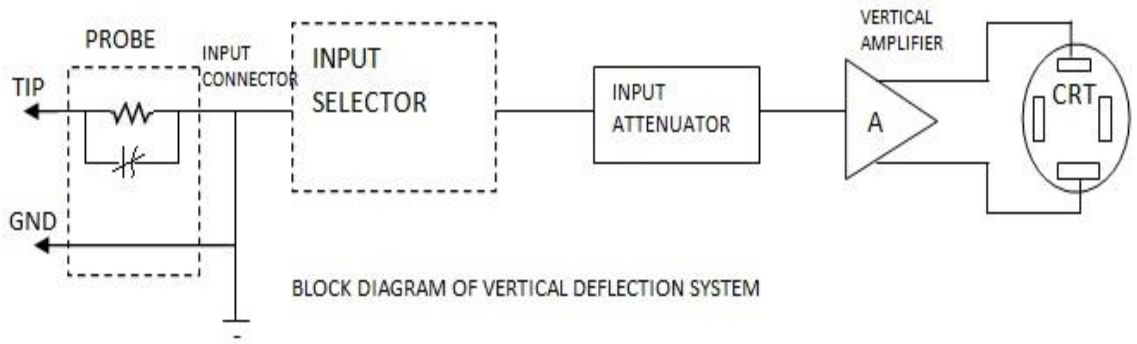
SUMMER-19 EXAMINATION
Model Answer
Subject Name: Electronic measurements and instrumentation Subject code: 22333

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in themodel 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 more Importance (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 any equivalent 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.	Sub Q. N.	Answers	Marking Scheme
1	(A)	**Attempt any FIVE of the following:**	**10- Total Marks**
	(a)	**Write any two applications of Instrumentation System.**	**2M**
	Ans:	Instrumentation is used to measure many parameters (physical values). These parameters include: • Pressure,either differential or static • Flow • Temperature • Levels of liquids, etc. • Density • Viscosity • Ionising radiation • Frequency	**(Any 2 correct pt. 2M)**

		• Current • Voltage • Inductance • Capacitance • Resistivity • Chemical composition • Chemical properties • Position • Vibration	
	(b)	**Define :** **(i) Resolution** **(ii) Accuracy**	**2M**
	Ans:	(i) **Resolution:** The smallest change in input to which instrument can respond is known as resolution. (ii) **Accuracy:** It is the degree of closeness with which an instrument reading approaches the true value of the quantity being measured. (any other relevant definition should also be considered)	**(1M for each definition)**
	(c)	**Sketch Block diagram of vertical deflection system used in CRO.**	**2M**
	Ans:	 BLOCK DIAGRAM OF VERTICAL DEFLECTION SYSTEM	**(2M for correct diagram)**

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	(d)	**Define :** **(i) Sensor** **(ii) Transducer**	**2M**
	Ans:	**(i) Sensor :** A device which detects or measures a physical property and records, indicates, or otherwise responds to it. **(ii) Transducer :** a device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa. (any other relevant definition should also be considered)	**(1M for each definition)**
	(e)	**List any four types of transducer.**	**2M**
	Ans:	**Types of Transducer based on Quantity to be Measured** • Temperature transducers • Pressure transducers • Displacement transducers • Flow transducers T**ypes of Transducer based on the Principle of Operation** • Photovoltaic • Piezoelectric • Chemical • Mutual Induction • Electromagnetic • Hall effect • Photoconductors **Types of Transducer based on Whether an External Power Source is required or not**	**(1M for each correct type)**

		• Active Transducer • Passive Transducer	
	(f)	**State need of level measurement.**	**2M**
	Ans:	In almost all industries, vast quantities of liquid such as water solvents, chemicals etc. are used in number of processes. It is widely employed to monitor as well as measure quantitatively the liquid content in the tanks, containers and vessels etc liquid level affects both pressure and rate of flow in and out of the container and therefore its measurement becomes important in a variety of processes encountered in modern manufacturing plants.	**(2M for need)**
	(g)	**Write objective of Data acquisition system.**	**2M**
	Ans:	**Objectives of Data Acquisition System:** • It must monitor the complete plant operation to maintain online optimum and safe operations. • It must provide an effective human communication system and be able to identify problem areas, thereby minimizing unit availability and maximizing unit through point at minimum cost. • It must be able to collect, summarize and store data for diagnosis of operation and record purpose • It must be able to compute unit performance indices using online,real time data. • It must be reliable, and not have a down time greater than 0.1%.	**(Any 2 correct pt. 2M)**

