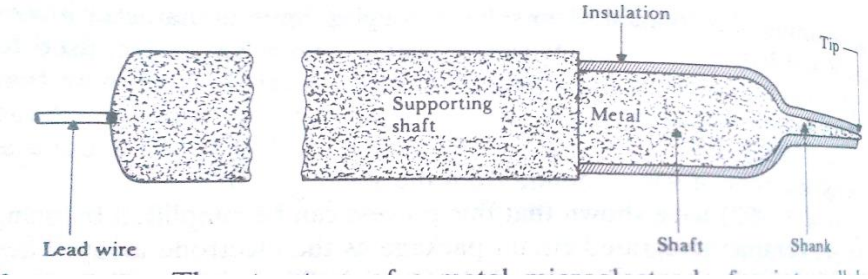
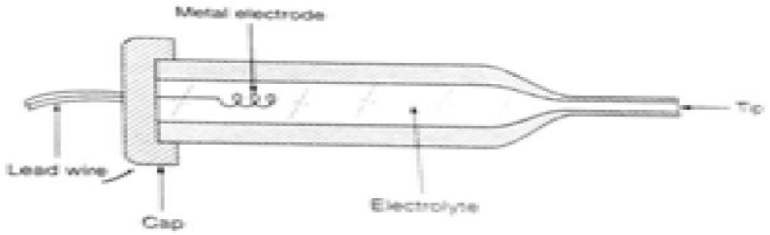
WINTER– 2018 EXAMINATION

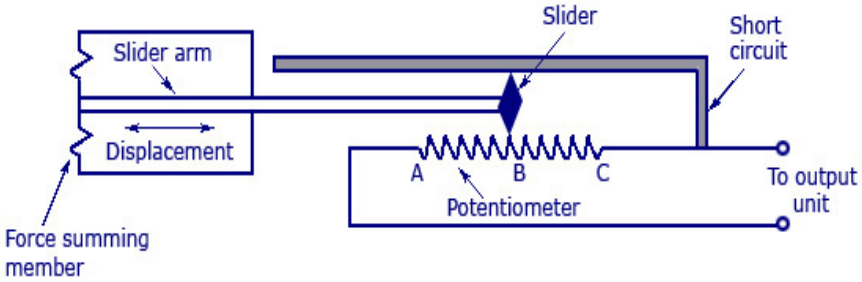
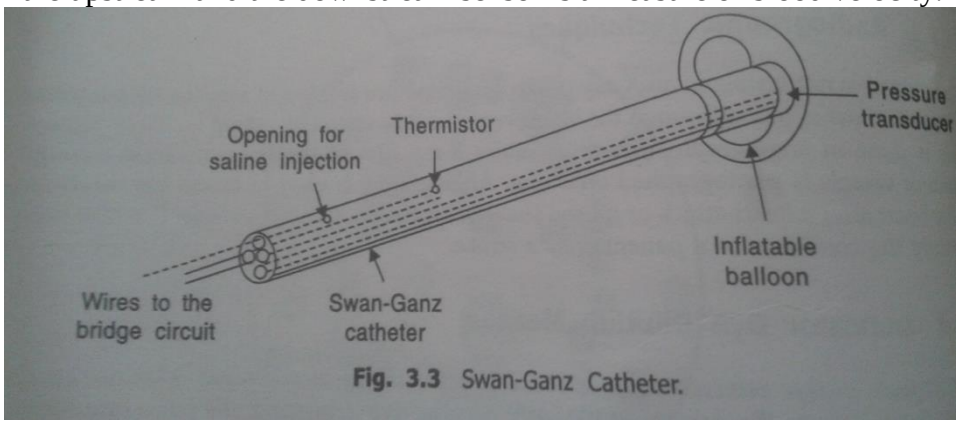
Model Answer **Subject Code:** 22348

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 any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case 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
1.		**Attempt any FIVE of the following:**	**10 M**
	a	**Define transducer and give any one example of it.** **Ans:** **Definition of transducer:** A transducer is a device that converts energy from one form to another. Usually a transducer converts a signal in one form of energy to a signal in another. **Examples of transducer:** 1. Thermocouple 2. RTD 3. Thermistor 4. LVDT 5. Bourdon tube 6. Piezoelectric transducers	**01** **01**
	b	**Define motion artifacts.** **Ans:** **Definition of motion artifacts:** If a pair of electrodes is in an electrolyte and one move while the other remains stationary, a potential difference appears between the two electrodes during this movement. This potential is known as motion artifacts.	**02**
	c	**State chemical equation for PCO_2 electrode.** **Ans:** $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$ **Fig: chemical equation for PCO_2 electrode**	**02**
	d	**State type of material used for making of thermistor.** **Ans:** **Materials used for making Thermistor:** It consists of mixture of oxides eg. Nickel, magnesium, manganese, cobalt, titanium, aluminium.	**02**
	e	**List four types of bourdon tubes used for pressure measurement.** **Ans:** **Types of bourdon tubes:**	

