**Winter– 15 EXAMINATION**

Subject Code: **17442** **Model Answer** Page No: 01_/20

**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.

**WINTER – 15 EXAMINATION**

Subject Code: **17442** **Model Answer** 

**Q. 1 a) Attempt Any Six of the Following.** **(12)**

**i) Define biometrics. List any two biosensors. (01 mark for definition 01 mark for list)**

**Ans:** Biometrics: The branch of science that includes the measurement of physiological variables and parameters is known as biometrics.

Eg. 1. PH Electrode
2. Thermister.
3. Resistance Temperature Detector
4. Thermocouple.
5. Bourdon tube (or any other sensors related to temperature, flow, pressure)

**ii) State any four sources of biomedical signals (1/2 mark for each group)**

**Ans:** 1) ECG: The bio potentials generated by the muscles of the heart result in ECG

2) EEG: It is bioelectric potential generated by the neuronal activity of the brain.

3) EMG: It is bioelectric potential associated with muscle activity constitute the EMG.

4) ERG: A record of the complex pattern of bioelectric potential obtained from the retina of the eye.

**iii) Draw diagram of plethesomography and label it.(02 mark for diagram)**

**Ans:**

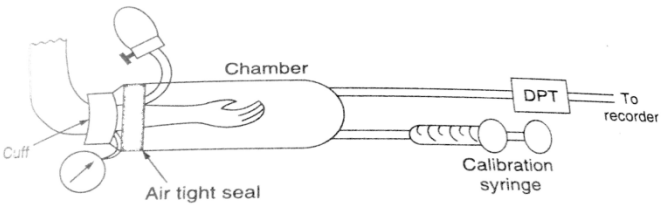



**Figure 5.34** Plethysmograph.

**iv) Define 1) Active transducer 2) Passive transducer. (01 mark each)**

**Ans**:1) Active transducer: Transducer that converts one form of energy directly into another that is it does not require external power supply is called active transducer . It is self generating transducer.

2) Passive transducer: The transducer which requires energy to be put it in order to translate changes due to measurand is called passive transducer .It requires external power supply.

**v) Define PH and state formula for measurement of PH. (1 mark for each.)**

**Ans**: Defination: The PH value means hydrogen ion concentration in the fluid or liquid.

Formula $PH= -\log_{10}[H+]=\log_{10}1/[H+]$.

**vi) Prepare a list of any four Biopotential electrode. (1/2 Mark for each)**

**Ans:** 1) Microelectrodes

2) Skin surface Electrode.

3) Needle Electrode.

4) Disposable Electrode

**vii) State any two materials used for the construction of 1)thermistor 2)RTD (01 Mark each)**

**Ans**: 1) Thermister: It consist of mixture of oxides eg. Nickel, , magnesium,mangnise,cobalt,titanium,aluminium.

2) RTD: platinum, nickel, and copper; platinum being the most commonly used.

viii) **State the see back effect**.(02 marks)

**Ans:** The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances.

**b) Attempt any <u>TWO</u> of the following. (08 marks)**

**i) Define**

**1) Accuracy**

**2) Precision**

**3) Error**

**4) Repeatability**

**(01 mark for each definition)**

**Ans:** 1) Accuracy: Accuracy refers to the closeness of a measured value to a standard or known value.

2) Precision: The precision of a measurement system, related to reproducibility and repeatability, is the degree to which repeated measurements under unchanged conditions show the same results)

3) Error: A measure of the estimated difference between the observed or calculated value of a quantity and its true value.

4) Repeatability: Reproducibility/ Repeatability is the degree to which an experiment or study can be accurately reproduced, or replicated, by someone else working independently, and is one of the main principles of the scientific method.

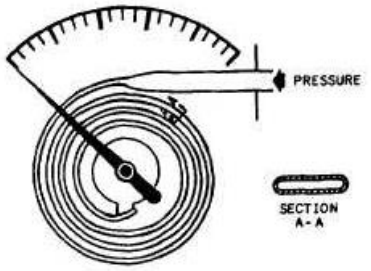
**ii) Prepare a list of types of bourdon tube and describe any one type in detail with neat sketch. (02 marks for list 02 marks for description)**

**Ans: 1)** spiral

2) C type

3) Helical

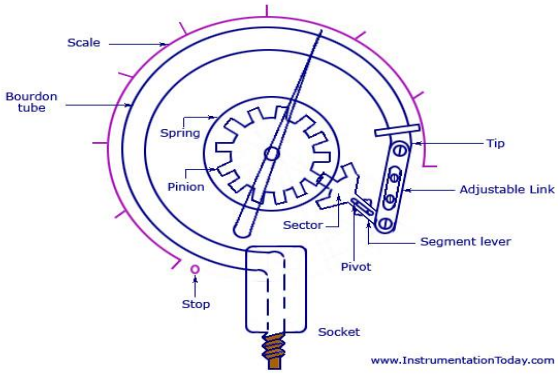
**1)** Spiral: Spiral type bourdon tubes are constructed by winding the long tube into several turns in the form spiral shape. One end of the bourdon tube is opened through which the pressure to be measured is applied whereas another end is closed. The sealed end of the bourdon tube is mechanically connected to a pointer .Whenever the fluid whose pressure is to be known is applied to the open end of the spiral tube, it tends to uncoil. Due to this a long movement of the tip (end) takes place and this displacement is transmitted to pointer. Therefore the pointer moves on the calibrated scale, thereby indicating the applied pressure. When compared to C-type bourdon tube spiral type bourdon tube produces the results with very high accuracy.




**2. C type Burdon tube:** As seen in the figure, the pressure input is given to a socket which is soldered to the tube at the base. The other end or free end of the device is sealed by a tip. This tip is connected to a segmental lever through an adjustable length link. The lever length may also be adjustable. The segmental lever is suitably pivoted and the spindle holds the pointer as shown in the figure.A hair spring is sometimes used to fasten the spindle of the frame of the instrument to provide necessary tension for proper meshing of the gear teeth and thereby freeing the system from the backlash.Any error due to friction in the spindle bearings is known as lost motion. The mechanical construction has to be highly accurate in the case of a Bourdon Tube Gauge.

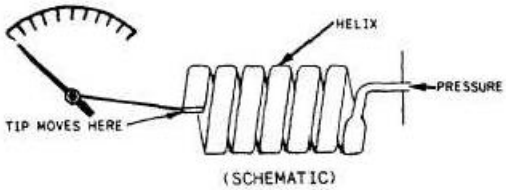
As the fluid pressure enters the bourdon tube, it tries to be reformed and because of a free tip available, this action causes the tip to travel in free space and the tube unwinds. The simultaneous actions of bending and tension due to the internal pressure make a non-linear movement of the free tip.

