coil wound round it. When the 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. The frequency of the pulses of induced voltage depends upon the number of teeth of the rotor and its speed of rotation. As the number of teeth of the rotor is known, the speed of rotation can be determined by measuring the frequency of pulses with an electronic counter. If the rotor has T teeth, the speed of rotation is n rps and number of pulses per second is P Number of pulses per revolution = T Speed n = (pulses per second /number of teeth) = (P/T) rps = (P/T) *60 rpm.	**Explanation 2M**

	f)	**Draw and explain the instrumentation system used measurement of liquid level using resistive sensor.**	**4M**
	Ans:	 **Working:** This method uses mercury as a conductor as shown in the figure. A number of Contact rods are placed at various liquid levels. As the level of liquid rises in the tank, head h increases. The level of mercury rises above the datum and shorts successive resistors R and increases the value of h directly. The ammeter connected in series is calibrated in terms of the liquid level and indicates the liquid level directly.	**Diagram 2M** **Explanation 2M**