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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

OMD551-BASIC OF BIOMEDICAL INSTRUMENTATION

SEMESTER V

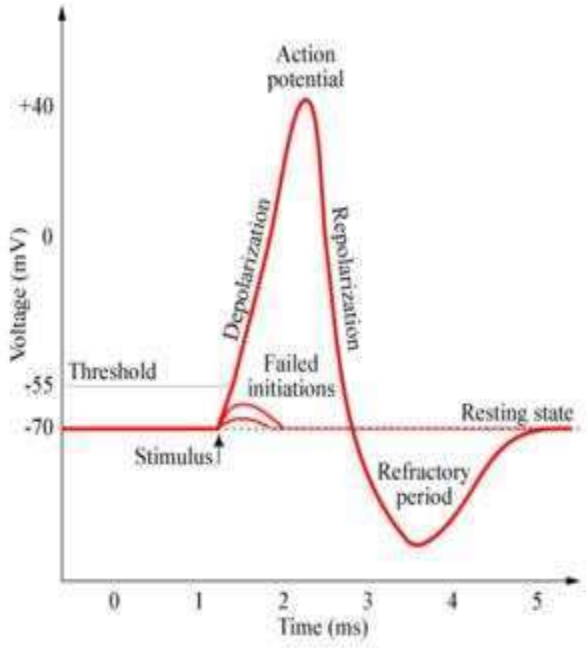
REGULATION 2017

Unit - I

1. **Define Resting Potential and Action potential**

Resting potential is defined as the electrical potential of an excitable cell relative to its surroundings when not stimulated or involved in passage of an impulse. It ranges from 60mVto -100mV

Action potential is defined as the change in electrical potential associated with the passage of an impulse along the membrane of a cell.



2. **Define depolarization and repolarisation.**

Depolarization is when a cell membrane's charge becomes positive to generate an action potential. This is usually caused by positive sodium and calcium ions going into the cell.Repolarization is when a cell membrane's charge returns to negative after depolarization. This is caused by positive potassium ions moving out of the cell.

3. **What is electrode? List out the types and explain**

It is a component used to pickup the biopotential signals. Bascially there are 2 types of electrode polarizable and non polarizable electrode.

Polarizable electrode are those in which no actual charge across the electrode electrolyte interface when current is applied.

Non polarizable electrode are those in which curent passes freely across the electrode electrolyte interface requiring no energy to make the transition.

4. **What are the classfication of non polarizable electrode?**

There are 2 types of non polarizable electrode 1) internal electrode 2) external electrode

Internal electrode- the electrode are inserted depth to body

External electrode – the electrodes are placed to the surface of the skin.

5. **List out some example of internal and external electrode and their uses.**

- **External electrode**
- Silver silver cholride electrode- EEG
- Calomel electrode - electrochemical applications
- Metal plate electrode (Surface) -ECG &EMG
- Suction electrode - ECG limb electrode
- Floating electrode - EMG
- Flexible electrode - ECG &Respiration by impedence technique
- **Internal electrode**
- Micro electrode or Needle electrode

6. **Define half cell potential.**

The half-cell potential is the potential developed at the electrode of a half cell due to the process of oxidation or reduction. This potential is used to indicate corrosion activity, and measures the tendency of one reaction, like oxidation, to proceed at its one half-cell electrode and similarly measures the corresponding tendency for reduction to proceed at the other half-cell electrode.

Each half-cell potential is associated with an electrode-solution potential difference. The potential magnitude depends on the nature of the specific electrode reaction and on the concentrations of the dissolved solution. The sign of this potential difference depends on the direction (oxidation or reduction) in which the electrode reaction proceeds.

A half-cell potential measurement is a non-destructive method to assess the corrosion risk of steels in concrete. This method is cheaper and can be easily used. In reinforcing concrete, an electrode forms one half of the cell and the reinforcing steels in the concrete form the other half cell. The behavior of steel in concrete can be characterized by measuring its half-cell potential. The chances of corrosion occurring on the steel in concrete and half-cell potential are directly proportional; the higher the potential, the higher the risk of corrosion occurrence.

7. How will you reduce the polarization effects of electrodes?

A depolarizer or depolariser, in electrochemistry, according to an IUPAC definition, is a synonym of electroactive substance, i.e., a substance which changes its oxidation state, or

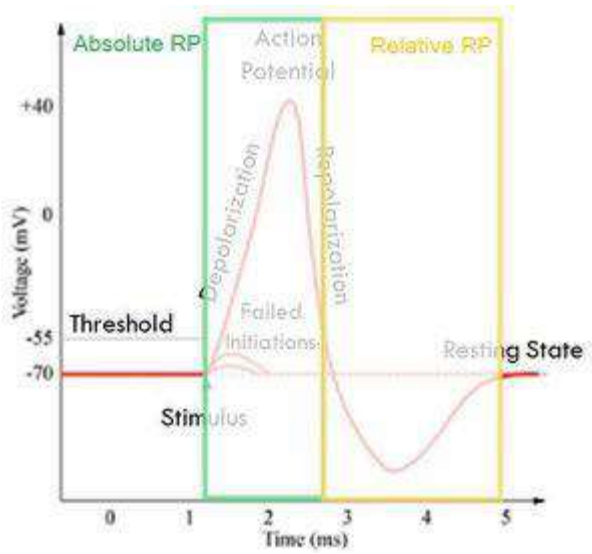
partakes in a formation or breaking of chemical bonds, in a charge-transfer step of an electrochemical reaction.
In the battery industry, the term "depolarizer" has been used to denote a substance used in a primary cell to prevent buildup of hydrogen gas bubbles. A battery depolarizer takes up electrons during discharge of the cell; therefore, it is always an oxidizing agent. The term "depolarizer" can be considered as outdated

or misleading, since it is based on the concept of "polarization" which is hardly realistic in many cases .

8. State the uses of electrode paste.
The Electrode Gel is best used when storing pads between sessions. The amount of moisture in the pad is related to the pad's adhesion. As the pads start to lose their moisture content, the adhesion is reduced. A small dab of gel spread over the pad's sticky side before it is placed on the film for storage will increase the moisture content and adhesion of the pad.