		1. C type bourdon tube. 2. Spiral type bourdon tube. 3. Helical type bourdon tube. 4. Twisted type bourdon tube	**02**
	f	**Define term pH. State range of pH value of normal arterial blood.** **Ans:** **Definition of pH**: The pH value means hydrogen ion concentration in the fluid or liquid. **Range of pH:** The normal arterial blood pH range is between 7.36 and 7.44 ($[H^+]$ between 44 and 36 nEq/L).	**01** **01**
	g	**Explain with sketches the construction of:** **i. Metal electrodes** **ii. Micropipette** **Ans:** **Metal electrodes:** Metallic electrode is formed from a fine needle of a suitable metal drawn to a fine tip. The metal microelectrodes are used in direct contact with the biological tissue and, therefore have a lower resistance. They polarize with smaller amplifier input currents. Hence they tend to develop unstable electrode offset potential and are therefore not preferred for steady state potential measurements.  **Fig: Metal electrode** **Micropipette:** These are drawn from Pyrex glass of special grade. The microcapollaries are usually filled with an electrolyte. These electrodes have improved stability can be obtained by properly choosing able to modify the electrical properties of the electrodes. The glass microelectrode has a substantial current carrying capacity because of the large surface contact area between the metal and electrolyte.  **Fig: Micropipette**	**1/2** **1/2** **1/2** **1/2**
2.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Describe with sketches construction and working of linear potentiometer.** **Ans:** **Construction and working of linear potentiometer:** A linear potentiometer consists of a potentiometer, which is short circuited by a slider. The other end of the slider is connected to a slider arm. The force summing device on the slider arm causes linear displacement of the slider causing the short circuit of a certain portion of the resistance in the potentiometer. Let the whole resistance	**02**

		positions on the potentiometer be ABC. Let the resistance position caused by the slider movement be BC. As the movement of the slider moves further to the right, the amount of resistance increases. This increase in resistance value can be noted according to the corresponding change in the linear displacement of the slider. The change in resistance can be calculated with the help of a Wheatstone bridge. Another easy method than calculating the resistance with the help of a bridge connection is to connect a constant current source in series with the potentiometer. Thus a voltage will be developed. This voltage can be measured and hence the resistance, R = V/I.  Linear Potentiometer **Fig: Linear potentiometer**	**02**
	b	**List advantages of optical fiber sensors.** **Ans:** **Advantages of optical fiber sensors:** 1. They are immune from crosstalk. 2. Optical fiber sensors are non-electrical and hence free from electrical interference. 3. There is high degree of mechanical flexibility. 4. The cost is low enough to make the sensors disposable for many applications.	**04**
	c	**Explain with sketch the flow measurement by thermal convection.** **Ans:** **The flow measurement by thermal convection:** Thermal velocity sensors depend on convective cooling of a heated sensor and are therefore sensitive only to local velocity. A hot object in colder-flowing medium is cooled by thermal convection. The rate of cooling is proportional to the rate of the flow of the medium. This principal is often used for measurement of blood velocity. In one of the method an electric heater is placed between two thermocouples or thermistors that are located some distance apart along the axis of the vessel. The temperature difference between the upstream and the downstream sensor is a measure of blood velocity.  Fig. 3.3 Swan-Ganz Catheter. **Fig: Thermal convection**	**02** **02**

	d	**Explain with sketch block diagram of Man Instrumentation System (MIS).** **Ans:**	

