Mohamed Sathak A.J College of Engineering

Siruseri,Chennai.

Department of Electrical and Electronics Engineering

Question Bank

Subject Code/Name: OMD551/Basics of Biomedical Instrumentation

Semester/Branch: V/ EEE

UNIT-I

PART-A

1. **What is resting potential?**
   The membrane potential measured when a equilibrium is reached with a potential difference across the cell membrane negative on the inside and positive on the outside is called resting potential. Range:70mV.

2. **What is action potential?**
   When a stimulus is applied to a cell at the resting stage, there will be a high concentration of the positive ions inside the cell. So there will be slightly high potential on the inside of the cell due to imbalance of potassium ions. This is called action potential.Range:20mV.

3. **What is bio electric potential?**
   Certain systems of the body generate their own monitoring signals conveying useful information about the functions they represent. Such signals are bio electric potentials and are related to nerve conduction, brain activity, heart beat etc.

4. **Define Absolute Refractory Period (ARP).**
   The **absolute refractory period** is a period of time after the initiation of one action potential when it is impossible to initiate a second action potential no matter how much the cell is depolarized.

5. **Define Relative refractory period (RRP).**
   The **relative refractory period** is a period after one action potential is initiated when it is possible to initiate a second action potential, but only with a greater depolarization than was necessary to initiate the first.

6. **Define Linearity.**

   Linearity of an instrument is defined as the degree to which variations in the output of an instrument follow input variation. Whenever the sensitivity of the instrument is constant overall levels of the input, then that instrument has better linearity. Linearity is essential to get accurate values.

7. State all or nothing law.

Regardless the method of excitation of cells or the intensity of the stimulus, which is assumed to be greater than the threshold of stimulus, the action potential is always the same for any given cell. This is known as the all or nothing law.

8. What is the functions sodium pump?

It is an active process, by which the sodium ions are quickly transported to the outside of the cell and the cell again becomes polarized& assumes its resting potential. The operation of this pump is linked with the influx of potassium into the cell, as if a cyclic process involving an exchange of sodium for potassium existed.

9. Define evoked potential.

Evoked potentials are the potentials developed in the brain as the responses to external stimuli like light, sound etc. The external stimuli are detected by the sense organs which causes changes in the electrical activity of the brain. It is also called Event related potential.

10. What are polarizable and non polarizable electrodes?

Perfectly Polarizable Electrodes:

The current across the interface is a displacement current and the electrode behaves like a capacitor. No electrodes' ions transfer. Instead, the ions and electrons (of the solution) at the surface of the metal become polarized. The charges orient at the interface to create an electric double layer; the metal then acts like a capacitor.

Ex: Platinum (Pt) electrode

Perfectly Non-Polarizable Electrode:

Current passes freely across the electrode-electrolyte interface, requiring no energy to make the transition. No over potentials. Non-polarizable electrodes are reversible (ions in the solution are charged and discharged).

Ex: Silver/silver chloride (Ag/AgCl) electrode.

11. Name different types of electrodes used for biomedical instrumentation system.

Surface Electrodes

Depth and Needle Electrodes

Micro electrodes

12. Mention the types of microelectrodes. What are their applications?

Types of micro electrode

1. Metal micro electrodes
2. Micropipet electrode

Applications of microelectrodes

1. Potential recording
2. Current injection

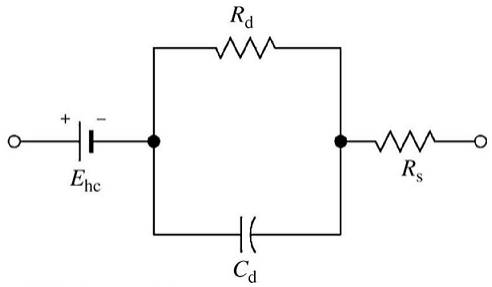
13. What are the salient features of needle electrode?

-Cannot be modeled as a series resistance and capacitance (there is no single useful model)
– The body/electrode has a highly nonlinear response to stimulation.
– Large currents can cause Cavitation, Cell damage or Heating.

14. Define Half-cell potential.

The interface of metallic ions in solution with their associated metal results in an electrical potential. That is called electrode potential. Half-cell potential is the voltage developed at the electrode-electrolyte interface.

The figure shows the equivalent circuit of Half cell potential.