This travel is suitable guided and amplified for the measurement of the internal pressure. But the main requirement of the device is that whenever the same pressure is applied, the movement of the tip should be the same and on withdrawal of the pressure the tip should return to the initial point. inner portion. The tube walls will have a thickness between 0.01 and 0.05 inches.




Bourdon Tube Pressure Gauge

3) Helical: A helical-type bourdon tube provides even greater tip movement than the spiral-type. High-pressure helical-types might have as many as twenty coils, while low-pressure helical-types might have two or three coils. Since the change in tip motion decreases as the applied pressure becomes larger, adding more coils compensates for this motion decrease.



**iii) State any four requirements of biomedical amplifier.(Any four 01 mark each)**

**Ans** 1) High input impedance -greater than 10 MΩ

2) Safety: protect the organism being studied careful design to prevent macro and micro shocks.

3) Isolation and protection circuitry to limit the current through the electrode to safe level

4) Output impedance of the amplifier should be low to drive any external load with minimal distortion.

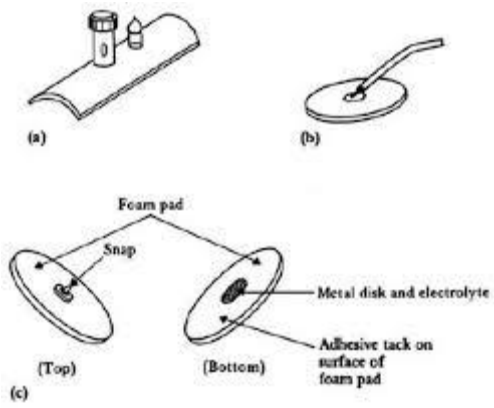
5) Gain greater than 1000 greater than 1000

6) Rapid calibration of the amplifier in laboratory conditions.

**Q.2. Attempt any four of the following. 16 marks**

**a) Draw a diagram of metal plate electrode and state its working.(Diagram-.02 marks ,Working -02 Marks)**

**Ans:**

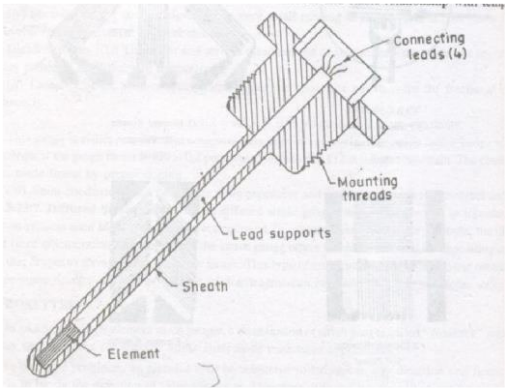


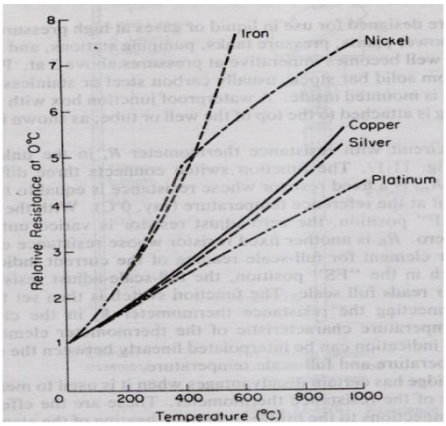

Working: Generally larger area surface electrodes are used to sense ECG potentials**.**Metel plate electrodes are generally used to measure ECG.Rectangular and circular plates from German silver, nickel silver or nickel plated steel are used as surface electrodes. When these electrodes are applied on the skin with electrode paste, tipical d.c resistance values are in the range from 2 to 10 kilo ohms, the high frequency impedance amounts to a few hundred ohms.

**b) Draw constructional diagram of RTD and characteristic of RTD. Describe construction of RTD.**

**(Draw construction- 01, Draw characteristic- 01, Describe construction -02 marks)**

**Ans:**



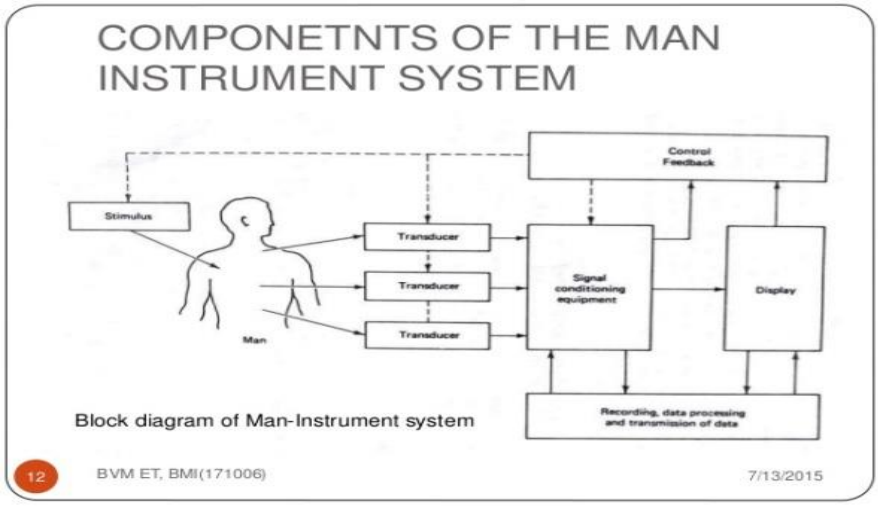



The construction is typically such that the wire is wound on a form (in a coil) on notched mica cross frame to achieve small size, improving the thermal conductivity to decrease the response time and a high rate of heat transfer is obtained. In the industrial RTD's, the coil is protected by a stainless steel sheath or a protective tube.

So that, the physical strain is negligible as the wire expands and increase the length of wire with the temperature change. If the strain on the wire is increasing, then the tension increases. Due to that, the resistance of the wire will change which is undesirable. So, we don't want to change the resistance of wire by any other unwanted changes except the temperature changes.

**c) Draw man instrumentation system diagram. State function of each part. (Draw -02 marks, Description -02 marks)**

**Ans:**




1) Stimulus

2) Transducer.

3) Control feedback

4) Signal conditioning.

5) Display.

6) Recording.

The man instrumentation system consists of above blocks.

1) Stimulus: Generally different signals (parameters) from human body is considered as stimulus .for eg. Temperature, pressure, ECG etc.