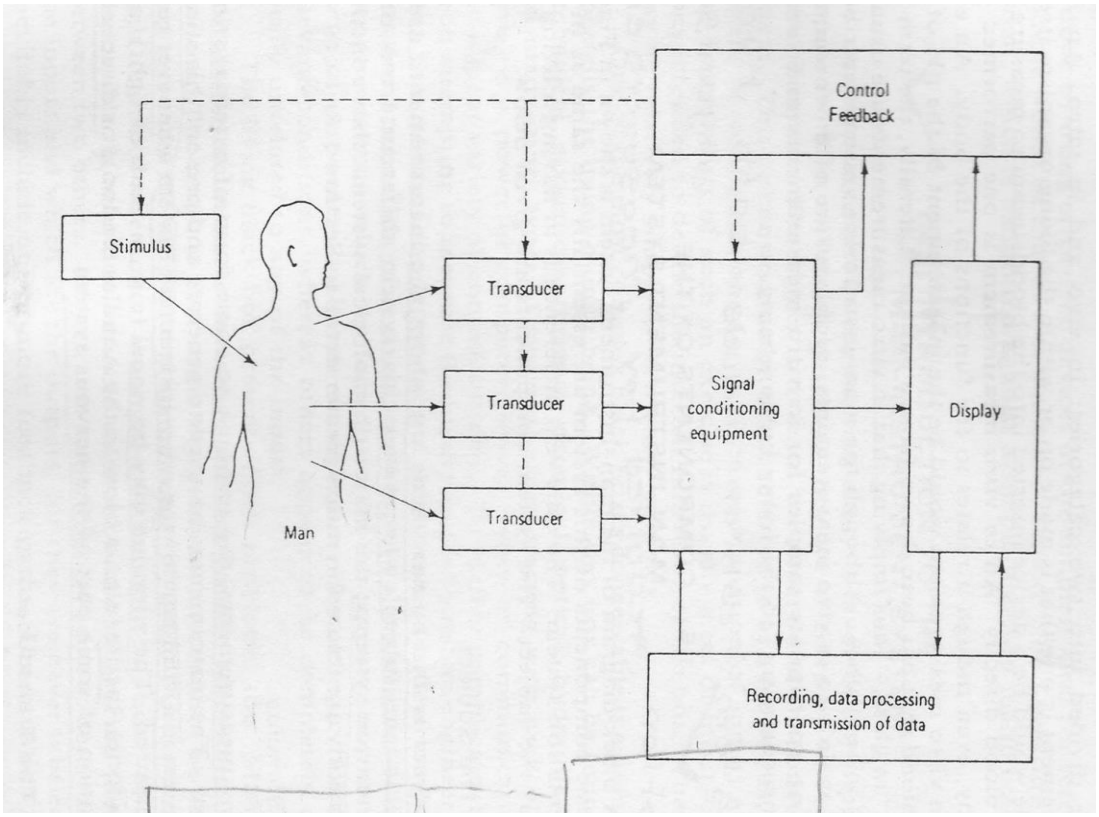


Fig: Man Instrumentation System

The subject: The subject is human being on whom the measurements are made.

Stimulus: The instrument used to generate and present this stimulus to the subject is a vital part of man – instrument system when responses are measured. Stimulus may be visual (e. g. flash of light), auditory (e.g. a tone), tactile (e.g. a blow to the Achilles tendon) or direct electrical stimulation of some part of nervous system.

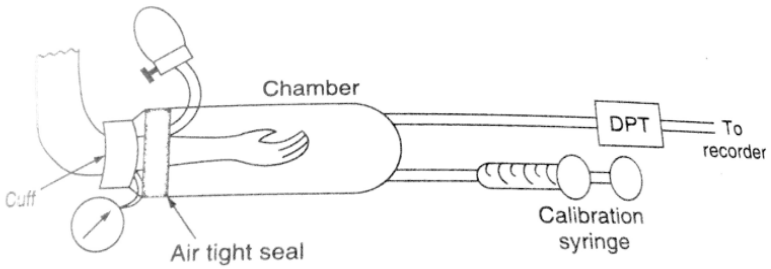
The Transducer: A device capable of converting one form of energy or signal to another. Here each transducer is used to produce an electrical signal that is analog of the phenomenon. Transducer may measure temperature, pressure, flow or any other variables found in body. **02**

Signal condition equipment: The part of instrumentation system that amplifies modifies or in any other way changes the electric output of transducer is called signal conditioning Equipment. It also combines or relates the output of two or more transducers output signal is greatly modified with respect to the input. **02**