9. Distinguish between metallic and non-metallic microelectrode.
Electrode terminal through which electric current passes between metallic and nonmetallicparts of an electric circuit. In most familiar circuits current is carried by metallic conductors, but insome circuits the current passes for some distance through a nonmetallic conductor. For example,in electrolysis current passes through a liquid electrolyte; in a fluorescent lamp current passesthrough a gas. An electrode is usually in the form of a wire, rod, or plate. It may be made of a metal,e.g., copper, lead, platinum, silver, or zinc, or of a nonmetal, commonly carbon.
The electrode through which current passes from the metallic to the nonmetallic conductor is called the anode,and that through which current passes from the nonmetallic to the metallic conductor, the cathode.(Electron flow is in a direction opposite that of conventionally defined current.) In most familiarelectric devices, current flows from the terminal at higher electric potential (the positive electrode) tothe terminal at lower electric potential (the negative electrode); therefore, the anode is usually thepositive electrode and the cathode the negative electrode.

10. Define absolute and relative refractory period.
Absolute: Is the period of time during which a second action potential ABSOLUTELY cannot be initiated, no matter how large the applied stimulus is. Relative: Is the interval immediately following the Absolute Refractory Period during which initiation of a second action potential is INHIBITED, but not impossible. As voltage-gated potassium channels open to terminate the action potential by repolarizing the membrane, the potassium conductance of the membrane increases and the K+ ions move out of the cell and bring the membrane potential closer to the equilibrium potential for potassium and this can lead to membrane hyperpolarization.



11. What are the salient features of needle electrodes?

Small needle electrodes are sometimes used for carrying out special EEG studies when they are inserted subcutaneously. Electrodes for electromyographic work are usually of the needle type.Needle electrodes are used in clinical electromyography, neurography and other electrophysiological investigations of the muscle tissues underneath the skin and in the deeper tissues. The material of the needle electrode is generally stainless steel. In spite of the fact that stainless steel is unfavourable electrode material from the point of view of noise, it is preferred in EMG work due to its mechanical solidity and low price. Needle electrodes are designed to be fully autoclavable and in any case they should be thoroughly sterilized before use.

12. 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.

13. 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.

14. What is meant by 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.

15. List the different types of Surface electrodes.

Metal Plate electrodes

Suction cup electrodes
Adhesive tape electrodes
Multi point electrodesFloating electrodes

16. List the different types of Micro electrodes.

Metal microelectrodes
Supported metal micro electrodes and Micropipette electrodes

17. List the different types of internal electrodes.

Wire loop electrode
Silver sphere cortical electrode and Multi element depth electrode

18. Give any 4 factors to be consider when design a medical equipment?
Accuracy,frequency,linearity ,s/n ratio, stability

19. Define sensitivity
The electrical output per unit change in the physical parameter high sensitivity is generally desirable for transducer

20. What is electrode potential?
The voltage developed by an electro-electrolyte interface is called electrode potential.

UNIT 2

1. **Define ECG**

Electrocardiography deals with the study of the electrical activity of heart muscles. The potentials originated in the individual fibres of heart muscle are added to produce ECG waveform.

2. **What are the different artefacts encountered while recording ECG?**

- Interference from the power line
- Shifting of the base line
- Muscle tremor.

3. **Define EEG**

Electroencephalography deals with the recording and study the electrical activity of brain .By means of electrode attached to the skull of a patient the brain waves can be picked up and recorded**.**

4. **What are the important bands of frequencies in EEG and state their importance**.

Waves	**Frequency (Hz)**	**Observation**
Delta(δ)	0.5 – 4	These wave occur in deep sleep in premature babies and in very serious organic brain disease

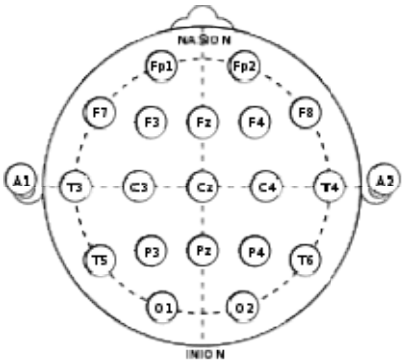
Theta (θ)	4 – 8	These wave occurs during emotional stress in some adults particularly during disappointment and frustration
Alpha(α)	8 – 13	They found in the normal persons when they are awake in a quiet, resting state. During sleep they disappear.
Beta(β)	13- 22	It is observed when the person is alert active, busy, or anxious thinking, active concentration

5. **What are the different artefacts encountered while recording EEG?**

- **Artifacts due to electrode problems may result from**
- Poor contact
- Improper positioning
- **Artifacts due to physiological positioning**
- The heart ECG
- Tongue and facial movement
- Eye movement
- **Artifacts due to electrical interference**
- 60V AC common mode interface

6. **What is montage system?**

The most commonly used electrode system for recording EEG signal is termed as 10-20 electrode system or montage electrode system.The electrodes are placed symmetrically on the both sides of the skull, at a distance of 10% and 20% appropriately form the distance between the extreme and points of the skull namely nasion, inion,right and left ear lobes.



7. **What is evoked potential?**

The external stimuli are detected by the sense organs which cause changes in the electrical activity of the brain. Due to this, potential is developed in the brain as the response to external stimului like light, sound etc. It is called as evoked potential.

8. Define EMG

Electromyography is the study of electrical activity of muscle fibres with the help of this the nerve conduction velocity is obtained.

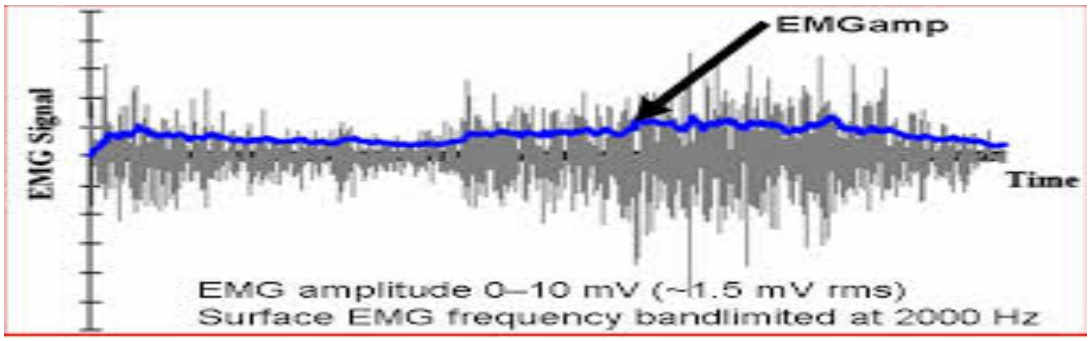
9. Define latency as related to EMG.