15. Give the Nernst equation of electrode potential.

The half-cell potential or electrode potential is measured with reference hydrogen electrode placed in the electrolyte near the metallic electrode. The half-cell potential developed can be expressed by the **Nernst equation**

$$E_{hc} = -\frac{RT}{nF} \ln \frac{C_1}{C_2} \frac{f_1}{f_2}$$

16. List the types of Surface electrodes.

Metal Plate Electrodes, Suction cup electrodes, Adhesive tap electrodes, Floating Electrodes.

17. What are the advantages of Silver-Silver chloride electrode?

- Half cell potential is 2.5mV only.
- Reduces the noise voltage and increases the stability.
- Stabilize the half cell potential and no movement artifacts.
- Reduces the electrode and electrolyte impedance.

UNIT-I - PART B

1. Draw the structure of a living cell of our body and explain in its Constituents detail.

2. Describe the generation and features of action potential and Resting Potential.

3. Sketch the block diagram of biomedical instrumentation system and explain the functions of each block.

4. Explain the construction and features of surface electrodes with examples.

5. Explain the various types of depth and needle electrodes used to measure EEG and EMG potentials.

6. Explain the types of micro electrodes with their associated equivalent circuits.

7. Describe the measurement of two electrodes with their associated equivalent circuits.

8. Discuss in detail about recording problems in bio medical instrumentation.

UNIT-II PART-A

1. Specify the frequency and amplitude range of any four bio electric signals.

Parameter	Frequency range	Amplitude	Type of Electrode
Electrocardiogrpahy (ECG)	0.05 to 120 Hz	0.1 to 5μV 1μV	Surface
Electroencephalography (EEG)	0.1 to 100 Hz	2 to 200μV 50μV	Scalp
Electromyography (EMG)	5 to 2000 Hz	0.1 to 5μV	Needle
Electroretinography (ERG)	Dc to 20Hz	0.5 to 1μV	Contact
Electro-oculography (EOG)	Dc to 100 Hz	10 to 3500μV	Contact

2. Define Electrocardiograph and Electroencephalograph.

- The electrocardiograph (ECG) is an instrument which records the electrical activity of the heart.
- The Electroencephalograph it is the instrument used for recording electrical activity of the brain by suitably placing electrodes on the scalp.

3. Define EOG and ERG.

The measure of corneal-retinal potential is called Electrooculogram (EOG).
The recording and interpreting the electrical activity of eye is called Electro retinogram.(ERG)

4. Define PCG.

Phonocardiograph is an instrument used for recording the sounds connected with the sounds connected with the pumping action of the heart. These sounds provide indication for heart rate, rhythmicity.

5. What are the electrodes used for EEG?

Silver chloride disc electrode
Depth electrode
Small needle electrode
Silver ball or pellet electrodes
Carbon cloth electrode

6. What are the electrodes used for EMG?

- Needle electrode
- Coaxial core electrode
- Capacitive type needle electrode.

7. What is the use of EMG?

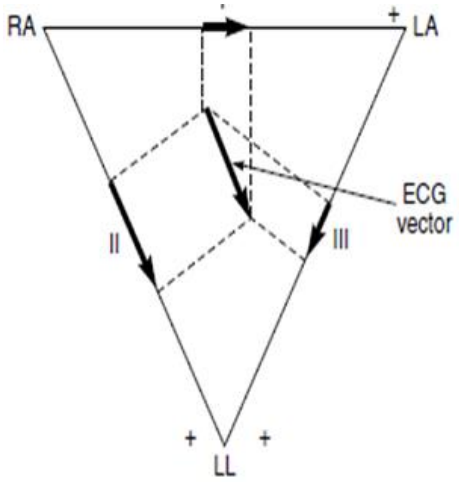
EMG is used for the measurement of action potentials muscles, either directly from the muscle or from the surface of the body.