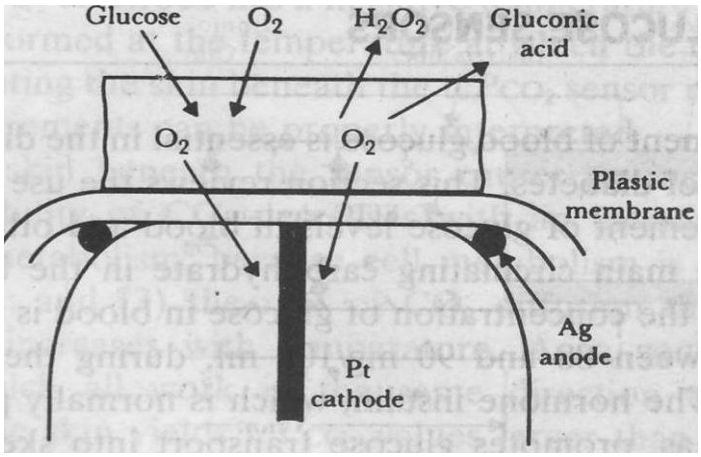
Display Equipment: Electric output of signal conditioning equipment must be converted into a form that can be perceived by one of man's senses and can convey information. Obtained by measurement in meaningful way. Input to display device is modified electric signal and its output is some is form of visual, audible or possible tactile information here display equipment may include graphic pen recorder.

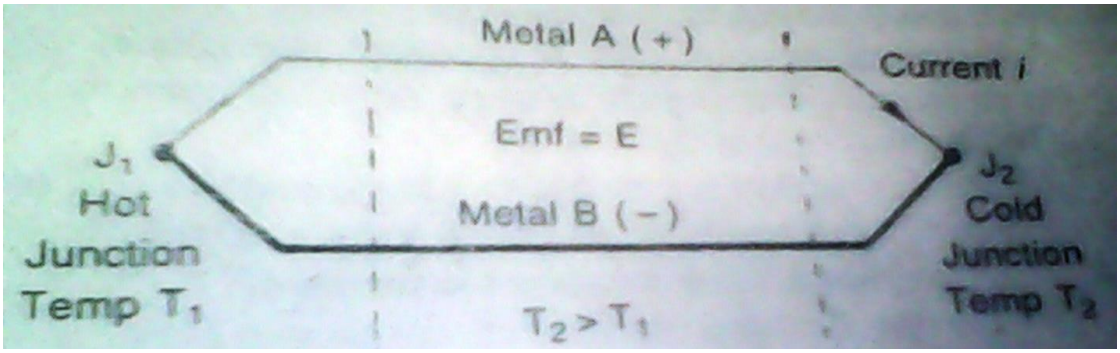
Recording Data: Processing & Transmission equipment - It is often necessary to record the measured information for possible latter use or to transmit it from one location to another on-line digital computer may be part of this system where automatic storage or processing data is required.

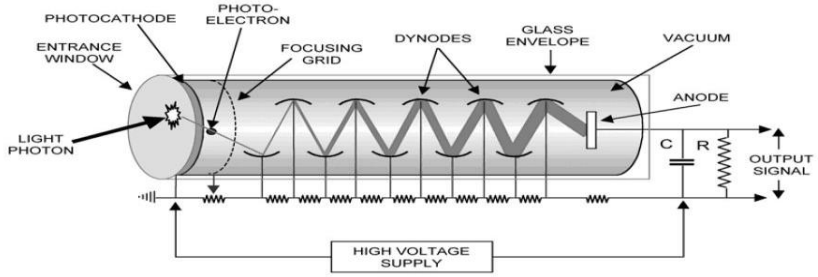
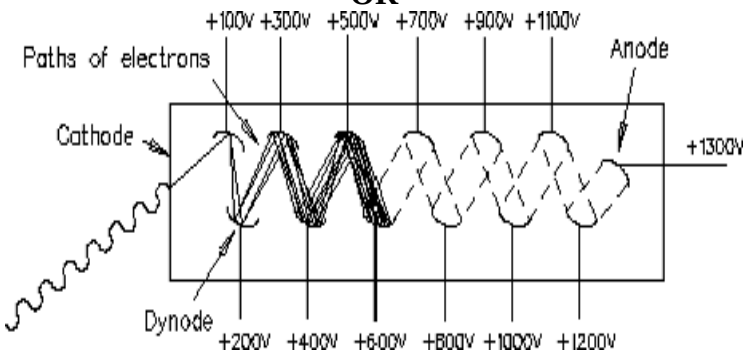
Control devices: A control system is incorporated where it is necessary or desirable to have automatic control of stimulus, transducers or any other part of man instrument system.