Q. No.	Sub Q. N.	Answers	Marking Scheme
2		**Attempt any THREE of the following:**	**12- Total Marks**

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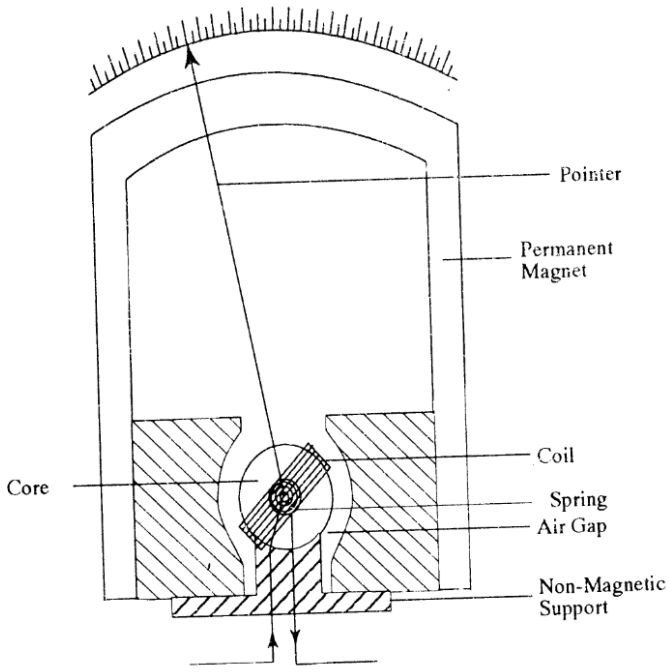
	(a)	**Define any two dynamic characteristics of measurements.**	**4M**
	Ans:	**1. Speed of response:** The rapidity with which instrument responds to make changes in the measured quantity is called as speed of response. **2. Fidelity:** The degree to which instrument indicates the change in measured variable without dynamic error is called as fidelity. **3. Lag:** The retardation on delay in the response of an instrument to make the change in measure quantity is known as lag. **4. Dynamic error:** The difference between the true value of a quantity changing with time and the value indicated by the instrument if no static error is assumed is called as dynamic error.	**(Any 2 correct pt. 2M each)**
	(b)	**Draw PMMC meter movement and describe it.**	**4M**
	Ans:		**2M for labeled diagram**

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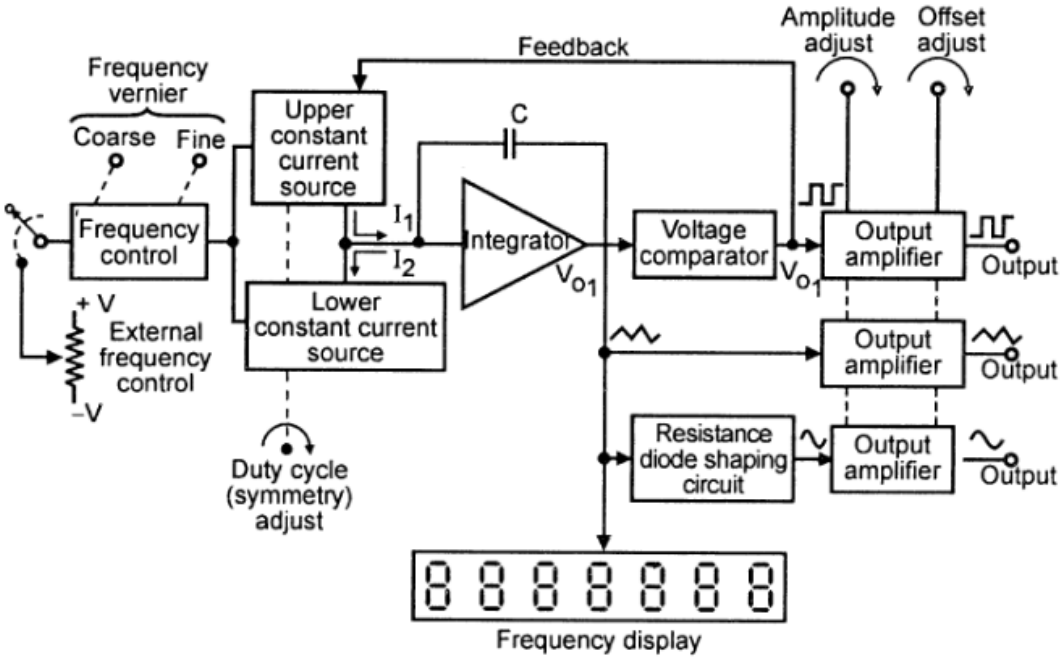
		OR **(Any other relevant diagram shall be considered)** **Working principle of PMMC:** 1. The working principle of PMMC is based on basic meter movement known as D'Arsonval principle stated as when current passes through the coil a deflecting torque is produced due to interaction between magnetic field produced by permanent magnet and magnetic field produced by moving coil. 2. Due to this torque coil deflects and this deflection is proportional to the current flowing through the coil. 3. The pointer attached with coil indicates the magnitude of quantity being measured. 4. Another torque is developed by spring known as controlling torque. This torque helps to stabilize the pointer 5. When controlling torque becomes equal to deflecting torque then pointer attached with scale become stable at equilibrium.	**2M for explanation**
	(c)	**Describe the block diagram of function generator.**	**4M**

Ans:



Block diagram of function Generator

OR

(Any other relevant diagram shall be considered)

02 marks for Diagram

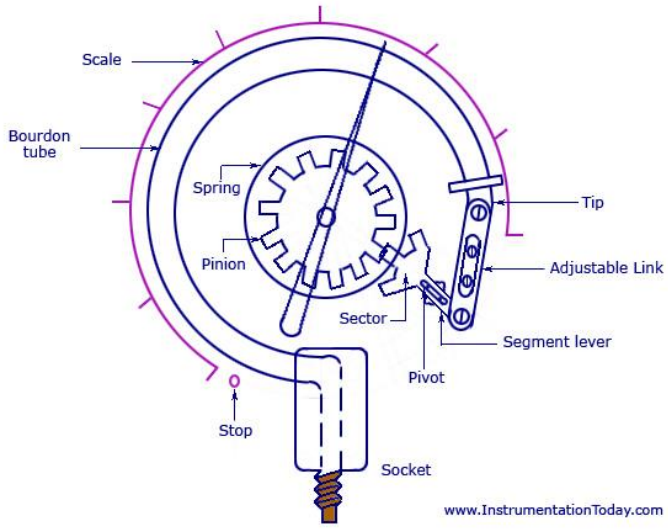
Principle of operation of function generator:

Function generator operates to produce different waveforms such as sine, square, triangular of adjustable frequency which is used to test functionality of various electronic circuits.