2) Transducer: Human parameters get converted in to electrical signal with the help of transducer.

3) Control feedback: Here the output signal of transducer is compared with standard value and a proper feedback signal is provided for controlling purpose.

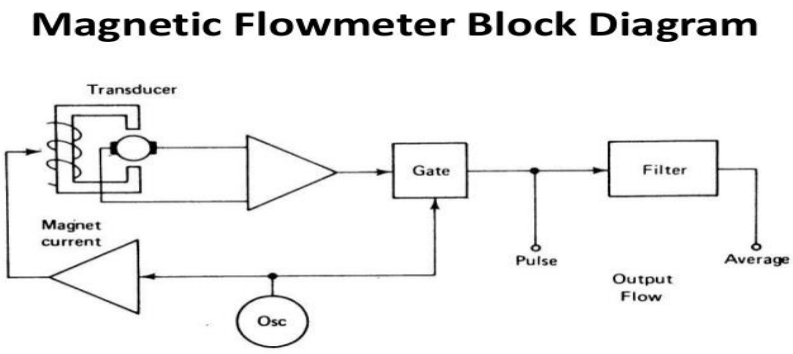
4) Signal Conditioning: Here the signal is processed i.e. it get filtered, amplified, noise get reduced, sharpened etc. for the proper operation.

5) Display: It may be graphical display or electronic display of human parameters.

6) Recording: For future purpose the signal may be recorded with the help of this block.

**d) Define Faraday's law of electromagnetic induction and draw electromagnetic blood flow meter and state it's any two applications. (Definition -01 mark, Draw- 02 marks, application -01 mark)**

**Ans: Defination:** Faraday's Law of Electromagnetic Induction state that whenever a conductor are placed in a varying magnetic field emf are induced which is called induced emf, if the conductor circuit are closed current are also induced which is called induced current.
This simply means that the induced emf is proportional to the rate of change of the magnetic flux through a coil.

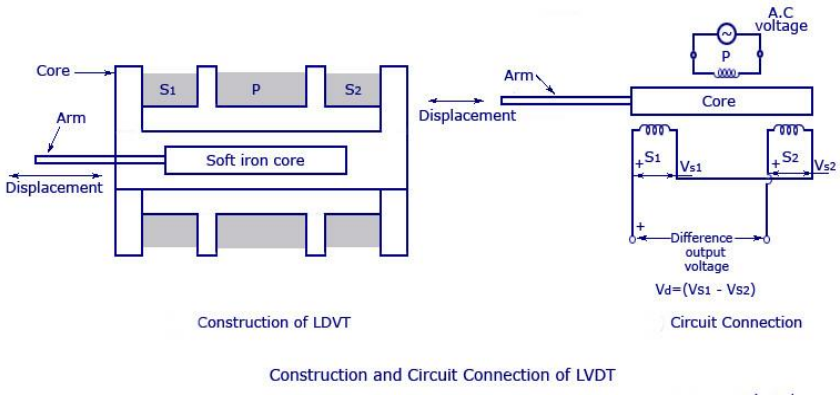



**Application**:1)For measurment of blood flow.

2)For arterial reconstruction.

**e) Draw the constructional diagram of LVDT and state it's working.(Diagram 02 marks, Working 02 marks)**

**Ans:**



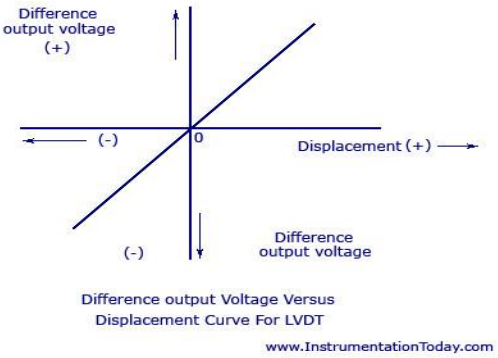

Construction and Circuit Connection of LVDT

**Working:** As shown in the figure above, an ac voltage with a frequency between (50-400) Hz 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.

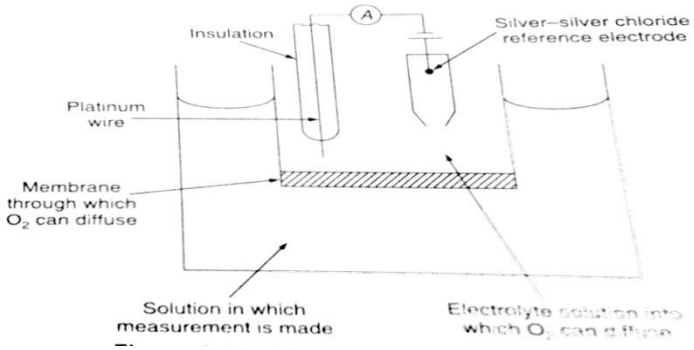



Difference output Voltage Vs Displacement Curve

The graph above shows the plot between the resulting voltage or voltage difference and displacement. The graph clearly shows that a linear function is obtained between the output voltage and core movement from the null position within a limited range of 4 millimeter. The displacement can be calculated from the magnitude of the output voltage. The output voltage is also displayed on a CRO or stored in a recorder.

**f) With neat sketches describe p02 electrode.** (Diagram- 02 marks, Description -02 marks)

**Ans:**




The $PO_2$ electrode is known as Clark electrode after its inventor and it is an $O_2$ sensor for blood. The electrode arrangement consists of two chambers and they are separated by polypropylene membrane i.e. permeable to $O_2$. The blood sample is injected into lower sample chamber as shown in the figure. The upper chamber contains the electrode.

The $O_2$ in the blood permits the polypropylene membrane and reacts chemically with a phosphate buffer contained in the upper chamber. The buffer maintains the solution pH at a constant level. The $O_2$ combines with water in the buffer producing electrons proportion to the number of $O_2$ molecules according to the formula:

$$O_2 + 2H_2O + 4e^- \rightarrow 4[OH]^+$$

The electron current is measured by the ammeter. It is directly proportional to $PO_2$. Electrons on the left side of the equation are produced by a source voltage that polarizes the electrode and has value 0.7V. This voltage is called polorographic voltage. The

electrode is called Clark's polorographic electrode. The meter scale is calibrated in units of $PO_2$ in the blood. This electrode current depends on current blood in the solution rather than membrane potential as it was in pH measurement.

**Q. 3. Attempt any FOUR of the following** **16**

**a) State any four objectives of medical instrumentation system. (01 mark for each objective any 04)**

**Ans:** 1)**Information Gathering**: In an information gathering system, instrumentation is used to measure natural phenomena and other variables to aid man in his quest for knowledge about himself and the universe in which he lives.