3.		**Attempt any THREE of the following:**	**12 M**
	a	**State different units of temperature. A Platinum RTD has resistance of 100 Ω at 30°C. Find its resistance at 50°C the resistance temperature coefficient of platinum is 0.00392 per degree.** **Ans:** **Units of temperature:** Fahrenheit (˚F), Centigrade (˚C), Kelvin (˚K), Rankine (˚R). **Solution**: Using the linear approximation , the resistance at any temperature Θ°C is **$R_t = R_o (1 + \alpha \Delta t)$** Given , Resistance at 50°C is , R50 =100 [1 + 0.00392 (50 - 30)] R50 =100 [1 + 0.00392 (20)] R50 =100 [1 + 0.0784] R50 =100 [1.0784] **R50 = 107.84 Ω**	**02** **02**
	b	**Explain meaning of plethysmograph. Draw any instrument used to measure blood volume in human body.** **Ans:** **Plethysmograph:** The measurement of blood flow is the measurement of volume changes in any part of the body that results from pulsation of blood occurring with each heartbeat. Such measurements are useful in the diagnosis of arterial obstruction as well as for pulse wave velocity measurement. Instruments measuring volume changes or providing outputs that can be related to them are called plethysmograph and the measurement of these volume changes is called as plethysmography.  Figure 5.34 Plethysmograph. **Fig: Plethysmograph**	**02** **02**
	c	**Compare active and passive transducers.** **Ans:** **Table: Compare active and passive transducers**	**04**

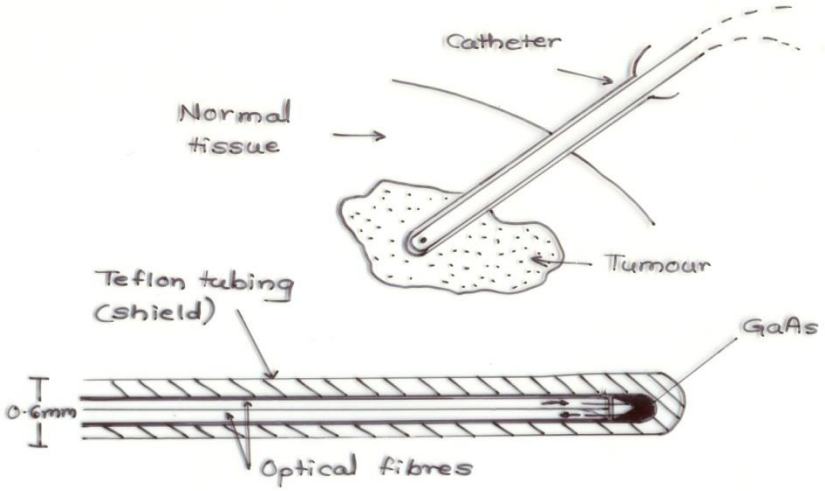
Active transducer	Passive Transducer
Transducer that converts one form of energy directly into another that is it does not require external power supply.	The transducer which requires energy to be put it in order to translate changes due to measured. It requires external power supply.
It is self-generating transducer	It is not self-generating transducer
Eg. Photovoltaic cell, thermocouple etc.	Eg: LVDT, Strain gauge.
These transducers develop their own voltage and current.	These transducers are not develops their own voltage and current.