This has capability of phase lock with other function generator or to a frequency standard and its output waveforms will have same accuracy and stability as standard source.

02 mark For Explanation

In operation, frequency is controlled by varying the magnitude of current which drives the integrator. The frequency controlled voltage regulates two current sources the upper current source supplies constant current to the integrator whose output voltage increases linearly with time. Voltage comparator multivibrator changes states at a predetermined maximum level of the integrator output voltage. This change cuts off the upper current supply and switch on lower current supply. The lower current source supplies a reverse

		current to integrator so that] its output decreases linearly with time. When output reaches predetermined minimum level, voltage comparator again change state and switch on the upper current source. The output of integrator is triangular waveform whose frequency is determined by the magnitude of current supplied by constant current sources.	
	(d)	**Explain the sketches , the working principle of Bourdon tube.**	**4M**
	Ans:	 Bourdon Tube Pressure Gauge **OR** **(Any other relevant diagram shall be considered)** **Working principle of Bourdon tube:-** • 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.	**2M for correct diagram** **2M for working principle**

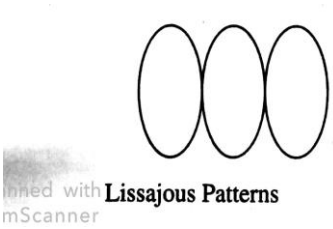
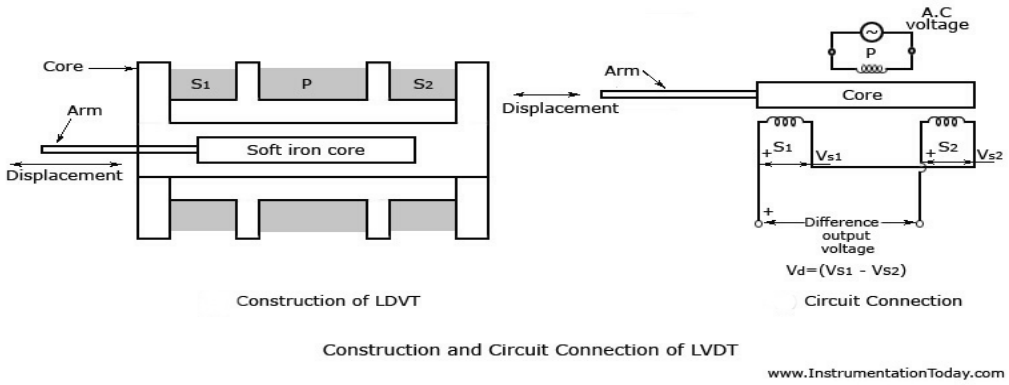
- The cross section view of C type bourdon tube under normal condition and pressurized condition is as shown in figure.
- The pressure which is to be measured is applied to the bourdon tube through open end. When this pressure enters the tube, the tube tends to straighten out proportional to applied 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.

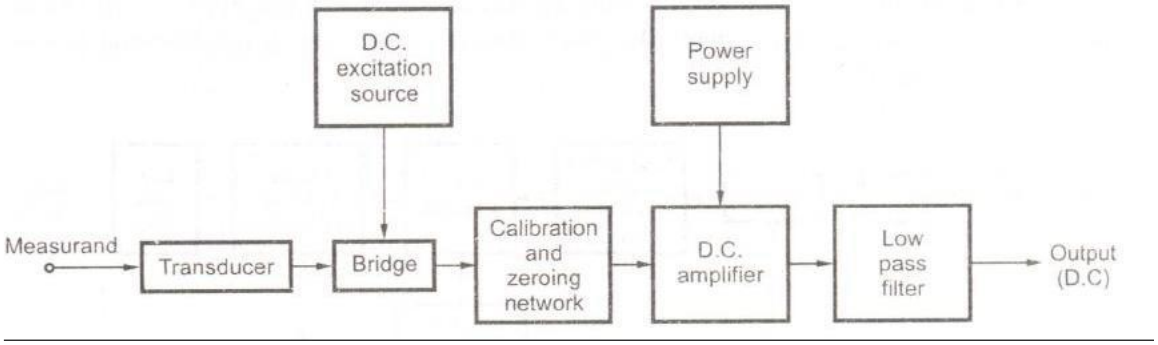
Q. No.	Sub Q. N.	Answers	Marking Scheme
3		**Attempt any THREE of the following :**	**12- Total Marks**
	(a)	**Compare Analog meter and Digital meter.**	**4M**

Ans:

Sr.No.	Parameter	Analog meter	Digital meter
1	Principle	Meter that gives analog output	Meter that gives digital output
2	Accuracy	The accuracy is less	The accuracy is More
3	Resolution	The resolution is less	The resolution is More
4	Power	Requires more power.	Requires less power.
5	Cost	Analog are cheap	Digital meter are expensive.