2) **Diagnosis:** Measurments are made to help in the detection and hopefully, the correction of some malfunction.

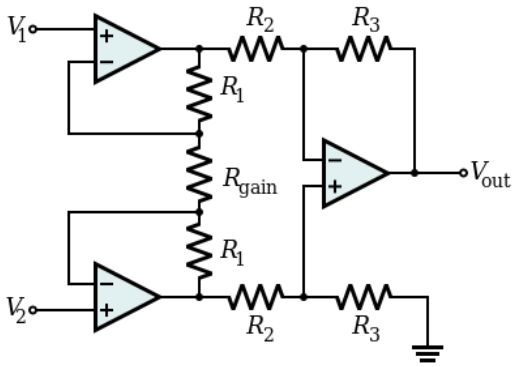
3) Evaluation: Measurements are used to determine the ability of a system to meet it's functional requirements.

4) **Monitoring**: it is used to obtain continuous or periodic information about the state of the system.

5) **Control**: Instrumentation is sometimes used to automatically control the operation of a system based on changes in one or more of the internal parameters or the output of the system.

b) **Draw instrumentation amplifier using 3 op amp and state the o/p equation. (Diagram 02 marks, equation 02 marks)**

**Ans:**



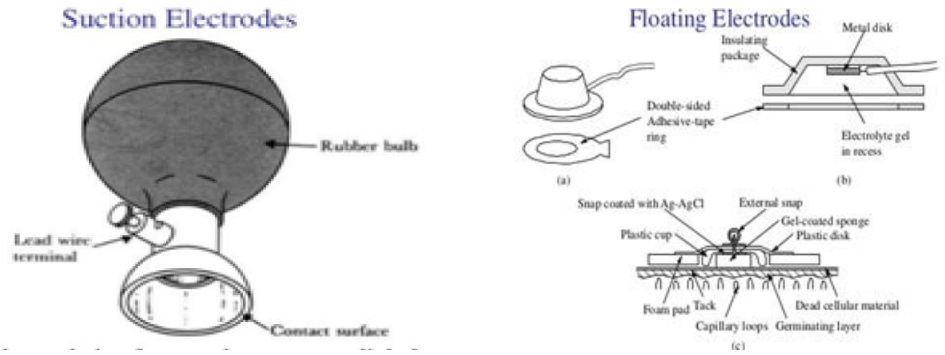

**Output Equation** :

**Voltage gain (Av) = Vo/(V2-V1) = (1 + 2R1/Rg ) x R3/R2**

c**) Draw diagram and state one use of i) Suction electrode ii) Floating electrode.**

**(Diagram 01 marks each, Use 01 mark each.)**

**Ans:**




**Use:**1.Suction electrodes are frequently used in electrocardiography as the pericordial (chest) leads.

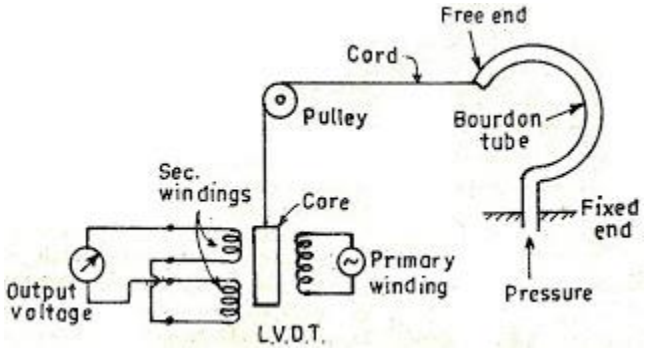
2. Floating electrodes are used in electrocardiography for diminish this artifact.

d) **Define primary and secondary transducer and give one example with neat diagram. (02 marks for each transducer)**

**Ans:** Primary transducer: Primary transducer: The Mechanical device which converts physical quantity to be measured into a mechanical signal. For eg.Burdon tube

Secondary transducer: The Electrical device which converts this mechanical signal to the electrical signal.

For eg: LVDT.




In the above diagram burden tube is primary transducer and LVDT is a secondary transducer.

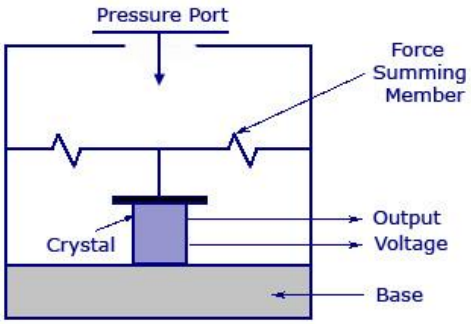
Note: Two separate diagrams for primary and secondary transducer are also considered.

**e) Draw piezoelectric transducer and state its working principle**

**Ans Draw 2 marks principle 2 marks**

Assymetrical 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.

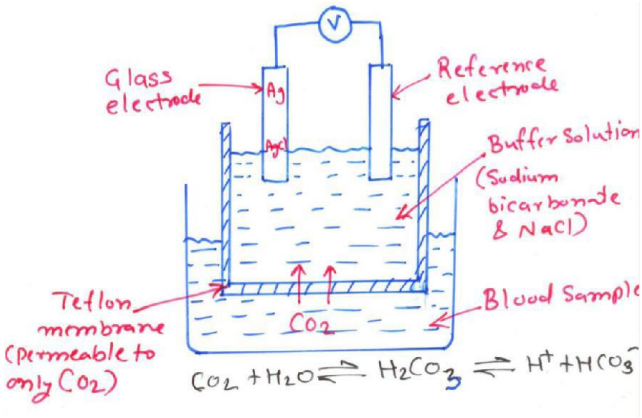
When an external force appears on the top the crystal, it produces an EMF across the crystal, which is proportional to the magnitude of the applied pressure. This is self generating type of transducer.




Piezo-Electric Transducer

**f) Draw pc02 electrode and describe its working. (Diagram 02 marks, description 02 marks)**

**Ans:**




Working: It consists of a standard glass pH electrode covered with the rubber membrane permeable to co2.Between the glass surface and membrane there is a thin film of water. The solution under test which contains dissolved co2 is presented to the outer surface of the rubber membrane.

After equilibrium the pH of the aqueous film is measured by the glass electrode and interpreted in terms of pCO2 on the basis of the linear relationship between log pco2 and ph of solution.