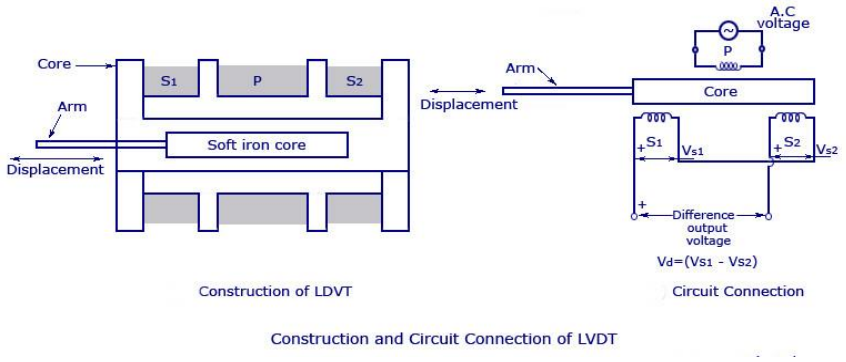
	d	**Explain following transducers.** **i. Capacitive transducers** **ii. Piezoelectric transducers** **Ans:** **Capacitive transducers:** A capacitance transducer, the variable to measure is converted into change in capacitance. A capacitor basically consist of two conductor (two plates) separated by dielectric medium (insulator).The variable to be measured will cause an effect either by increasing the distance between two plates or by changing the dielectric constant. Capacitance of parallel plate capacitor whose plates are displaced by a distance d is given as $C = \varepsilon_0 \varepsilon_r A/d$ Where A is the area of cross-section of the plates, ε_0 ε_r are absolute an relative dielectric constant of the medium respectively **Piezoelectric transducers:** Asymmetrical crystalline materials such as: Quartz, Rochelle salt, Barium Titanate and PZT (Lead Zirconate Titanate) produce an EMF when they are placed under stress. This property is used in piezoelectric transducers where a crystal is placed between a solid base and force summing member. When an external force appears on the top the crystal, it produces an EMF across the crystal, which is proportional to the magnitude of the applied pressure. This is self-generating type of transducer.	**02** **02**
4.		**Attempt any <u>THREE</u> of the following:**	**12 M**
	a	**Explain with sketches operating principle of blood glucose sensor.** **Ans:**  **Fig: Blood glucose sensor** The principle behind glucose meter is based on reaction that are analyses by electro chemical sensor on strip there are layer plastic base plate of other layer containing chemical. There is layer containing two electrode silicon or other similar metal there is also layer of immobilize enzyme glucose oxides and other layer containing micro crystalline potation terrycynide specifically the reaction of interested is between glucose and glucose oxides the glucose in blood sample react with the glucose oxides to form gluconic acid which then react with terrycynide.	**02** **02**
	b	**Classify the given transducers as a primary transducers or secondary transducers.** **1. LVDT** **2. Strain gauge** **3. RTD** **4. Bourdon tube.**	

		Ans: **LVDT:** Secondary Transducer **Strain gauge:** Primary Transducer **RTD:** Primary Transducer **Bourdon tube:** Primary Transducer	 **01** **01** **01** **01**
	c	**Explain with sketches the construction of thermocouple and its principle of working.** **Ans:**  **Fig: Thermocouple** **Construction and principle working of thermocouple:** The working of the thermocouple is based on the seebeck effect. When the heat is applied to junction (hot junction) of two dissimilar metals, an emf is generated which can measured at the other junction (cold junction). The two dissimilar metals form an electric circuit, and current flows as a result of the generated emf. This current will continue to flow as long as $T_1 > T_2$. Metal B is describe as negative with respect to a metal A if current flows into it at the cold junction. The emf produces is function of the difference in temperature of hot and cold junctions	**02** **02**
	d	**Parameter or measuring technique with their measuring range has been given bellow. Suggest standard sensor used for measurement.** **i. Blood pressure arterial direct range (10 -100 mm) Hg.** **ii. PO_2 range (30-100 mm Hg)** **iii. Blood flow range (1- 300 ml/s)** **iv. Electromyograph (0.1- 5 mv) (EMG)** **Ans:** i. **Blood pressure arterial direct range (10-100mmHg):** Strain gauge manometer. ii. **PO_2 range (30-100 mm Hg):** Specific electrode volumetric or manometric (PO_2 electrode volumetric or manometric) iii. **Blood flow range (1- 300 ml/s):** Flow meter electrometric or Ultrasound. iv. **Electromyograph (0.1- 5 mv) (EMG):** Needle electrode	 **01** **01** **01** **01**
5.		**Attempt any <u>TWO</u> of the following:**	**12 M**
	a	**With help of neat diagram give constructional details of photomultiplier tube and describe it working.** **Ans:** **Construction of photomultiplier tube:** The entire assembly of the photomultiplier is housed inside a high vacuum tube. The photocathode material can be chosen to optimize the photomultiplier for a particular region of the electromagnetic spectrum. Any metal will exhibit some photoelectric properties - however, the materials most commonly used for photocathodes are alloys of alkali metals, or compound semiconductors, which tend to have a very low work function. Popular materials include S-20 Multialkali (alloy of sodium, potassium,	**02**