1M each (any 4 points)

		6	Observational error	Have observational error	No observational error	
		7	Examples	Potentiometer, DC ammeter, PMMC	DMM , DSO	
	(b)	**Calculate the frequency of channel -1 input for an oscilloscope when shows the following Lissajous patterns. Assume the channel – 2 frequency 15kHz.**  Lissajous Patterns				**4M**
	Ans:	**Channel 1 Frequency/ Channel 2 frequency = 3/1** **Channel 1 frequency = 3 * 15khz** **= 45 khz**				**4M**
	(c)	**Sketch and describe the working principle of LVDT.**				**4M**
	Ans:	**Diagram**  **Explaintion:** LVDT is the example of inductive transducer, in LVDT any physical displacement of the core cause the voltage of any secondary winding to increase while simultaneously reducing the voltage in the other secondary winding. The difference of the two voltages appears across the output terminal of the transducer and gives a measurement of the physical position of the core. **Construction of LVDT:**				**2M** **2M**

		A differential transducer consists of a primary winding and two secondary winding. The windings are arranged concentrically and next to each other. They are wound over a narrow bobbin which is usually of a non- magnetic and insulating material. A core in the shape of road is attached to the transducer sensing a shaft. An AC source is applied across the primary winding and core varies the coupling between it and two secondary windings. **.:**E0=E1-E2	
	(d)	**(i) Define signal conditioning system.** **(ii) Draw the circuit diagram of DC signal conditioning circuit.**	**4M**
	Ans:	**(i)** **Signal conditioning** is the manipulation of a **signal in** a way that prepares it for the next stage of processing. Many applications involve environmental or structural measurement, such as temperature and vibration, from sensors. **(ii)** **Circuit** 	**2M** **2M**

Q. No.	Sub Q. N.	Answers	Marking Scheme
4		**Attempt any THREE of the following :**	**12- Total**

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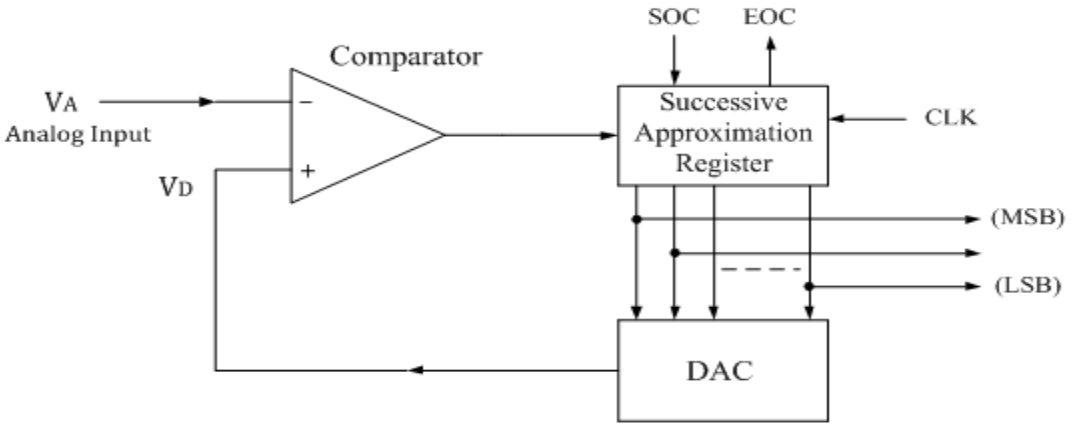
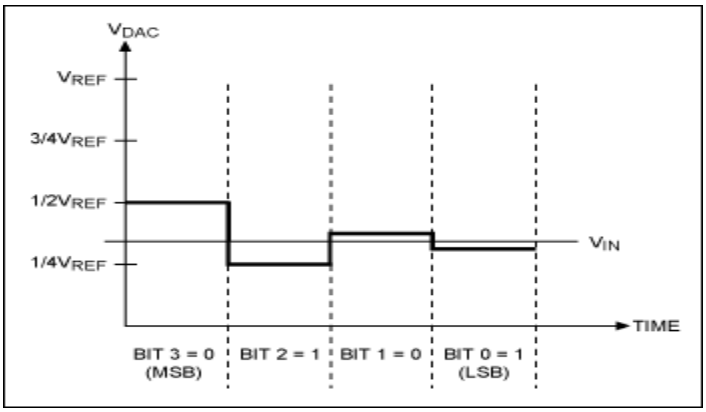
			Marks
	(a)	**Draw the block diagram of successive approximation type ADC.Draw the SAR register waveforms for unknown voltage . V_X = σ volts.**	**4M**
	Ans:	 **Block diagram of successive approximation type ADC** **SAR register waveforms**  **Note: Any relevant waveform must be considered**	**Block Diagram -2M** **Waveform-2M**
	(b)	**A 1 mA meters movement with an internal resistance of 100 Ω is to be converted into a 0-100mA. Calculate the value of shunt resistance required.**	**4M**
	Ans:	Im = 1mA, Rm=100Ω, I= 100mA **Rsh = Im Rm/ (I-Im)** **Rsh = 100/99** **Rsh = 1.01 ohms**	**1 M** **1M** **1M** **1M**