**Q. 4.Attempt any <u>FOUR</u> of the following** **16**

**a) Describe flow measurement by thermal convection with neat diagram.**

**(Description 02 mark, Diagram 02 mark)**

**Ans:-** 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.

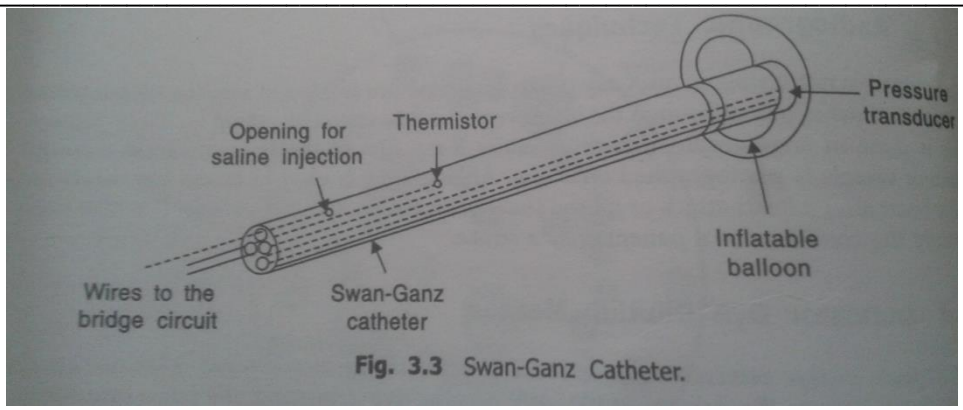
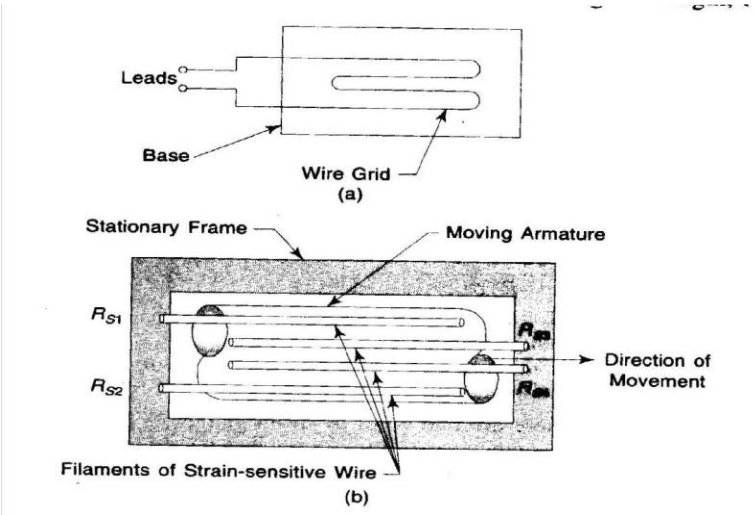


Fig. 3.3 Swan-Ganz Catheter.

**b) Describe boned and unbounded strain gauge. What is gauge factor?**

**(Description of boned and unbounded strain gauge -3 mark, gauge factor 01 mark)**

**Ans:-**




(a) Bounded strain gauge (b) Unbounded strain gauge.

Bounded strain gauge: In bounded strain gauge(Fig. a), a grid of fine wire is cemented to a thin paper sheet or very thin Bakelite sheet, and covered with a protective sheet of paper or thin Bakelite. The paper sheet is bounded with an adhesive material to the structure under study. When the surface to which the strain gauge is bounded is disturbed because of an applied force (or load), the strain gauge is also strained. The resistance of the wire changes on account of change in length and diameter of the wire. The size of the grid varies with the application. They can be as small as 3mm* 3mm square. Usually they are larger, but seldom more than 2.5 cm long and 1.25 cm wide. The strain gauge is useful only for measuring very small displacements. However, larger displacements can be measured by bounding the gauge to flexible element such as a thin cantilever beam and applying the unknown displacement to the end of the beam.

Unbounded strain gauge:

Unbounded strain gauge: The unbounded strain gauge (Fig. b) consists of a stationary frame and an armature that is supported in the centre of the frame. The armature can move only in one direction and its travel is that direction is limited by four filaments of strain-sensitivity wire wound between rigid insulators that are mounted on the frame and on the armature. The filaments are of equal length.When an external force is applied to the strain gauge, the armature moves in the direction indicated. The filaments Rs1 and Rs2 increase in length, whereas the filaments Rs3 and Rs4 decrease in length. The resistance change of the four filaments is proportional to their change in length, and this change can be measured with a Wheatstone bridge. The unbalance current indicated by galvanometer is calibrated in term o f the magnitude of displacement of the armature. A linkage pin can be attached to the armature in order to measure displacement directly.

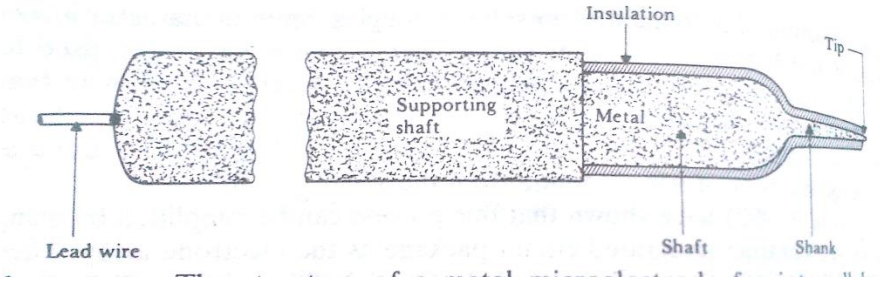
**Gauge Factor:** The ratio of the resulting resistance change ▲R/R to the change in length ▲L/L is called the gauge factor.

**c) Describe construction of micropipette and microelectrode.**

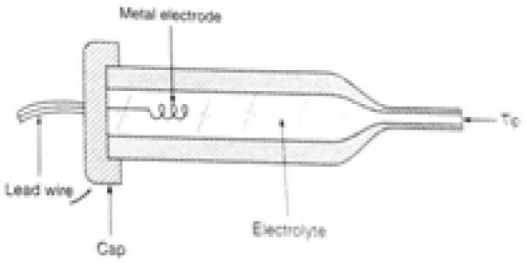
**(02 mark each with diagram)**

**Ans:-**

**Metal-Microelectrode:** 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.




**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.




**d) Define thermocouple and state their any four types. State any two application of thermocouple.**

**(Defination-1 mark, any four types-02 mark, application-01 mark)**

**Ans: Thermocouple:** When two wires of different material are joined together at the either end, forming two junctions which are maintained at different temperature, a thermo-electromotive force (emf) is generated causing a current to flow around the circuit. This arrangement is called thermocouple.