Latency is defined as the elapsed time between the stimulating impulse and the muscle action potential. In other words it is the time delay between stimulus and response

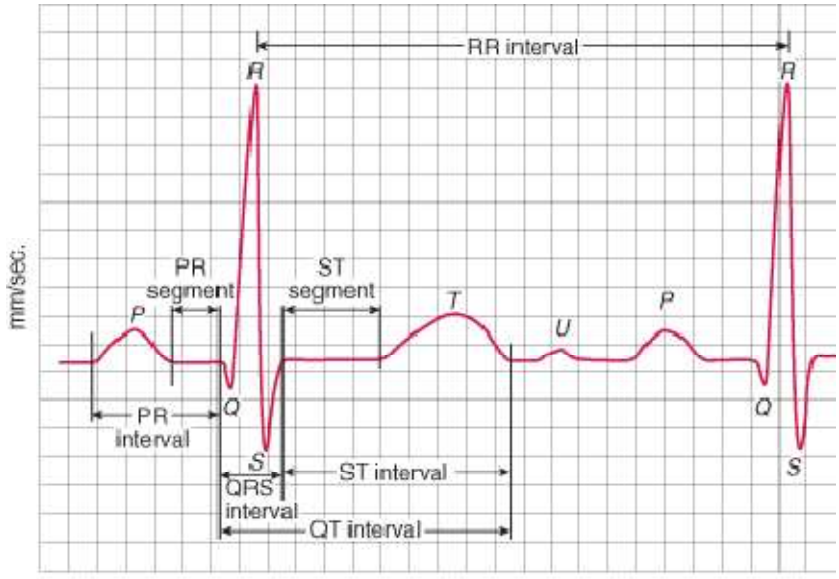
10. Define – Conduction Velocity

Conduction velocity is defined as the rate at which an action potential moves down a fiber or is propagated from cell to cell. It is also called as Nerve conduction rate.

11. Draw the typical EMG waveform.



12. Draw the typical ECG waveform.



Wave	Amplitude (mV)	Duration (sec)

P	0.25	0.12 – 0.22 (P – R interval)
R	1.06	0.07 – 0.1
T	0.1 – 0.5	0.05 – 0.15 (S – T segment)
QRS Complex	-	0.09

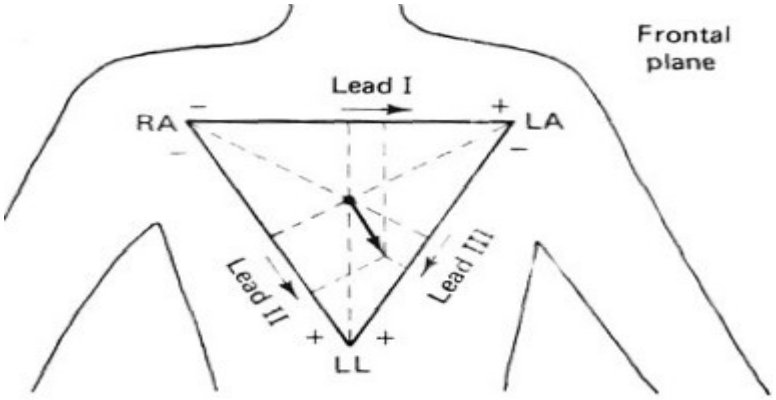
13. What are the different types of ECG lead configuration?

- Bipolar limb leads
- Augmented unipolar limb leads
- Chest leads
- Frank lead system

14. Write the physiological nature of ECG waveform

- P wave - Atrial polarization or contraction
- R wave - repolarization of the artia and the depolarization of ventricles
- T wave - ventricular repolarization
- S-T interval - ventricular contraction
- U wave - slow repolarization of the ventricles

15. Draw the Einthoven Triangle



16. Define latency in EMG

The interval between the stimulation of a compound muscle and the observed response.Normal nerve conductionvelocity is above 40 m/sec in the lower extremities and above 50 m/sec in the upperextremities, but age, muscle disease, temperature, and other factors can influence the velo city.

17. What are unipolar and bipolar modes of EMG?

In a unipolar measurement the output signals are formed by several input electrodes that are amplified against one so called reference. This can be an electrode, or a calculated internal reference potential. This is not a two channel recording, but a multichannel measurement. This type of recording is often used when measuring EEG or multichannel ECG. A new field of unipolar measurements is the high density surface EMG, where for instance 128 channels are measured using so called grid electrodes.

Two types of unipolar measurement principles are known:

- Common reference
- Average reference

The common reference amplifier just has one electrode, which is used as one part of every bipolar input and several other electrodes that form the other parts of the bipolar inputs.In the average reference amplifier there is no electrode that acts as the reference for the measurement system. Instead, the multichannel bipolar derivatives are made by using one electrode as one part of the input of each bipolar amplifier, and the mean of all the connected electrodes as the other input of each bipolar amplifier.The average reference principle has several advantages over the common reference principle. It should be stressed, however, that the way in which the signals are recorded and the way they are analyzed are two different things.

18. Define NCV

NCV is defined as nerve conduction velocity,the time taken to pass the through a neuron.

NCV=difference between the electrodes/time

19. What are the electrode used for the measurement of EMG?

Needle electrode

Surface electrode

20. What are abnormalities of ECG?

- 1 ORDER STROKE
- 2ORDER STROKE
- ARRTHYMIA

UNIT 3

1. Write the effect of power line interference in bio signal recording?

Modern biomedical amplifiers have a very high common mode rejection ratio. Nevertheless, recordings are often contaminated by residual power-line interference. Traditional analogue and digital filters are known to suppress ECG components near to the power-line frequency. Different types of digital notch filters are widely used despite their inherent contradiction: tolerable signal

distortion needs a narrow frequency band, which leads to ineffective filtering in cases of larger frequency deviation of the interference. Adaptive filtering introduces unacceptable transient response time, especially after steep and large QRS complexes. Other available techniques such as Fourier transform do not work in real time. The subtraction procedure is found to cope better with this problem.