8. List the brainwaves and their frequency.

Alpha	8 -13 Hz
Beta	13 - 30 Hz
Theta	4-8 Hz
Delta	0.5-4 Hz

9. **Define Einthoven triangle.**

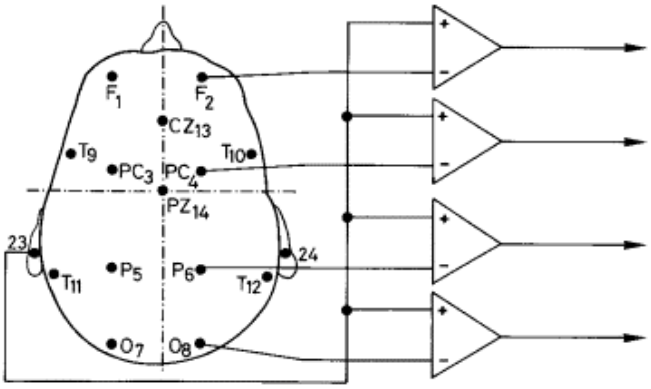
The closed path RA to LA to LL and back to RA is called Einthoven triangle. According to Einthoven the frontal plane of the body and cardiac electric field vector forms the two dimensional plane.



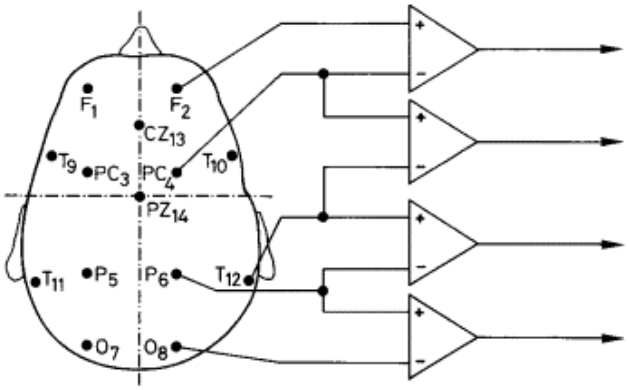
10. What are the applications of ECG?

1.Diagnostics
2. Heart functional analysis
3. Implants pacemaker
4. Heart rate variability

11. Draw the unipolar and bipolar modes of EEG.



Unipolar-Potential of each electrode is compared with reference electrode normally connected to right ear.



Bipolar- potential difference between a pair of electrodes is measured.

12. What is evoked potential?

Evoked potential (EP) tests measure the electrical activity of the brain in response to stimulation of specific sensory nerve pathways.

13. What is unipolar and Bipolar mode of EMG?

Unipolar Mode: Needle electrodes inserted into the muscle as active electrodes and reference electrode placed over the surface.

Bipolar Mode: Record the Potential difference between two electrodes one is used as active electrode and other is used as reference electrode.

14. Define the term latency in EMG.

Latency is defined as the elapsed time between the stimulating impulse and the muscle action potential.

15. Determine the conduction velocity of motor nerves.

Time t_1 is the elapsed time between the stimulating impulse and muscle action potential of two electrodes place on the distance l_1.

Time $t_2$is the elapsed time between the stimulating impulse and muscle action potential of two electrodes place on the distance l_2.

Conduction Velocity = Distance (l_1-l_2) / Latency (t_1- t_2)

16. What are the applications of EMG?

Rehabilitation
Functional analysis
active Prothetics, Orthesis
Biomechanics, Sports medicine

17. What are the applications of EEG?

- Diagnostics (Epilepsy, Oncology, ..)
- Cognitive Sciences
- Sleep Analysis
- Human Computer Interfaces (BCIs)
- Pharmacology
- Intensive Care, Monitoring

PART-B

1. (i) Explain Einthoven triangle and describe how ECG lead configurations are employed.

(ii) Clearly describe the different lead systems for recording ECG Waveform.

2. Illustrate the placement of electrodes to measure EMG waveform and recording procedure.

3. Describe the EEG electrode lead system with unipolar, bipolar and average modes of measurement.

4. Describe the 10-20 electrode system used in EEG and give the uses of EEG waveforms.

5. Explain the practical considerations of recording EEG, ECG and EMG.

UNIT-III

PART-A

1. **What is the need for bio amplifier?**

Generally, biological/bioelectric signals have low amplitude and low frequency. Therefore, to increase the amplitude level of biosignals amplifiers are designed. The outputs from these amplifiers are used for further analysis and they appear as ECG, EMG, or any bioelectric waveforms. Such amplifiers are defined as Bio Amplifiers or Biomedical Amplifiers.