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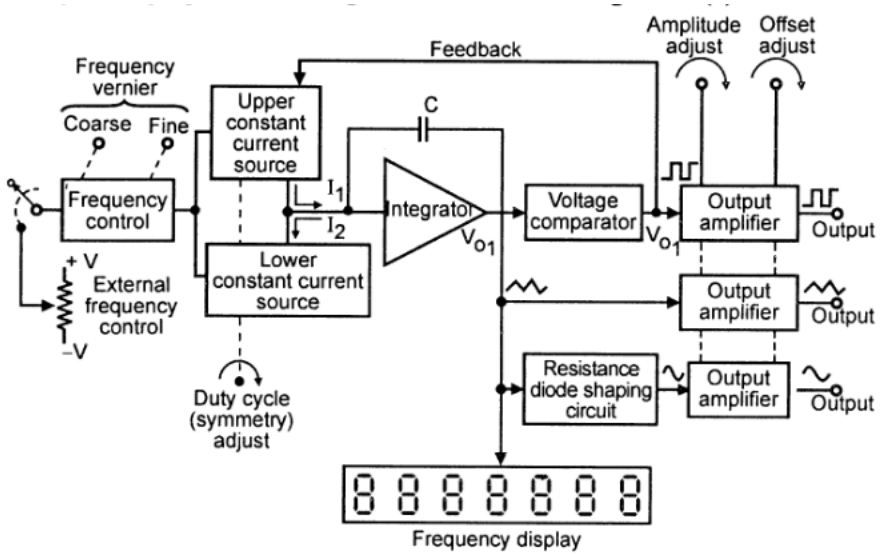
	(c)	**Sketch the block diagram of function generator & describe the circuit of sine wave generation.**	**4M**
	Ans:	**Block Diagram**  . Explanation- For generation of sinewave , out of the three knobs- sine, square and triangular , the sine knob is pressed, output is adjusted for required frequency and amplitude using frequency and amplitude	**3M** **1M**
	(d)	**Compare thermistor and thermocouple.**	**4M**
	Ans:		**1M each (any 4 points)**

Sr.No.	Parameter	Thermistor	Thermocouple
1	Materials	Metal oxides	Two dissimilar metals
2	Response	Nonlinear	Linear

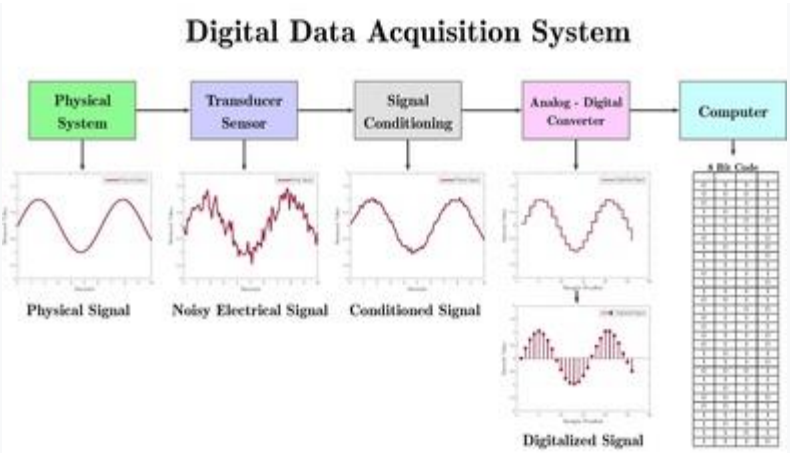
3	Range of temperature	-150^{0}C to 300^{0}C	-200 ^{0}C to 2000 ^{0}C	
4	Size	Small in size	Large as compared to thermistor	
5	Whether active or passive	Passive	**active**	
6	Transduction principle	Resistive transducer	Thermo electric effect	

(e) **Draw and describe general Data acquisition system .** **4M**

Ans: **2M**

Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. Data acquisition systems, abbreviated by the acronyms *DAS* or *DAQ*, typically convert analog waveforms into digital values for processing. The components of data acquisition systems include: Sensors, to convert physical parameters to electrical signals. Signal conditioning circuitry, to convert sensor signals into a form that can be converted to digital values. Analog-to-digital converters, to convert conditioned sensor signals to digital values. Data acquisition applications are usually controlled by software programs developed using various general purpose programming languages

Digital Data Acquisition System Block Diagram **2M**



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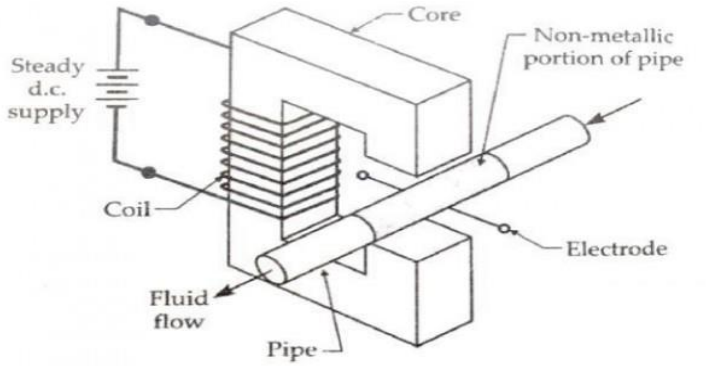
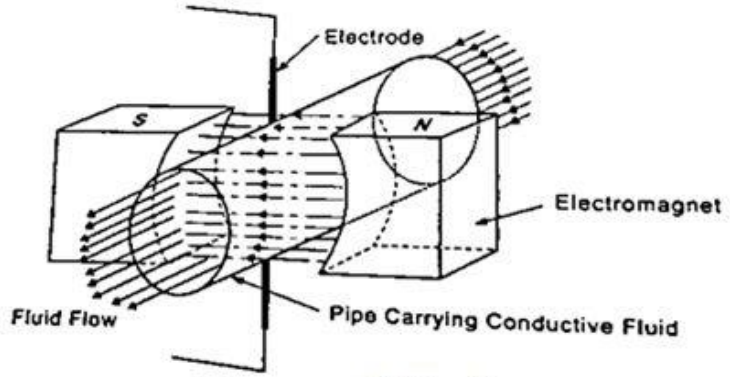
Q. No.	Sub Q. N.	Answers	Marking Scheme
5.		**Attempt any TWO of the following:**	**12- Total Marks**
	(a)	**Describe the need for calibration.**	**6M**
	Ans:	Calibration is defined as the comparison of measured value with standard. Why required? The accuracy of all measuring devices degrade over time. This is typically caused by normal wear and tear. However, changes in accuracy can also be caused by electric or mechanical shock or a hazardous manufacturing environment (e.x., oils, metal chips etc.). Depending on the type of the instrument and the environment in which it is being used, it may degrade very quickly or over a long period of time. The bottom line is that, calibration improves the accuracy of the measuring device. Accurate measuring devices improve product quality. A measuring device should be calibrated: According to recommendation of the manufacturer. After any mechanical or electrical shock. Periodically (annually, quarterly, monthly)	**6M**
	(b)	**Explain the electro-magnetic flow meter with neat sketch and write it's application.**	**6M**
	Ans:	Electromagnetic flow meter: Principle of Operation: 1. The operation of an Electro-magnetic flow meter is based upon Faraday's Law, which states that the voltage induced across any conductor as it moves at right angles through a	(**Principle -1M** **Diagram -2M** **Working**