2. **What is the need for band pass filters in biological pre-amplifiers?**

   A band-pass filter (also bandpass filter, BPF) is a device that passes frequencies within a certain range and rejects (attenuates) frequencies outside that range.based on power spectra estimation of the QRS complex,that a band pass filter with the center frequency 17HZ,and a Q of five ,yield the best signal to noise ratio.

   - By using a bandpass filter rather than a lowpass filter, the amplitude of low frequency noise as well as the low frequency components of the ECG will be reduced without affecting the *QRS*.
   - Since the frequency spectrum of the foetal ECG differs somewhat from the maternal ECG, some initial signal separation is achieved by using the appropriate bandpassfiltering in each channel. The bandpass filter, therefore, enhancesthe signal/noise ratio—the noise in this context being, for example, foetal movements at lowfrequencies and maternal placental blood flow at high frequencies.
   - Pacemaker sensing amplifiers employ bandpass filters to discriminate between R-wave and T-wave. A consequence of this is that R-waves of smaller slew rate are also attenuated and therefore, it is likely that an R-wave with an amplitude exceeding the R-wave sensitivity of the sensing amplifier may not be sensed. This is of critical importance in cases of low amplitude R-waves (under 5 mV) where even moderate attenuation could lead to sensing problems.

3. **Write any two conditions of biological preamplifiers.**
   - The single-ended output, often differential input.
   - High common mode rejection ratio(CMRR).
   - Extremely high-input impedance.
   - Variable gain adequate to do the job intended.
   - Frequency response suitable for the application. In the case of a universal bioelectric amplifier, the response should be variable through switch selection.Zero suppression. This feature allows shift about the zero baseline by nullimg offsets inherent in the signal.

4. **What is powerline interference?**

   Filtering such PLI signal is a challenging problem given that the frequency of the time-varying powerline signal lies within the frequency range of the ECG and EEG signals [1,2]. Another well-known method for cancelling the 50/60-Hz interference is using a notch 50/60-Hz filter.the inference may be due to the stray effect of alternating current on the patient or patient table.

5. Differentiate single ended and differential ended mode of a biological amplifier.

One of the most common questions asked is the difference between single-ended and differential inputs, and what applications they should be considered in. First, a simple definition:

- DIFFERENTIAL INPUTS - A signal input circuit where SIGNAL LO and SIGNAL HI are electrically floating with respect to ANALOG GROUND. For example, a differential input A/D card will have one HI (+) and one LOW (-) pin for each input. There will also be a LLGND (LOW LEVEL GROUND) pin which may be used if a ground connection is required. This allows the measurement of the voltage difference between two signals tied to the same ground and provides superior common-mode noise rejection. Where differential inputs should be used? Whenever electromagnetic interference (EMI) or radio frequency interference (RFI) is present, a voltage can be induced on BOTH signal wires. A differential input amplifier will reject the COMMON MODE VOLTAGE, provided that the common mode voltage plus the input signal does not exceed the device's CMR specification. The effect on a single-ended input is usually a voltage fluctuation between signal high and signal ground.
- SINGLE-ENDED INPUTS - A single-ended input has no common mode range because there is only ONE low wire, which is shared by all inputs. For example, if you have an A/D board with 16 single-ended inputs, there will be 16 HIGH (+) lines and one LOW (-) line (sometimes called LLGND). Some cards may have several LOW lines to provide extra places to make your ground connection, however, these lines are tied together and are basically the same thing.

6. **When to use single-ended or differential inputs?**
   Differential inputs provide a more stable reading when EMI or RFI is present, and therefore, it is recommended to use them whenever noise is generally a problem. This is especially true when measuring THERMOCOUPLE, STRAIN GAGE and BRIDGE TYPE PRESSURE SENSOR inputs, since they produce very small signals that are very susceptible to noise.Single-ended inputs are lower in cost, and provide twice the number of inputs for the same size wiring connector, since they require only one analog HIGH (+) input per channel and one LLGND (-) shared by all inputs. Differential inputs require signal HIGH and LOW inputs for each channel and one common shared LLGND. Single-ended inputs save connector space, cost, and are easier to install.

7. Why do we require isolation amplifiers in a biomedical instrument?

Isolation amplifiers are commonly used for providing protection against leakage currents. Theybreak the ohmic continuity of electric signals between the input and output of the amplifier. Theisolation includes different supply voltage sources and different grounds on each side of the isolation barrier. Three methods are used in the design of isolation amplifiers: (i) transformer isolation (ii) optical isolation (iii) capacitive isolation.

8. Mention the different types of filters used in biosignal measurement.

The ECG waveform is processed by two digital filters: a detection filter and a classification filter. The detection filter removes low frequency noise (baseline wander) and muscle artifact. *P*waves and *T* waves are diminished. This filter helps avoid an erroneous detection of tall *T* wavesas beats. Even though the shape of the *QRS*is distorted, the output from the detection filter is usedonly for beat detection.The classification filter removes signal irregularities, and preserves the important features ofthe*QRS*. So, the resulting ECG output can be used for feature measurements and beat classification.The biosignals, say for example ECG, originate from the body potentials whereas the noise is mainly from the man-made electrical sources. 50-60Hz Power-line frequencies are the worst enemies in bio-potential amplification/processing so you need to filter out these first. Usually a notch filter is applied to remove these power-line components and a low pass filter is used to restrict other high frequency signals entering into your system. This is needed particular to avoid the aliasing effect (filter act as anti-aliasing) in sampled systems with digital processing of the signals.

9. What are the characteristics of a DC amplifier?

It may need balanced differential inputs giving a high Common Mode Rejection Ratio (CMRR).It should have extremely good thermal and long term stability.