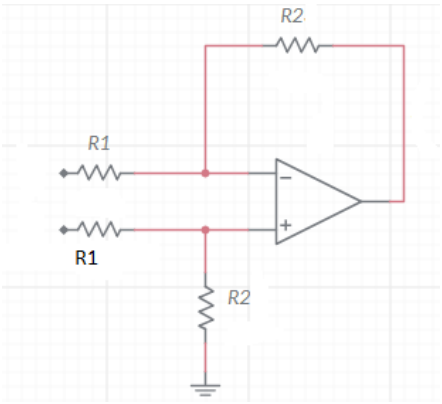
2. **List out the basic requirements of bio amplifiers.**

    1. The **biological amplifier** should have a high input impedance value. The range of value lies between 2 MΩ and 10 MΩ depending on the applications. Higher impedance value reduces distortion of the signal.
    2. When electrodes pick up biopotentials from the human body, the input circuit should be protected. Every bio-amplifier should consist of isolation and protection circuits, to prevent the patients from electrical shocks.
    3. Since the output of a bioelectric signal is in millivolts or microvolt range, the voltage gain value of the amplifier should be higher than 100dB.
    4. Throughout the entire bandwidth range, a constant gain should be maintained.
    5. A bio-amplifier should have a small output impedance.
    6. Common Mode Rejection Ratio (CMRR) value of amplifier should be greater than 80dB to reduce the interference from common mode signal.

3. **What are the types of bio amplifiers?**

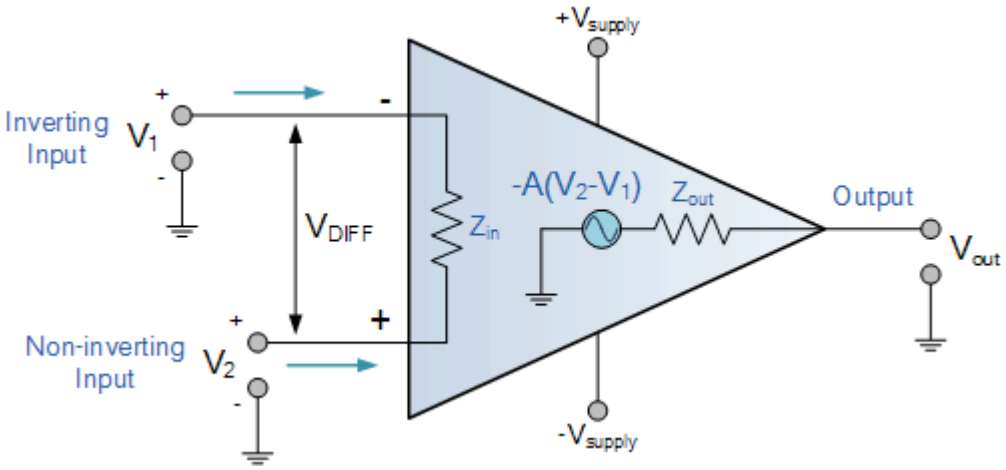
    1. Differential Amplifier
    2. Operational Amplifier
    3. Instrumentation Amplifier
    4. Chopper Amplifier
    5. Isolation Amplifier

4. **Draw the differential differential amplifier circuit used in bio amplifier.**



$$V_0 = \frac{R_2}{R_1}(V_1 - V_2)$$

5. **Draw the ideal equivalent circuit of an Op-amp.**



6. **Why Operational amplifiers are preferred to design Bio amplifiers?**

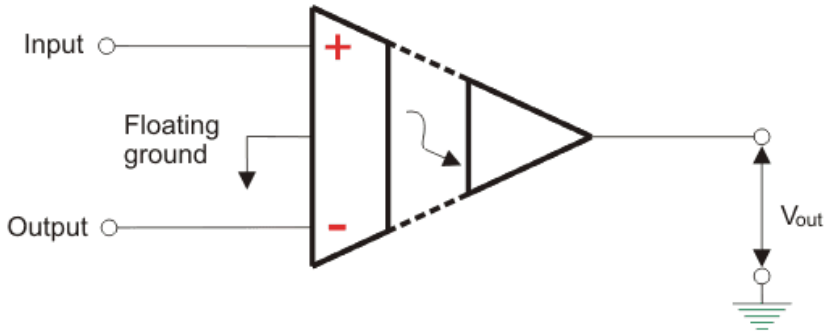
Op-amp is having the following characteristics. These characteristics are met the requirements of bio amplifiers. So op-amp used in designing bio amplifiers.