magnetic field is proportional to the velocity of that conductor.

2. E is proportional to B x L x V where: E = B x L x V E = The voltage generated in a conductor B = The magnetic field strength L = The length of the conductor V = The velocity of the conductor.



OR



Electromagnetic Flow Meter

Construction & Working:

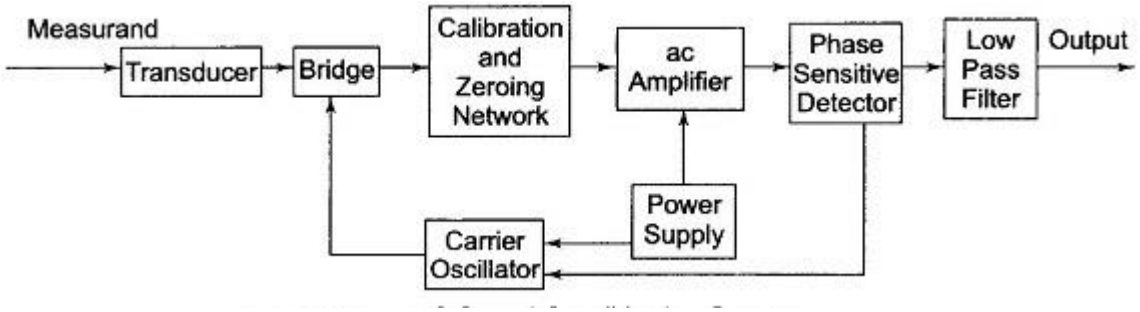
1. It consists of a pair of Electrodes mounted in opposite direction of a non-conducting, non-magnetic pipe carrying liquid whose flow is to be measured.

2. It is surrounded by an electromagnet which produces a magnetic field.

3. The conductive fluid is passed through the pipe.

4. As the fluid passes, its motion relative to field produces an e.m.f. proportional to velocity according to Faradays law.

-2m applicati on -1M)

		5. This output e.m.f. is collected by the electrodes and is given to external circuit. 6. The e.m.f. or voltages produced are small especially at low flow rates. 7. The pipe must be non-conductive, non-magnetic. Application:- • They can usually measure multidirectional flow, either upstream or downstream. • It used for measurement extremely low flow rates. • It can be also used for measurement of flow rate of slurries, greasy materials.	
	(c)	**Describe the circuit diagram of AC signal conditioning.**	**6M**
	Ans:	The block diagram of a.c. signal conditioning system:-  AC signal conditioning system **Working:-** This is carrier type a.c. signal conditioning system. The transducer used is variable resistance or variable inductance transducer. The carrier oscillator generates a carrier signal of the frequency of about 50 Hz to 200 kHz. The carrier frequencies are higher and are at least 5 to 10 times the signal frequencies. The bridge output is amplitude modulated carrier frequency signal. The a.c. amplifier is used to amplify this signal. A separate power supply is required for the a.c. amplifier. The amplified signal is demodulated using phase sensitive demodulator. The advantage of using phase sensitive demodulator is that the polarity of d.c. output indicates the direction of the parameter change in the bridge output. Unless and until spurious and noise signals modulate the carrier, they will not affect the data signal quality and till then are not important. Active filters are used to reject mains frequency pick up. This	Diagram-3M Working -3M

prevents the overloading of a.c. amplifier. Filtering out of carrier frequency components of the data signal is done by phase sensitive demodulator. The applications of such system are in use with variable reactance transducers and for the systems where signals are required to be transmitted through long cables, to connect the transducers to the signal conditioning system.

This type of signal conditioning includes the circuits like sample and hold, multiplexers ,analog to digital converters etc.

Q. No.	Sub Q. N.	Answers	Marking Scheme
6.		**Attempt any TWO of the following :**	**12- Total Marks**
	(a)	**(i) Compare CRO and DSO.** **(ii) State the formula for phase measurement using CRO with necessary diagram.**	**6M**
	Ans:	**(i)**	**(Any Three- 3M)**

CRO	DSO
Directly reads analog voltage and displays it on screen.	It reads the analog voltage and converts it into digital form before being displayed on the screen.
Do not require ADC, microprocessor and acquisition memory	Requires ADC, microprocessor and acquisition memory
Can only analyze signal in real time as there is no storage memory available.	Can analyze signal in real time as well as can analyze previously acquired large samples of data with facility of storage available.
Can not analyze high frequency sharp rise time transients	Can analyze high frequency transients due to advanced DSP algorithms available and ported on microprocessor which can

			operate on stored samples of input voltage.	