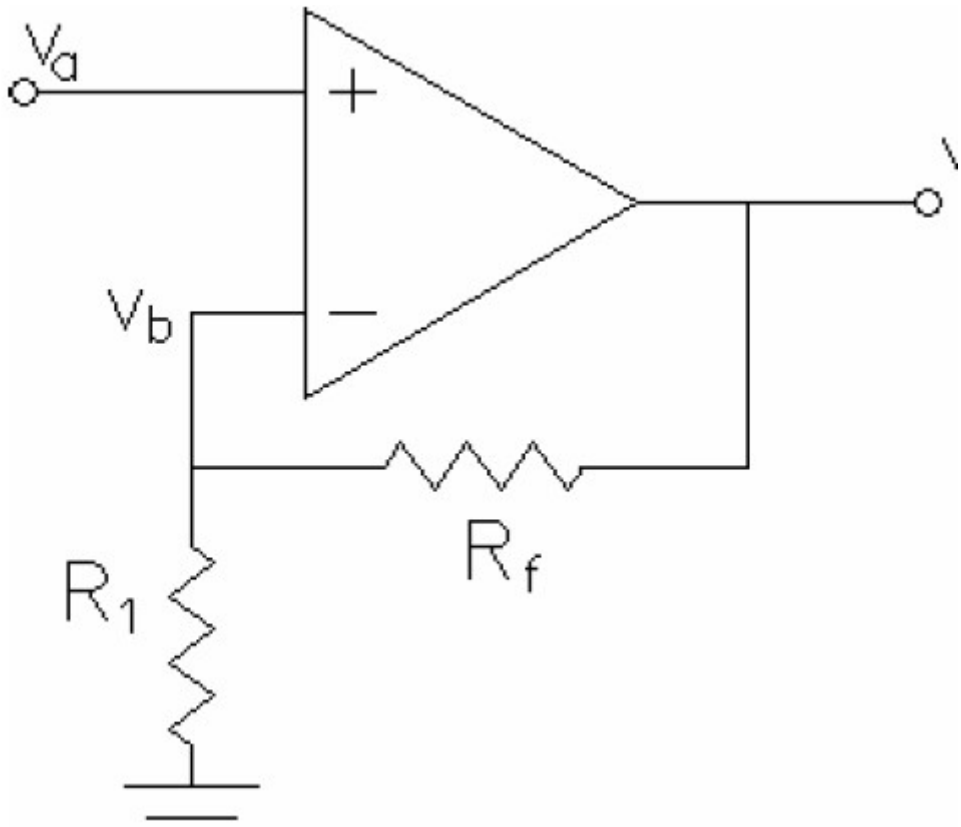
10. What are the types of chopper amplifier?

- Mechanical chopper amplifier
- Non mechanical chopper amplifier

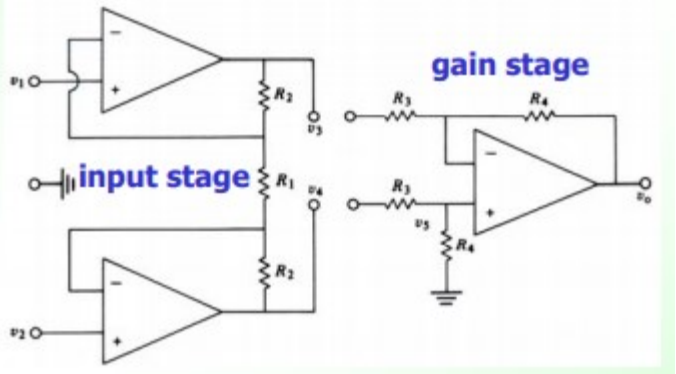
11. Mention the characteristics of instrumentation amplifier

High gain
High CMRR
Low output impedance

12. Draw the circuit diagram of a non-inverting amplifier ?[AUC May 2008]



13. **Mention the applications of an instrumentation amplifier.[AUC May 2009]**
    - Data acquisition system.
    - Temperature indicator
    - Temperature controller.
    - Light intensity meter
14. **Why active guard drive is necessary for an instrumentation amplifier?[AUC MAY 2012]**
    - The common ground is shared by variety of circuits.
    - Due to ground loop interference , additional voltage drop develops and lead to error in low voltage measurement.
    - Due to distributed cable capacitances degradation of CMRR occurs.
    - The active guard drive eliminates all these problems.
15. **Draw the instrumentation amplifier diagram**



16. **What is frequency distortion?**
    - if filter specification does not match the frequency content of biopotential
    - then the result is hig qy h and low frequency distortion

17. what is mean by preamplifier?

UNIT 4

1. **Explain the principle of electromagnetic blood flow measurement.**

Faraday's law of electromagnetic induction which states that when a conductor is moved at right angles through a magnetic field in a direction at right angles both to the magnetic field and its length, an emf is induced in the conductor. In the flowmeter, an electromagnetic assembly provides the magnetic field placed at right angles to the blood vessel (Fig. 11.1) in which the flow is to be measured. The blood stream, which is a conductor, cuts the magnetic field and voltage is induced in the blood stream. This induced voltage is picked up by two electrodes incorporated in the magnetic assembly. The magnitude of the voltage picked up is directly proportional to the strength of the magnetic field, the diameter of the blood
vessel and the velocity of blood flow, i.e.

$e = CHVd$

where e = induced voltage

H = strength of the magnetic field

V = velocity of blood flow

d = diameter of the blood vessel

C = constant of proportionality

2. **What is thermal dilution in cardiac output measurement?**

Measurement of **Cardiac Output**-The blood temperature is **measured** by a thermistor at the catheter tip, which lies within the pulmonary artery, and a computer is used to acquire the **thermodilution** profile; that is, the computer quantifies the change in blood temperature as it flows over the thermistor surface.

3. **What is cardiac output and stroke volume?**

Cardiac output, expressed in liters/minute, is the amount of blood the heart pumps in 1 minute. Cardiac output is logically equal to the product of the stroke volume and the number of beats per minute (heart rate).

stroke volume (**SV**) is the volume of blood pumped from the left ventricle per beat. Stroke volume is calculated using measurements of ventricle volumes from an echocardiogram and subtracting the volume of the blood in the ventricle at the end of a beat (called end-systolic volume) from the volume of blood just prior to the beat (called end-diastolic volume). The term *stroke volume* can apply to each of the two ventricles of the heart, although it usually refers to the left ventricle. The stroke volumes for each ventricle are generally equal, both being approximately 70 mL in a healthy 70-kg man.