**Types of thermocouples**:

Nickel alloy thermocouples-type E(cromel-constantan),type J(Iron –constantan), type K(cromel alumel),type M ,type N(Any other relevant types)

**Application:**

1. For measuring temperatures from within the body at sites like esophagus, rectum, etc.
2. Thermocouples are suitable for measuring over a large temperature range, from −270 up to 3000 °C.

**e) Classify transducer on the basis of process used physical or chemical principle and application.**

**Ans:** 4 points for 4 marks

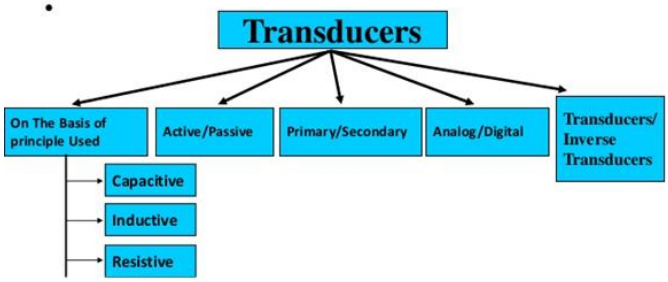
Some of the common methods of classifying transducers are given below

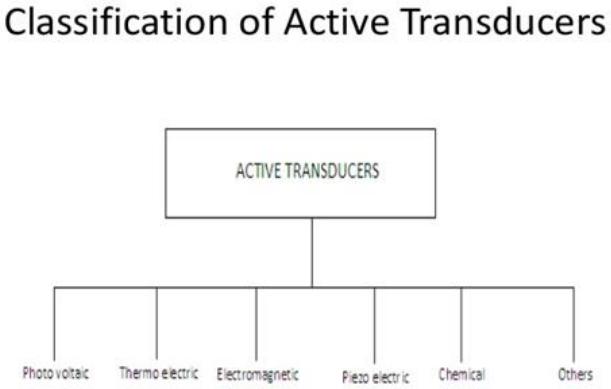
1) Based on their application.

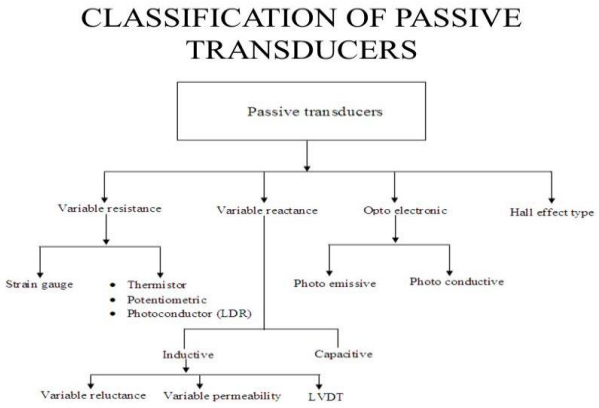
2) Based on the method of converting the non-electric signal into electric signal.

3) Based on the output electrical quantity to be produced.

4) 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, voltage, current or inductance. Thus, during transduction, there may be changes in resistance, capacitance and induction, which in turn change the output voltage or current.
5) Based on whether the transducer is active or passive.




**f) Draw pH electrode and explain its working.**

**(Diagram-02mark, Working-02 mark)**

**Note: consider any relevant diagram**

**Ans:** Glass electrode is normally used as a pH electrode.fig shows the glass electrode consists of spherical bulb of 0.5cm diameter. The membrane of thin glass bulb permits the passage of only hydrogen ions in the form of $H_2O^+$ .Inside the glass bulb Ag/Agcl electrode is immersed in chloride buffer solution. The other side of the bulb is kept at the other solution unknown pH. The measuring circuit and solution being measured is closes through potassium chloride salt bridge and calomel electrode. In this case two arrangements are required one for reference and the other for unknown solution. Nowadays glass electrode and reference electrode are available in the same enclosure.

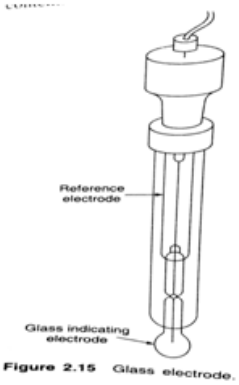


Figure 2.15 Glass electrode.

**Q. 5. Attempt any FOUR of the following** **16 Marks**

**a) State the two types of diaphragm and describe its working. State the working of bellows.**

**Ans:(2 marks each)**

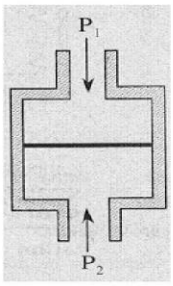
1. Flat diaphragm.

2. Corrugated diaphragm: Corrugated diaphragm gives a better deflection.

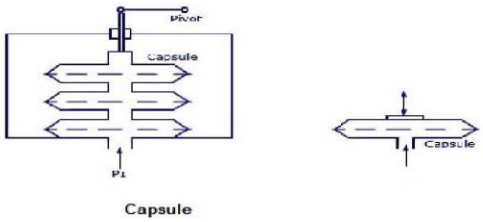
3. Capsule: Capsule consists of two diaphragms which are welded, brazed or soldered.

4. Bellows

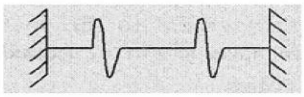
**Working of bellows:** A bellows is made up of 0.1mm thick stainless steel or brass from a single piece of meatal.One end is fixed and the free end is displaced under the influence of pressure, displacement being proportional to the applied pressure**.**