(ii)Phase measurement using CRO:

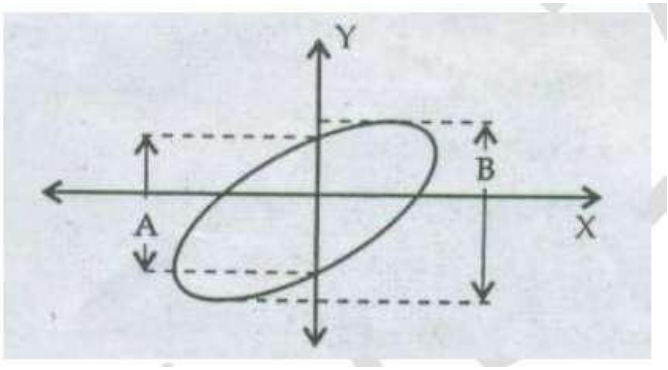
The phase measurement can be done by using Lissajous figures.

The CRO is set to operate in the X- Y mode, then the display obtained on the screen of a CRO is called Lissajous pattern, when two sine waves of the same frequency are applied to the CRO. (One vertical and one horizontal deflection plates). **3M**

Depending on the phase shift between the two signals, the shape of the Lissajous pattern will go on changing.

The phase shift is given by,

Θ = sin-1 (A/B)



A. The Lissajous pattern will be an ellipse if the sine waves of equal frequency but phase shift between 00 and 900 are applied to the two channels of CRO. The Lissajous pattern will be as shown below-

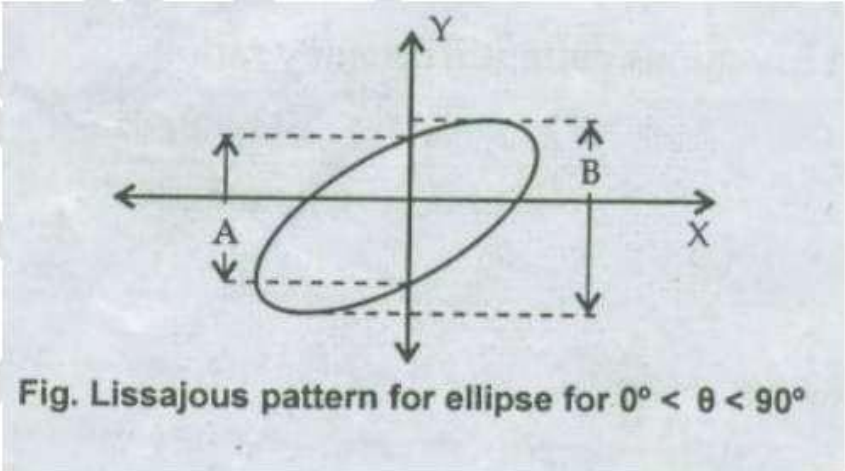
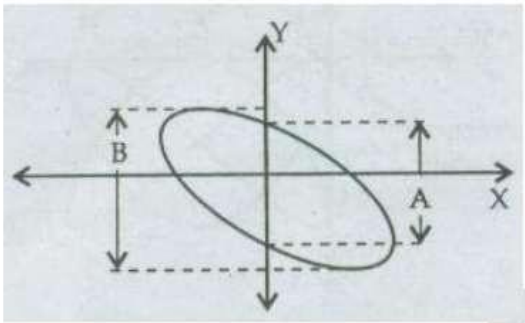
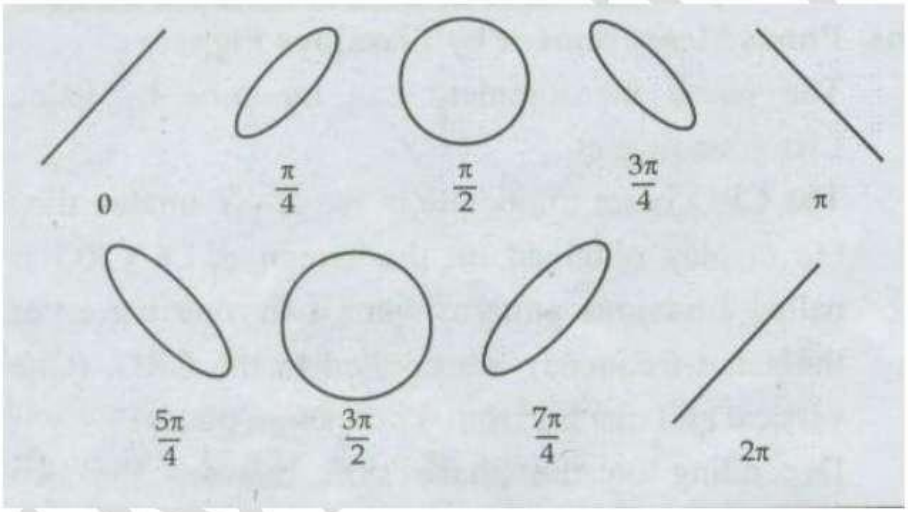


Fig. Lissajous pattern for ellipse for 0° < θ < 90°

B. For the phase difference above 90^0 and less than 180^0, the ellipse appears as shown



C. Different Lissajous figure for phase difference 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0, 315^0, 360^0 are shown below respectively



(b) **(i) Write one example and application of thermal, optical, magnetic and electric sensor.** **6M**

(ii) State four selection criteria of transducer.