4. What is korotkoft sound?

When cuff in inflated to a pressure that only partially occludes the brachial artery turbulence isgenerated in thee blood as it spurts through the tiny arterial opening during each systole. Thesounds generated by this turbulence are called korotkoft sounds.

5. What are the methods used to measure blood pressure is directly?

Catheterization method involving the sensing of blood pressure through a liquid column. In thismethod the transducers is external to the body and blood pressure is transmitted through a salinesolution column in a catheter to this transducers. This method also involves the placement oftransducers through a catheter at the actual site of measurement in the blood stream. Percutaneousmethods in which the blood pressure is sensed in the vessel just under the skin by the use of aneedle or catheter. Implantation technique in which the transducer is more permanently placed inthe blood vessel.

6. What is meant by Doppler Effect?

The frequency of the reflected ultrasonic energy is increased or decreased by a moving interface.The amount of frequency shift can be expressed as, $f=2V/\lambda$, f=shift in frequency of the reflected wave, V=velocity of the interface, λ=wavelength of the transmitted ultrasound. The frequency increases when interface moves towards the transducer & decreases when it moves away.

7. Give the methods for measuring blood flow.

1.Indirect method – sphygmomanometer.
2.Direct method
3.Percutaneous insertion
4.Catheterization (vessel cut down)
5.Implantation of a transducer in a vessel or in the heart.

8. What is cardiac output and its normal rate?

Blood flow is highest in the pulmonary artery and the aorta, where the blood vessels leave the heart. The flow at these points is called cardiac output, is between 3.5 and 5liters/min in a normal adult at rest.

9. What are the causes of Cerebrovascular accident (CVA)?

When the blood flow in a certain vessel is completely obstructed, the tissue in the area supplied by this vessel may die. Such an obstruction in a blood flow of the brain is one of the causes of CVA or stroke.

10. What are the methods involved in direct blood pressure measurement?

 Auscultator method
 Palpatory method

11. Give the principle of transduction of heart sounds.

The sounds and murmurs which originate from the heart can be picked up from the chest using stethoscope or by transduction of heart sounds in to electrical signal.

12. What is meant by mean arterial pressure?

The cuff pressure at the point of maximum oscillations usually corresponds to the mean arterial pressure. The point above the mean pressure at which the oscillations begin to rapidly increase in amplitude correlates with the diastolic pressure (Fig. 6.31). These correlations have been derived and proven empirically but are not yet well explained by any physiologic theory. The actual determination of blood pressure by an oscillometric device is performed by a proprietary algorithm developed by the manufacturer of the device. The oscillometric method is based on oscillometric pulses (pressure pulses) generated in the cuff during inflation or deflation. Blood pressure values are usually determined by the application of mathematical criteria to the locus or

envelope formed by plotting a certain characteristic, called the oscillometric pulse index, of the oscillometric pulses against the baseline cuff pressure (Fig. 6.32). The baseline-to-peak amplitude, peak-to-peak amplitude, or a quantity based on the partial or full time-integral of the oscillometric pulse can be used as the oscillometric pulse index. The baseline cuff pressure at which the envelope peaks (maximum height) is generally regarded as the MAP (mean arterial pressure). Height-based and slope-based criteria have been used to determine systolic and diastolic pressures.

13. **Define systole and diastole.**

Diastolic pressure occurs near the beginning of the cardiac cycle. It is the minimum pressure in the arteries when the pumping chambers of the heart — ventricles — fill with blood. Near the end of the cardiac cycle,**systolic pressure**, or peak pressure, occurs when the ventricles contract.As the heart beats, it pumps blood through a system of blood vessels, which carry blood to every part of the body. Blood pressure is the force that blood exerts on the walls of blood vessels. All or any of the events related to the flow or blood pressure that occurs from the beginning of one heartbeat to the beginning of the next is called a cardiac cycle. Problems in the cardiac cycle can cause low or high blood pressure.

14. Comparison chart for systole and diastole pressure.

Diastolic versus Systolic comparison chart		
	Diastolic	**Systolic**
Definition	It is the pressure that is exerted on the walls of the various arteries around the body in between heart beats when the heart is relaxed.	It measures the amount of pressure that blood exerts on arteries and vessels while the heart is beating.
Normal range	60 – 80 mmHg (adults); 65 mmHg (infants); 65 mmHg (6 to 9 years)	90 – 120 mmHg (adults); 95 mmHg (infants); 100 mmHg (6 to 9 years)
Importance with age	Diastolic readings are particularly important in monitoring blood pressure in younger individuals.	As a person's age increases, so does the importance of their systolic blood pressure measurement.
Blood Pressure	Diastolic represents the minimum pressure in the arteries.	Systolic represents the maximum pressure exerted on the arteries.

Ventricles of the heart	Fill with blood	Left ventricles contract
Blood Vessels	Relaxed	Contracted
Blood Pressure reading	The lower number is diastolic pressure.	The higher number is systolic pressure.
Etymology	"Diastolic" comes from the Greek diastole meaning "a drawing apart."	"Systolic" comes from the Greek systole meaning "a drawing together or a contraction."

15. **How respiration rate is measured using thermistor method**?

Since air is warmed during its passage through the lungs and the respiratory tract, there is a detectable difference of temperature between inspired and expired air. This difference of temperature can be best sensed by using a thermistor placed in front of the nostrils by means of a suitable holding device. In case the difference in temperature of the outside air and that of the expired air is small, the thermistor can even be initially heated to an appropriate temperature and the variation of its resistance in synchronism with the respiration rate, as a result of the cooling effect of the air stream, can be detected. This can be achieved with thermistor dissipations of about 5 to 25 mW. subject.

16. **What are the direct methods of blood pressure measurement?**

The direct method of pressure measurement is used when the highest degree of absolute accuracy,dynamic response and continuous monitoring is required. The method is also used to measure thepressure in deep regions inaccessible by indirect means. For direct measurement, a catheter or aneedle type probe is inserted through a vein or artery to the area of interest. Two types of probescan be used. Measurement of blood pressure by the direct method, though an invasive technique, gives notonly the systolic, diastolic and mean pressures, but also a visualization of the pulse contour andsuch information as stroke volume, duration of systole, ejection time and other variables. Once anarterial catheter is in place, it is also convenient for drawing blood samples to determine thecardiac output (by dye dilution curve method), blood gases and other chemistries.