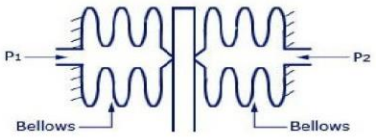


Flat diaphragm



Capsule


Corrugated diaphragm



Bellows

**b) Draw diagram of ultrasonic blood flow meter and describe its working.**

**(Diagram-02 mark, Working-02 mark)**

**Ans:-**

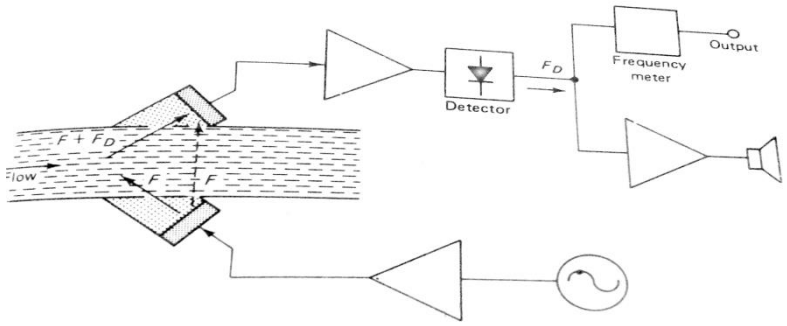


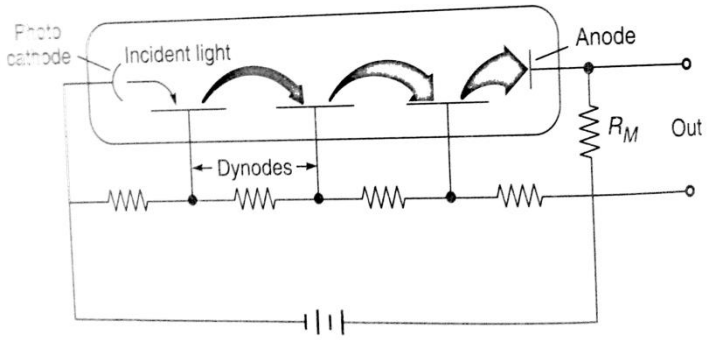

**Figure 6.36.** Ultrasonic blood flow meter, Doppler type.

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 transist 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 lengthened. 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 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. Its frequency is either $F+F_D$ or $F-F_D$ ,depending on the direction of flow.
The Doppler component $F_D$ is proportional to the velocity of flowing blood A fraction of transmitted ultrasonic energy, however, reaches the second transducer directly, with th frequency being unchanged.After amplification of the composite signal the Doppler frequency can be obtained at the output of the detector as the difference between direct and scattered signal components. With the blood velocity in the range normally encountered the Doppler signal is typically in the low frequency range. Because of the velocity profile of the flowing blood the Doppler signal is not a narrow band noise therefore from the loud speaker or earphone the Doppler signal of pulsation blood flow can be heard as characteristics swish. When the transducers are placed in a suitable mount which defines the area of blood vessels frequency meter is used to measure Doppler frequency can be calibrated in flow rate units.

**c) State the working principle of photomultiplier tube. Draw its constructional sketch with neat label.**

**((Diagram-02 mark, Working principle -02 mark)**

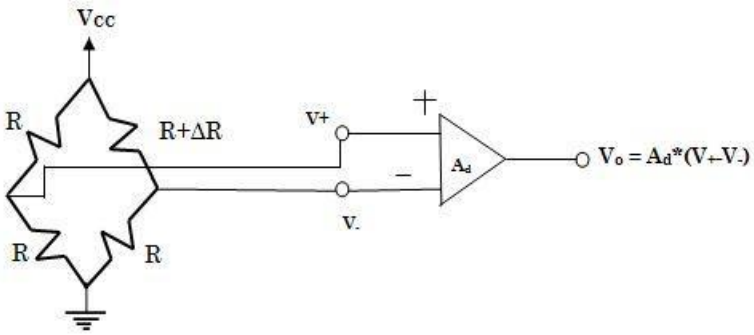
**Ans:** A photomultiplier tube is a vacuum tube consisting of an input window, a photocathode, focusing electrodes, an electron multiplier and an anode usually sealed into an evacuated glass tube.Light which enters a photomultiplier tube is detected and produce an output signal through the following processes,
1) Light passes through the input window.
2) Light excites the electrons in the photocathode so that photoelectrons are emitted into the vacuum (external photoelectric effect).
3) Photoelectrons are accelerated and focused by the focusing electrode onto the first dynode where they are multiplied by means of secondary electron emission. This secondary electron emission is repeated at each of the successive dynodes.
4) The multiplied secondary electrons emitted from the last dynode are finally collected by the anode.




**d) Draw and explain Bridge amplifier.**

**(Diagram-02mark,Descrption-02mark)**

**Ans:-**




In the figure shown above the resistance shown as R+ΔR can be any sensor such as platinum resistor, strain gauge, thermistor, e.t.c . The resistors labeled as R are reference resistors with which the varying resistance can be measured. Since the opamp is in open loop configuration the output of opamp is given as

$$Vo = Ad*(V+-V-)$$

Where Ad is open loop differential gain of opamp. The current flowing through the input terminals of an op amp will be zero(except for small bias currents) due to infinite input resistance of opamp. let $\Delta R/R = \delta$,The output voltage of opamp reduces to $Vo = Ad*V*(-\delta)/4$. When all the resistors are matched i.e. $\delta=0$, output voltage goes to zero.

**e) Define dynamic characteristics of transducers. Write any three dynamic characteristics.**

**(Define dynamic characteristics -01 mark, any three dynamic characteristics-03 mark)**

Ans:- **Dynamic characteristics:** The relationship between the system input and output when the measured quantity (measurand) is varying rapidly.

1) Speed of Response: It is defined as the rapidity with which a measurement system responds to changes in the measured quantity.

2) Measuring Lag: It is the retardation or delay in the response of a measurement system to changes in measured quantity. It is of 2 Types A) Retardation type B) Time delay type.

3) Fidelity: It is defined as the degree to which a measurement system indicates changes in a measured quantity without any dynamic error.

4) Dynamic Error / Measurement Error: It is the difference between true values of quantity (under measurement system if no static error is assumed.

**f) State and explain any two sources of biomedical signals.**

**(02 mark each )**

**Ans:-1.** Bio-electric signals:-These are unique to the biomedical system. They are generated by nerve cells and muscle cells. Their basic source is the cell membrane potential. The most common examples of bioelectric signal are the ECG and EEG.
**2.** Bio-acoustic signals: These signals are obtained from sounds created by Biological system and provide information about underlying phenomenon .Eg. Flow of blood in heart through valves, flow of air in lungs.
3. Bio-mechanical signals:-These signals are obtained from mechanical function of biological system it includes all types of motion and displacement signal.Eg.Motion of chest wall.
4. Bio-chemical signals: - These types of signals are obtained from the measurements of chemical compositions. Eg- composition of various ions, partial pressure of oxygen or co2 in living tissues or from sample.
5. Bio-magnetic signals:-In bioelectric signals, some organs produce very weak electromagnetic signals; measurement of these signals is called "Bio-magneticsignals."
6. Bio-optical signal:- These signals are generated as result of optical function of the biological system, occurring either naturally or induced by the measurement process. Eg.blood oxygenation may be estimated by measuring the transmitted /back scattered light from a tissue at different wavelength.
7. Bio-impedance signal:- The impedance of the tissue is a source of important information concerning its composition, blood distribution and blood volume etc.The measurement of galvanic skin response is typical example of this type of signal.