Differential Voltage Gain=∞
Common mode Voltage gain= 0
Input resistance =∞
Output resistance= 0
Bandwidth=∞

7. **What is Isolation amplifier?**

In a biomedical instrumentation, the main purpose of the isolation amplifier is the protection of the patient by eliminating the hazard of electric shock resulting from the interaction among patient, amplifier, and other electric devices in the patient's environment, specifically defibrillators and electrosurgical equipment.

8. **Draw the symbol of isolation amplifier**.



Symbol of Isolation Amplifier

9. What are the types of isolation amplifiers used in Bio-medical instrumentation?

Three methods are used in the design of isolation amplifiers:

(i) Transformer isolation
(ii) Optical isolation
(iii) Capacitive isolation.

10. Instrumentation amplifiers are preferred over differential amplifiers. Justify?

The differential amplifier is well suited for most of the applications in biomedical Measurements. However, it has the following limitations:

- The amplifier has limited input impedance and therefore, draws some current from the signal source and loads them to some extent.
- The CMRR of the amplifier may not exceed 60 dB in most of the cases, which is usually inadequate in modern biomedical instrumentation systems.

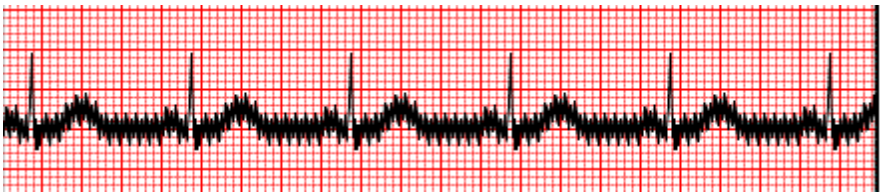
These limitations have been overcome by Instrumentation amplifier due to it has High input impedance and high CMRR.

11. What are the advantages of Instrumentation amplifiers?

The instrumentation amplifier also has some useful features like low offset voltage, high CMRR (Common mode rejection ratio), high input resistance, high gain etc.

12. How power line interferences are affected the ECG waveform?

When the machine or the patient is not properly grounded, power line interference may even completely obscure the ECG waveform.



13. What are the techniques adopted to eliminate power line interferences in ECG signal?

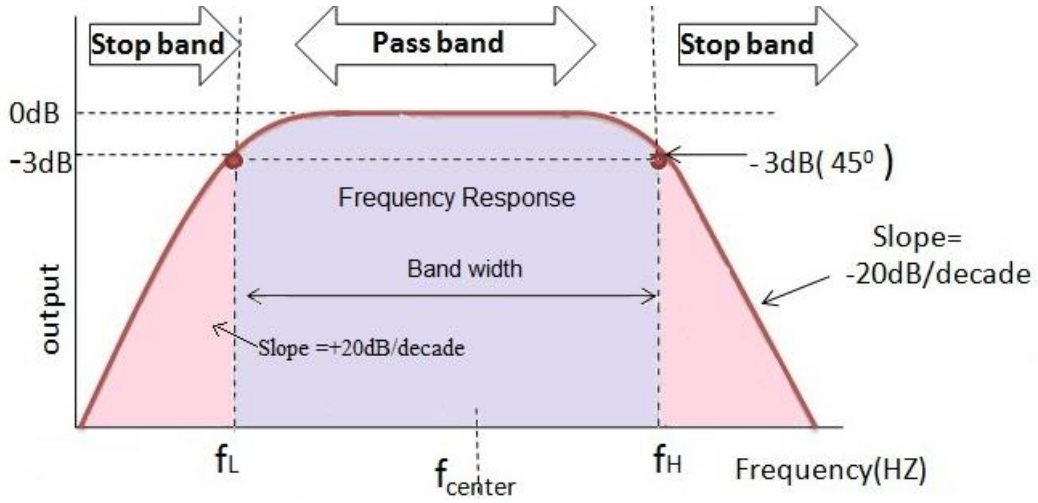
Shielding techniques are used to eliminate the interferences in ECG waveform.

1. Electro static shielding:- Place a ground conducting plane between the source of the electric field and the measurement system.
2. Magnetic shield: Use high permeability materials.
3. Use twisted cables to reduce magnetic flux and loop area.

14. Why band pass filter used in ECG amplifier?

The frequency bandwidth of ECG signal is 0.05Hz to 100Hz. So band pass filter is used to select the particular range of frequencies from ECG signal.