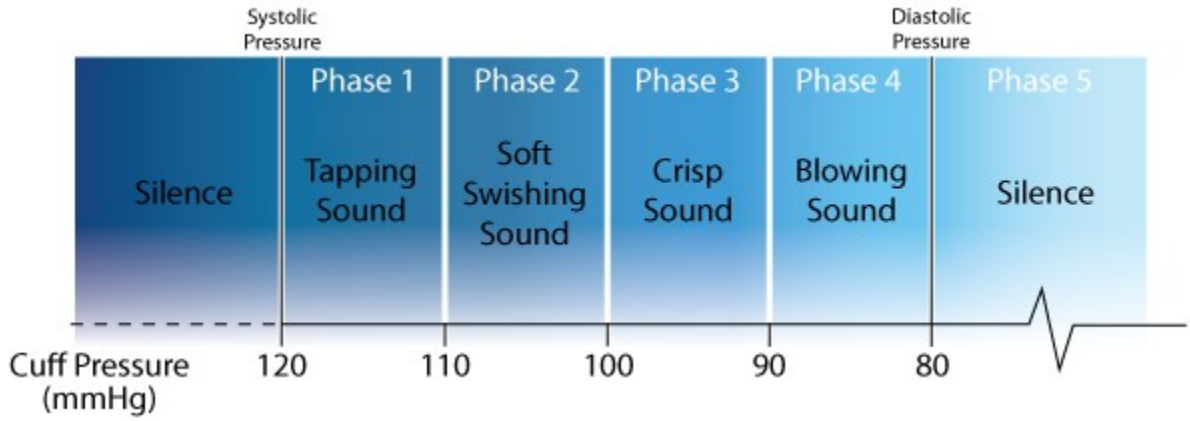
17. **Define and mention the significance of korotkoff sounds.**

Korotkoff sounds (or K-Sounds) are the "tapping" sounds heard with a stethoscope as the cuff is gradually deflated. Traditionally, these sounds have been classified into five different phases (K-1, K-2, K-3, K-4, K-5) and are shown in the figure below.

- K-1 (Phase 1): The appearance of the clear "tapping" sounds as the cuff is gradually deflated. The first clear "tapping" sound is defined as the systolic pressure.
- K-2 (Phase 2): The sounds in K-2 become softer and longer and are characterized by

a swishing sound since the blood flow in the artery increases.

- K-3 (Phase 3): The sounds become crisper and louder in K-3 which is similar to the sounds heard in K-1.
- K-4 (Phase 4): As the blood flow starts to become less turbulent in the artery, the sounds in K-4 are muffled and softer. Some professionals record diastolic during Phase 4 and Phase 5
- K-5 (Phase 5): In K-5, the sounds disappear completely since the blood flow through the artery has returned to normal. The last audible sound is defined as the diastolic pressure.



Korotkoff sounds are blood flow sounds that healthcare providers observe while taking blood pressure with a sphygmomanometer over the brachial artery in the antecubital fossa. These sounds appear and disappear as the blood pressure cuff is inflated and deflated.

18. **How can the pulse be detected using piezoelectric crystals?**

The method consists in putting a cuff around the upper part of the patient's arm and place microphone over the brachial artery. The compressed air required for inflating the cuff is provided by a pumping system incorporated in the apparatus. Usually the inflating is done to a preset pressure level, well beyond the systolic value at the rate of approximately 30 mmHg/s. The pressure in the cuff is then decreased at a relatively slow pace at the rate of 3–5 mmHg/s. The cuff is to be applied in such a way that the veins are not occluded. While air is allowed to leak from the cuff, the Korotkoff sounds are picked up by a special piezoelectric microphone. The corresponding electrical signals are fed to a preamplifier. The amplified signals are then passed on to a bandpass filter having a bandwidth of 25 to 125 Hz. With this passband, a good signaI-to-noise ratio is achieved when recording Korotkoff sounds from the brachial artery beneath the lower edge of the cuff. The system is so designed that the appearance of the first Korotkoff sound switches in the systolic manometer and locks the reading on the indicating meter. In a similar way, the diastolic value is fixed by the last Korotkoff sound. The cuff is completely deflated, automatically, after an interval of 2–5 s after the determination of the diastolic value.

19. Define respiration rate.

The respiration rate is the number of breaths a person takes per minute. The rate is usually measured when a person is at rest and simply involves counting the number of breaths for one

minute by counting how many times the chest rises. Respiration rates may increase with fever, illness, and with other medical conditions. When checking respiration, it is important to also note whether a person has any difficulty breathing. Normal respiration rates for an adult person at rest range from 12 to 16 breaths per minute.

20. What are the methods to measure the respiration rate?

Displacement method, thermistor method, impedance pneumography and CO_2 method.

21. Write short notes on auscultatory method of pressure measurement?

The auscultatory method (also known as the Riva Rocci Korotkoff or manual method for blood pressure measurement) is the LISTENING of Korotkoff sounds in the brachial artery. The gold standard for clinical blood pressure measurement has always been to take a blood pressure using the auscultatory method where a trained healthcare provider uses a sphygmomanometer and listens for the Korotkoff sounds using a stethoscope. However, there are many variables that affect the accuracy of this method and numerous studies have shown that physicians and healthcare providers rarely follow the established guidelines for taking proper manual blood pressure measurements.

22. Write short notes on oscillometric method of pressure measurement?

The oscillometric technique operates on the principle that as an occluding cuff deflates from a level above the systolic pressure, the artery walls begin to vibrate or oscillate as the blood flows turbulently through the partially occluded artery and these vibrations will be sensed in the transducer system monitoring cuff pressure. As the pressure in the cuff further decrease, the oscillations increase to a maximum amplitude and then decrease until the cuff fully deflates and blood flow returns to normal.The cuff pressure at the point of maximum oscillations usually corresponds to the mean arterialpressure. The point above the mean pressure at which the oscillations begin to rapidly increase inamplitude correlates with the diastolic pressure. These correlations have been derivedand proven empirically but are not yet well explained by any physiologic theory. The actualdetermination of blood pressure by an oscillometric device is performed by a proprietary algorithmdeveloped by the manufacturer of the device.