Ans: (i)

sensor	examples	application
Thermal Sensor	• Glass thermometer • Bimetallic thermometer • Thermocouples • Thermister • RTD • pyrometers	• The temperature sensors are used in the military/Defence. • It can be used in the home automation systems like air conditioners, refrigerators, microwave Owens • It can also use in the industries like warehouses, mushroom cultivation. • The temperature sensors are used to measure the temperature of the boilers in thermal power plants
Optical sensor	• Photoelectric tachometer • Optical pyrometers • Stroboscope • Photoelectric pressure transducer.	• Speed measurement • Temperature measurement • Pressure measurement. • Optical sensors are integral parts of many common devices, including computers, copy machines (xerox) and light fixtures

Any 1ex-1M

Any 1 app-1M

		that turn on automatically in the dark.
Magnetic sensor	• LVDT • RVDT • Electromagnetic flow meter • Inductive pick-up • Eddy current tachometer.	• Linear and angular displacement measurement • Flow measurement • Speed measurement.
Electric sensors	• Piezo-electric transducer • Resisitive transducer • Thermocouple • Strain gauge	• Pressure measurement • Linear and angular displacement measurement • Speed measurement • Temperature measurement • Strain measurement

(ii) selection criteria of transducer:

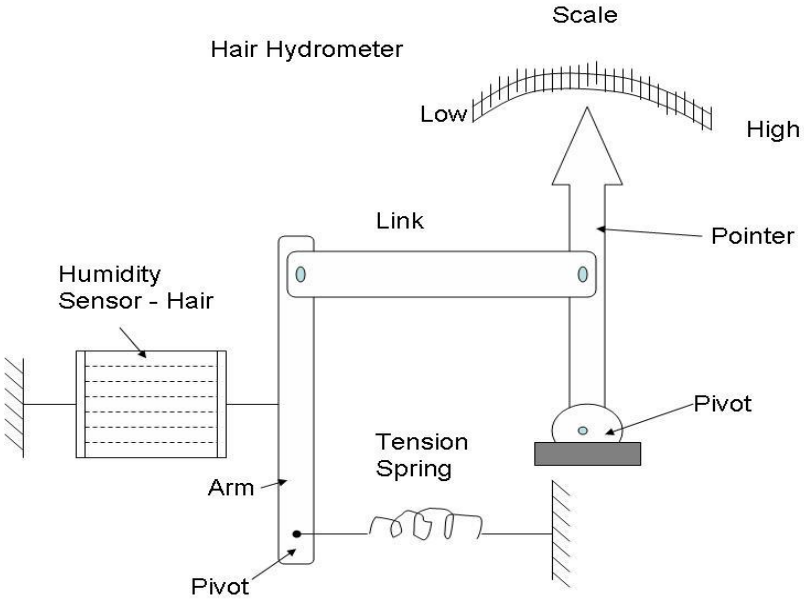
- **Operating Principle :** The transducers are selected on the basis of operating principle it may be resistive, inductive, capacitive, optical etc.
- **Operating range :** The range of transducer should be appropriate for measurement to get a good resolution.
- **Accuracy :** The accuracy should be as high as possible or as per the measurement.
- **Range :** The transducer can give good result within its specified range, so select transducer as per the operating range.
- **Sensitivity :** The transducer should be more sensitive to produce the output or sensitivity should be as per requirement.
- **Loading effect :** The transducer's input impedance should be high and output impedance should be low to avoid loading effect.
- **Errors :** The error produced by the transducer should be low as possible.
- **Environmental compatibility :** The transducer should maintain input and output characteristic for the selected environmental condition.

(Any four- 3M)

OR

1.Operating range

		2. Operating principle 3. Sensitivity 4. Accuracy 5. Frequency response and resonant frequency 6. Errors 7. Environmental compatibility 8. Usage and ruggedness. 9. Electrical aspect. 10. Stability and Reliability 11. Loading effect 12. Static characteristics 13. General selection criteria	
	(c)	**(i) State the principle of Humidity measurement using hygrometer.** **(ii) State the type of humidity measurement and range with it.**	**6M**
	Ans:	**(i) Principle of Hair hygrometer:-** Due to humidity, several materials undergo a change in physical, chemical and electrical properties. This property is used in a transducer designed and calibrated to directly read the relative humidity. Certain hygroscopic materials, such as human hair, animal membranes, wood, paper, etc., undergo changes in the linear dimensions when they absorb moisture from the surrounding air. This change in the linear dimension is used as the measurement of the humidity present in the air. **Construction of Hair hygrometer**	**Diagram -2M** **Working -1m)**



Human hair is used as a humidity sensor. The hair is arranged on a parallel beam and separated from each other to expose them to the surrounding air / atmosphere. Number of hairs are placed in parallel to increase the mechanical strength.

This hair arrangement is placed under a small tension by the use of a tension spring to ensure proper functioning.

The hair arrangement is connected to an arm and a link arrangement and the link is attached to a pointer rotated at one end. The pointer sweeps over a calibrated scale of humidity

Working of hair hygrometer:

When air humidity is to be measured, this air is made to surround the hair arrangement and the hair arrangement absorbs moisture from the surrounding air and expands or contracts in the linear direction.

This expansion or contraction of the hair arrangement moves the arm and the link and, therefore, the pointer to a suitable position on the calibrated scale and, therefore, indicates the humidity present in the air / atmosphere.

Any 3- 3m

(ii) **type of humidity measurement:-**

1.hygrometers:-

- Hair hygrometer
- Sling psychrometer
- Digital hygrometer

		• Dew point hygrometer. 2. Wet bulb and dry bulb thermometer. **Range with it.** • Hair hygrometer-humidity range 20to 90% over the temperature range 5 degree to 40 degree Celsius. • Sling psychrometer –humidity range 0 to 100% RH.	