		antimony and caesium), and indium gallium phosphide (InGaAs). **Working of photomultiplier tube:** Photomultiplier tubes operate using photoelectric effect and secondary emission. When light is incident on the photocathode, it emits electrons into the vacuum tube. These electrons are focused towards the electron multipliers (dynodes), which multiply the signal by secondary emission. These multiplied electrons are converted into an output signal by the anode.	**02**
		 **Fig: Photomultiplier tube**	**02**
		OR  **Fig: Photomultiplier tube**	
	b	**Explain the basic operation of:** **i. Electromagnetic blood flow measurement.** **ii. Ultrasonic blood flow measurement.** **Ans:** **Electromagnetic blood flow measurement:** The electromagnetic flow meter measures instantaneous pulsatile flow of blood. It operates with any conductive liquid, such as saline or blood. The meter is placed such that the part of body through which the blood is to be determines like limb is subjected to the electric field. The flow meter depends on the movement of blood, which has a conductance similar to that of saline. Faraday's law of induction gives the formula for the induced emf. When blood flows in the vessel with velocity u and passes through the magnetic field B, the induced emf e is measured at the electrodes.	**03**
		Ultrasonic blood flow measurement: In ultrasound blood flow meter a beam of ultrasonic energy is used to measure velocity of flowing blood. This can be done in two ways. In transit time ultrasonic flow meter pulsed beam is directed to a blood vessel through a shallow angle and it's transmit time is measured. When blood flow in the direction of energy transmission the transmit time is shorted. If it flows in opposite direction the transmit time will be lengthen. The ultrasonic flow meter based on Doppler principle and oscillator operating at frequency of several MHz excites piezoelectric transducer. This transducer is coupled through a wall of exposed blood vessels and sends the ultrasonic beam with frequency floating through blood. Small part of transmitted energy is scattered back and is received by second	**03**

		transducer arranged opposite to first one. Because the scattering occurs mainly as a result of moving blood cells, reflected signal has a different frequency due to Doppler Effect. This frequency is $f + f_d$ or $f - f_d$ depending on the direction of flow. The Doppler component f_d proportional to the velocity of flowing blood.	
	c	**Explain concept of:** **i. Carbon nanotube as biosensors** **ii. Electrodes for EEG and EMG.** **Ans:** **Carbon nanotube as biosensors:** Carbon nanotubes are allotropes of carbon with a cylindrical nanostructure. Nanotubes are members of the fullerene structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene. Nanotubes are categorized as single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs). Single-walled nanotube (SWNT) within a larger single-walled nanotube. Multi-walled nanotubes (MWNTs) consist of multiple rolled layers (concentric tubes) of graphene. In the medical diagnostics arena, nanotechnology-based biosensors could be used, for example, to replace more costly and tedious laboratory methods for monitoring a patient's blood for proteins, chemicals, and pathogens. Our goal is to build an interdisciplinary team based on the expertise developed on carbon nanotubes, to develop novel, rapid-response biochemical sensors selective for targeted chemical and biological molecules. MWNTs and Ta substrates can be easily attached to the surface of a planar electrode using conductive silver paint as a biosensing electrode. Firstly, these MWNTs have a high electrochemically accessible surface area, high electrical conductivity, and useful mechanical properties for developing electrochemical sensors in selectively detecting uric acid (UA) in the presence of L-ascorbic acid (L-AA). Secondly, MWNTs can be used as a nonenzymatic sensor to detect glucose with high sensitivity and stability in alkaline medium. Thirdly, we have successfully constructed a hemin-modified MWNT electrode in the development of a novel oxygen sensor for working at a relatively low potential. **Electrodes for EEG:** **Disposable EEG electrodes:** are widely used, since they can be quickly and easily applied. These electrodes are connected by snapping them onto a "lead" cable or wire that connects to a recording machine. **Reusable EEG electrodes:** are not as large as the disposables, and this gives them an advantage in that they are able to be placed closer to the skin in areas with a lot of hair. They are used with headbands or caps, and they need to be cleaned carefully after each use. **Needle EEG electrode:** is in the form of a needle that punctures the skin, called a subdermal needle. These EEG electrodes can be either disposable or reusable. **Electrodes for EMG:** **Surface EMG electrode:** Provide a non-invasive technique for measurement and detection of EMG signal. These electrodes are simple and very easy to implement. Surface EMG electrodes have found their use in neuromuscular recordings, sports medical evaluations. **Needle EMG electrode:** are widely used in clinical procedures in neuromuscular evaluations. The tip of the needle electrode is bare and used as a detection surface. It contains an insulated wire in the cannula. **Fine wire EMG electrode:** Wire electrodes are made from any small diameter, highly oxidizing and stiff wire with insulation. Alloys of platinum, silver, nickel and chromium are typically used. They are less painful than needle electrodes.	**03** **1/2** **1/2** **1/2** **1/2** **1/2** **1/2**