**Q. 6. Attempt any <u>FOUR</u> of the following**. **16 Marks**

**a) State and explain the working of capacitive transducer with neat sketch and mathematical equation.**

**(Description-02 mark, Diagram-01 mark, equation-01 mark)**

**Ans:-** A capacitance transducer , the variable to measured 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, $\varepsilon_0$ $\varepsilon_r$ are absolute an relative dielectric constant of the medium respectively

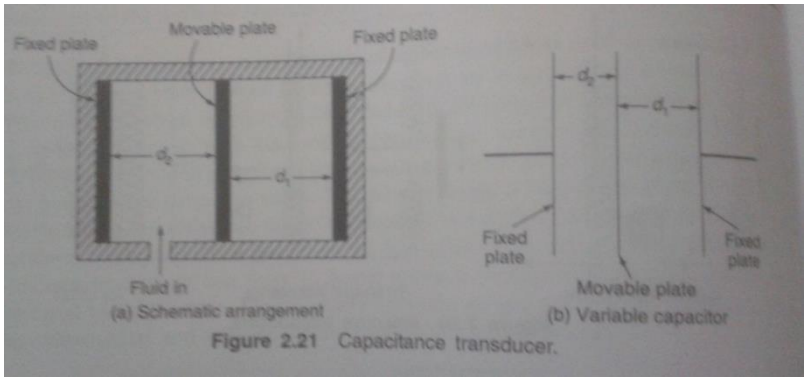
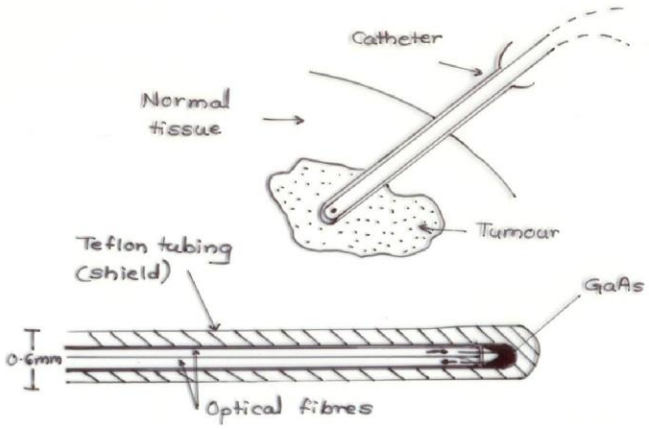


Figure 2.21 Capacitance transducer.

**b) With the help of neat labelled diagram give constructional details of the Ga As semiconductor probe.**

**(Diagram -2 marks, explanation -2 marks)**

**Ans:-**




The figure shows GaAs semiconductor temperature probe. Small prism shape sample of single crystal undopped GaAs is epoxid at the end of two side by side optical fibers. The sensors of fibbers 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 non metallic probe is particularly suitable for temperature measurement in the strong electromagnetic heating field used in heating tissue for cancer therapy

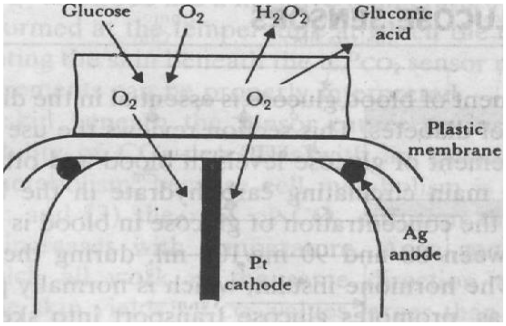
**c) Describe the working of flow measurement by indicator dilution.**

**Ans:-** **Description 4 marks**

Indicator dilution principle states that if we introduce into or remove from a stream of fluid a known amount of indicator & measure the concentration difference upstream & downstream of the injection site , we can estimate the volume flow of the fluid.
Two methods are generally employed for introducing the indicator in the blood stream ,it may be injected at a constant rate or as a bolus. The method of continuous infusion suffers from the disadvantage that most indicators recirculate ,& this prevents a maxima from being achieved. In the bolus injection method , a small but known quantity of an indicator such as a dye or radioisotope is administered into the circulation. It is injected into a large vein or preferably into the right heart itself. After passing through the right heart, lungs& the left heart. The indicator appears in the arterial circulation. The presence of an indicator in the peripheral artery is detected by a suitable (photoelectric) transducer &is displayed on a chart recorder. This way we get the cardiac output curve. This is also called dilution curve.

**d) Draw an explain blood glucose sensor.**
**(Diagram-02 mark, Description -02 mark)**

**Ans:-**




The principle behind glucose meter is base 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 potatiomterrycynide 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.

**e) Define motion Artifact and state the use of Jelly.**
**(Motion Artifact-02 mark, Use of Jelly-02 mark)**

**Ans: - Motion Artifact:** 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

**Use of Jelly:**

1. Jellies have been used to facilitate a more intimate contact between the subject's skin and the recording electrodes.
2. Thus reducing the skin contact impedance.

**f) Draw neat sketch of radiation thermometry. Write it's any two advantages and two applications.**

**(Diagram-02mark, Advantages-01 mark, Applications-01 mark)**

**Ans: -**

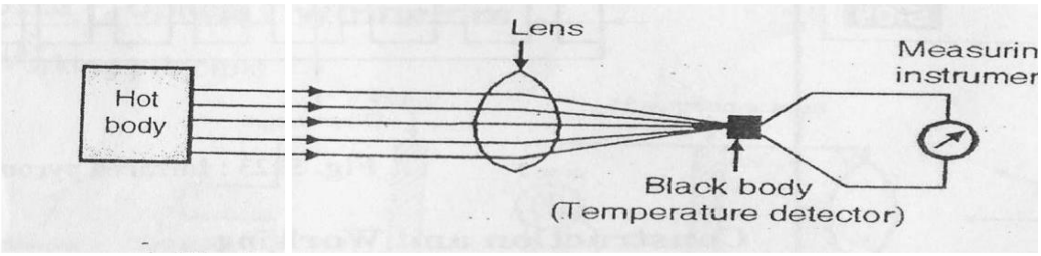



Diagram of radiation thermometry

**Advantages:**

3. Temperature of body can be measured without physical contact of the sensor.
4. Measurement with fast respond.
5. Measurement on moving object.
6. Used for high temperature measurement for long period.

**Applications:**

7. Radiation thermometry used to measure internal or core body temperature of the human.
8. It can also be used to find tissue destruction from frost bite and burns and to detect various peripheral blood circulatory disorders.

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