15. Draw the frequency response of band pass filter.



UNIT-III- PART-B

1. Construct the differential amplifier circuit with bridge transducer and derive the output voltage expression.
2. What are the disadvantages of differential amplifier? Construct an Instrumentation amplifier using 3 Op-amps and derive the general expression of the gain.
3. Why isolation amplifiers are needed in the biomedical instrumentation? Explain the construction and working of Transformer type and optical isolation amplifiers.
4. What is power line interference? Explain the effects of power line interference in ECG signal and also discuss elimination techniques.
5. Explain how the common mode voltage can be reduced in the right leg driven ECG amplifier with neat circuit diagram.
6. Draw the band pass filter used to filter an ECG signal for the specified frequency range and obtain the frequency response.

UNIT-IV

PART-A

1. How to measure the body temperature?

The transducer normally used for temperature measurement in a patient monitoring system is a Thermistor or thermometer. Changes in resistance of the thermistor with changes in temperature are measured in a bridge circuit and indicated on a calibrated meter. The measuring range is 30–42°C.

2. Define respiration rate.

The primary functions of the respiratory system are to supply oxygen and remove carbon dioxide from the tissues. The action of breathing is controlled by a muscular action causing the volume of the lung to increase and decrease to effect a precise and sensitive control of the tension of carbon dioxide in the arterial blood. Under normal circumstances, this is rhythmic action with the result that the respiration rate.

3. List the different types of method used to measure respiration rate.

1. Displacement method
2. Thermistor method
3. Impedance Pneumography
4. CO_2 method of respiration rate
5. Apnoea Detectors

4. State the principle of respiration rate measurement by CO_2 method.

When infrared rays are passed through the expired air containing a certain amount of CO2, some of the radiations are absorbed by it. There is a proportional loss of heat energy associated with the rays. The detector changes the loss in heating effect of the rays into an electrical signal. This signal is used to obtain the average respiration rate.

5. Define Apnoea.

Apnoea is the cessation of breathing which may precede the arrest of the heart and circulation in several clinical situations such as head injury, drug overdose, anaesthetic complications and obstructive respiratory diseases.

Apnoea may also occur in premature babies during the first weeks of life because of their immature nervous system. If apnoea persists for a prolonged period, brain function can be severely damaged.

6. What is Apnoea detector?

Apnoea detectors are used to monitor respiration rate. Apnoea monitors are generally designed to give audio-visual signals under apnoeic conditions when no respiration occurs within a selectable period of 10, 20 or 30 s.

The apnoea monitors are basically motion detectors and are thus subject to other motion artefacts also which could give false readings. The instruments must, therefore, provide means of elimination of these error sources.

7. What are Plethysmographs?

The pulse pressure and waveform are indicators for blood pressure and flow. Instruments used to detect the arterial pulse and pulse pressure waveforms in the extremities are called plethysmographs. Most plethysmograph techniques respond to a change in the volume of blood as a measure of blood pressure.

8. List the methods used to measure pulse rate.

The methods used for the detection of volume (pulse) changes due to blood flow are:

- Electrical impedance changes
- Strain gauge or microphone (mechanical)
- Optical changes (changes in density)

9. What are systolic, diastolic and mean pressure? Mention its normal values.

The maximum pressure reached during cardiac ejection is called systolic pressure (120 mmHg) and the minimum pressure occurring at the end of a ventricular relaxation is termed as diastolic pressure (80 mmHg). The mean arterial pressure over one cardiac cycle is approximated by adding one-third of the pulse pressure (difference between systolic and diastolic values) to the

diastolic pressure. All blood pressure measurements are made with reference to the atmospheric pressure.

10. What are the advantages of measurement of blood pressure by direct method?

Measurement of blood pressure by the direct method, though an invasive technique, gives not only the systolic, diastolic and mean pressures, but also a visualization of the pulse contour and such information as stroke volume, duration of systole, ejection time and other variables. Once an arterial catheter is in place, it is also convenient for drawing blood samples to determine the cardiac output (by dye dilution curve method), blood gases and other chemistries.

11. What is Sphygmomanometer?

A Sphygmomanometer is an instrument for measuring blood pressure, typically consisting of an inflatable rubber cuff which is applied to the arm to the arm and connected to a column of mercury scale. The systolic and diastolic blood pressure determined by increasing and gradually decreasing the pressure in the cuff.