6.		**Attempt any TWO of the following:**	**12 M**
	a	**Explain principle of optical temperature sensor based on variation of refractive index with temperature. Give range of temperatures (hyper thermia) normally used for cancer treatment.** **Ans:** **Optical temperature sensor:** The figure shows GaAs semiconductor temperature probe. Small prism shape sample of single crystal Undoped GaAs is epoxide at the end of two side by side optical fibers. The sensors of fibers are quite small and compatible with biological implementation been sheathed. One fiber transmits light from a LED source where it is passed through GaAs and collected by other fiber for detection in the read out. Some of the optical power travelling through semiconductor is absorbed by the process raising valance band electron across forbidden energy gap into the conduction band because the forbidden energy gap is a sensitive material for temperature. Amount of power absorbed is increased with temperature. This nonmetallic probe is particularly suitable for temperature measurement in the strong electromagnetic heating field used in heating tissue for cancer therapy. Single sensor probe with an outer diameter of 0.6 mm and 4 point temperature sensor probe of 1.1 mm diameter based on this technique are commercially available  **Fig: Optical temperature sensor** **Range of temperatures (hyper thermia) normally used for cancer treatment:** Hyperthermia (also called thermal therapy or thermotherapy) is a type of cancer treatment in which body tissue is exposed to high temperatures (up to **113°F**).	**02** **02** **02**
	b	**Explain term Bio MEMS. List applications of Bio MEMS.** **Ans:** Bio-MEMS mean biomedical or biological microelectromechanical systems. Bio-MEMS have considerable overlap, and are sometimes considered synonymous, with lab-on-a-chip (LOC) and micro total analysis systems (μTAS). Bio-MEMS are typically more focused on mechanical parts and microfabrication technologies made suitable for biological applications. Lab-on-a-chip is concerned with miniaturization and integration of laboratory processes and experiments into single (often microfluidic) chips. In this definition, lab-on-a-chip devices do not strictly have biological applications, although most do or are amendable to be adapted for biological purposes. Similarly, micro total analysis systems may not have biological applications in mind, and are usually dedicated to chemical analysis.	**02**

		Applications of Bio MEMS: (Any four) 1. Proteomics 2. Genomics 3. Molecular diagnostics 4. Tissue engineering 5. Single cell analysis and implantable microdevices. 6. Surgical microsystems (intelligent micro-invasive surgical tools) 7. Diagnostic microsystems (biochips and related microinstrumentation) 8. Therapeutic microsystems (health care management systems). 9. MEMS in precision surgery-ophthalmology 10. MEMS in biomolecular recognition 11. MEMS in autonomous therapy management systems 12. Micropumps for drug delivery.	**04**
	c	**For arterial pressure measurement LVDT is used. Describe bias working of LVDT along with neat sketch.** **Ans:**  Construction and Circuit Connection of LVDT **Fig: LVDT** As shown in the figure above, an AC voltage with a frequency between (50-400Hz) is supplied to the primary winding. Thus, two voltages VS1 and VS2 are obtained at the two secondary windings S1 and S2 respectively. The output voltage will be the difference between the two voltages (VS1-VS2) as they are combined in series. Let us consider three different positions of the soft iron core inside the former. **Null Position**: This is also called the central position as the soft iron core will remain in the exact center of the former. Thus the linking magnetic flux produced in the two secondary windings will be equal. The voltage induced because of them will also be equal. Thus the resulting voltage VS1-VS2 = 0. **Right of Null Position**: In this position, the linking flux at the winding S2 has a value more than the linking flux at the winding S1. Thus, the resulting voltage VS1-VS2 will be in phase with VS2. **Left of Null Position**: In this position, the linking flux at the winding S2 has a value less than the linking flux at the winding S1. Thus, the resulting voltage VS1-VS2 will be in phase with VS1. From the working it is clear that the difference in voltage, VS1-VS2 will depend on the right or left shift of the core from the null position. Also, the resulting voltage is in phase with the primary winding voltage for the change of the arm in one direction, and is 180 degrees out of phase for the change of the arm position in the other direction. The magnitude and displacement can be easily calculated or plotted by calculating the magnitude and phase of the resulting voltage.	**03** **03**