12. Define Korotkoff sound.

To obtain a blood pressure measurement with a sphygmomanometer and a stethoscope, the pressure cuff on the upper arm is first inflated to a pressure well above systolic pressure. At this point no sounds can be heard through the stethoscope, which is placed over the brachial artery, for that artery has been collapsed by the pressure of the cuff. The pressure in the cuff is then gradually reduced. As soon as cuff pressure falls below systolic pressure, small amounts of blood spurt past the cuff and **Korotkoff** sounds begin to be heard through the stethoscope. The pressure of the cuff that is indicated on the manometer when the first **Korotkoff** sound is heard is recorded as the systolic blood pressure.

13. List the various types of methods used to measure Blood pressure.

Non-Invasive or Indirect methods

Auscultatory Method (Sphygmanometer)

Palpatory Method(Riva-Rocci Method)

Ultrasonic Method

Oscillometric Method

Invasive

Extravascular

Intravascular

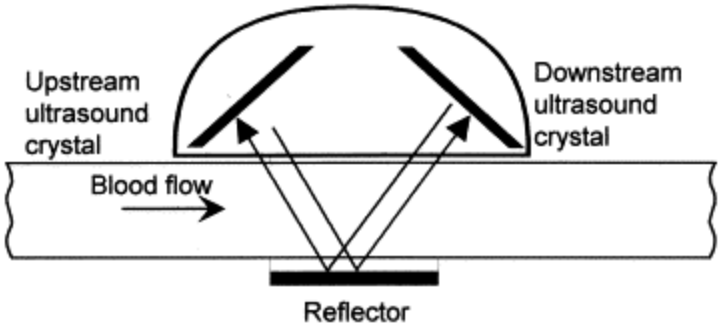
Sensor or transducer method (Electronic manometer)

14. **Differentiate Auscultatory and Palpatory methods of BP measurement.**

Palpatory Method	Auscultatory Method
It records the Systole blood pressure at which the pulse feel in the artery.	It records systole blood pressure through korotkoff sound by stethoscope which is placed in the artery.
Measurement of diastole pressure is difficult.	Diastole blood pressure is measured at which the korotkoff sound will disappear.

15. State the principle behind to measure blood flow using transit time method.

The transit time method uses two piezoelectric crystals transducer transmitting ultrasound through the blood vessel toward a reflector on the other side of the vessel .Volume flow is calculated by measuring the difference between transit times upstream and downstream in the blood vessel.



16. What is the need for cardiac output measurement?

Cardiac output, describes the volume of blood being pumped by the heart, in particular by the left or right ventricle, per unit time. Cardiac output is the product of the heart rate (HR), or the number of heart beats per minute (bpm), and the stroke volume (SV), which is the volume of blood pumped from the ventricle per beat; thus, CO = HR × SV. Values for cardiac output are usually denoted as L/min.

17. List the different types of methods are used to measure cardiac output.

1. Fick's method
2. Indicator dilution method- Dye dilution –Thermal dilution Methods
3. Impedance technique
4. Ultrasound method

18. State Boyle's law.

It states that at constant temperature, the volume of gas varies inversely with the pressure.

$$V2/V1 = P1/P2$$

here temperature T= constant V2= Final volume V1 = Initial volume P1=Original (initial) pressure P2 = Final pressure

19. What is spirometer?

Spirometer is an instrument used to measure lungs capacity and volume. spirometers are calibrated container ,that collect gas and make measurements of lung volume.

20. What is the reason for decrease of cardiac output?

The reason for decrease of cardiac output may be due to low blood pressure, reduced tissue oxygenation, poor renal function, shock and acidosis.

21. What is meant by dead air?

The volume of air that is not available for gas exchange with the blood is known dead air. It is less than 30% of the total volume.

PART-B

1. Describe the methods used for respiration rate measurement.
2. Explain the types of temperature measurement in detail.
3. Sketch the block diagram of automated sphygmomanometer for blood pressure measurement and explain its operation.
4. Discuss the principle and working of ultrasound blood flow meters.
5. Draw the block diagram of electronic manometer and explain the measurement of blood pressure.
6. Give the theory behind the indicator dilution and dye dilution method and explain the measurement technique for cardiac output using that method.