UNIT 5

1. **What are photometers?**

A **photometer**, generally, is an instrument that measures light intensity or the optical properties of solutions or surfaces. Most photometers detect the light with photoresistors, photodiodes or photomultipliers. To analyze the light, the photometer may measure the light after it has passed through a filter or through a monochromator for determination at defined wavelengths or for analysis of the spectral distribution of the light.

2. **What are the prinicipal components of auto analyser?**

 auto-sampler,proportioning pump,manifold,photocolorimeter,recorder (chart recorder).

 The sampler consists of a sample tray and a metal probe. The sample tray holds the cups that the sample is poured into. The tray on this model can hold up to 40 cups.

 The loaded sample tray rotates and the metal probe dips into each cup and aspirates a portion (1ml or less) of the contents for a given time interval. Near the probe wash receptacle is a sampler wheel.

 The sampler wheel determines the speed of the sampler and the ratio of sample to rinse. The speed and ratio is different for various chemical determinations or assays.

3. **How does the pH value determine the acidity or alkalinity in blood?**

The term pH means potentials of Hydrogen. Acidity and alkalinity are expressed on the pH scale, which ranges from 0 (strongly acidic) to 14 (strongly basic, or alkaline). A pH of 7.0, in the middle of this scale, is neutral. Blood is normally slightly basic, alkaline, with a pH range of 7.35 to 7.45. To function properly, the body maintains the pH of blood close to 7.40. An important property of blood is its degree of acidity and alkalinity, and this is referred to as acid-base balance. The acidity or alkalinity of the blood is indicated on the pH scale. The acidity level increases when the level of acidic compounds in the blood rises or when the level of alkaline compounds in the blood falls. Alkalinity levels increases with the reverse process.

The level of acidic or alkaline compounds in the body rises through increased intake, production, or decreased elimination and falls through decreased intake, production, or increased elimination

4. **What is the principle of colorimeter?**

A colorimeter is a device used in colorimetry. In scientific fields the word generally refers to the device that measures the absorbance of particular wavelengthsof light by a specific solution. This device is commonly used to determine the concentration of a known solute in a given solution by the application of the Beer-Lambert law, which states that the concentration of a solute is proportional to the absorbance.

5. **What is an autoanalyser and what are it's advantages and disadvantages?**

The autoanalyzer sequentially measures blood chemistry and displays this on a graphic readout.

Advantage:

Rapid test results

More samples tested simultaneously.

Disadvantages:

One problem with automatic analysers is certain identification of samples. Patient data can be intermixed with that of other patients if care is not taken.

Patient's life may hinge on accurate measurement obtained by clinical instrumentation.

6. **What are the differences between spectrophotometer and colorimeter?**

S.NO	Spectrophotometer	Colorimeter
1	A spectrophotometer is an instrument designed for physical sample analysis via full spectrum color measurement. By providing wavelength-by-wavelength spectral analysis of a sample's reflectance, absorbance, or transmittance properties, it produces precise data beyond that observable by the human eye.	A colorimeter is designed to perform a type of psychophysical sample analysis by mimicking human eye-brain perception. In other words, it is designed to see color the way we do.
2	Colorimeters are extraordinarily accurate for straightforward color measurement and ideally suited for determination of color difference, fastness, and strength as well as routine comparisons of similar colors. As such, they can be invaluable for color quality control and are primarily	Spectrophotometers offer a higher level of flexibility and versatility than colorimeters due in part to the fact that they offer multiple illuminant/observer combinations and can operate in multiple geometric arrangements, including 45°/0° and d/8°. As such, spectrophotometers are capable of measuring metamerism, identifying colorant strength,
	used in the production and inspection phases of manufacturing.	analyzing a comprehensive range of sample types, and giving users a choice between including or excluding specular reflectance to account for geometric attributes.
3	While colorimeters can produce highly accurate color measurements, they also have several shortcomings; they are not able to identify metamerism or colorant strength, are not ideally suited for color formulation, and cannot be used under variable illuminant/observer conditions.	Although historically spectrophotometers have been significantly larger and more complex instruments that made them unattractive to some, today's technological advances have made it possible to manufacture smaller and more user-friendly spectrophotometers, eliminating many of those concerns. However, not all manufacturers require the capabilities of spectrophotometric instruments and may find that their needs are met by a colorimeter.

7. **Mention the clinical significance of PO2 and PCO2 in blood.**

pCO2 (partial pressure of carbon dioxide) reflects the the amount of carbon dioxide gas dissolved in the blood. Indirectly, the pCO2 reflects the exchange of this gas through the lungs to the outside air.

PO2 (partial pressure of oxygen) reflects the amount of oxygen gas dissolved in the blood. It primarily measures the effectiveness of the lungs in pulling oxygen into the blood stream from the atmosphere.

8. What is Fick's technique?

Developed by Adolf Eugen Fick (1829–1901), the Fick principle has been applied to the measurement of cardiac output. Its underlying principles may also be applied in a variety of clinical situations.

The essence of the Fick principle is that blood flow to an organ can be calculated using a marker substance if the following information is known:

- Amount of marker substance taken up by the organ per unit time
- Concentration of marker substance in arterial blood supplying the organ
- Concentration of marker substance in venous blood leaving the organ

In Fick's original method, the "organ" was the entire human body and the marker substance was oxygen.

The principle may be applied in different ways. For example, if the blood flow to an organ is known, together with the arterial and venous concentrations of the marker substance, the uptake of marker substance by the organ may then be calculated.

9. What is the principle of blood glucose sensor?

A **glucose** meter is a medical device for determining the approximate concentration of **glucose** in the **blood**. ... A small drop of **blood**, obtained by pricking the skin with a lancet, is placed on a disposable test strip that the meter reads and uses to calculate the **blood glucose** level.

10. What are the methods of blood cells counting?

Manual cell counting : counting chamber

Automatic cell counting : flow resistance, flow cytometry

Indirect cell couting: Spectrophotometry

HAND OUT

UNIT -1
BIO POTENTIAL ELECTRODES

ORGIN OF BIOPOTENTIAL AND ITS PROPAGATION

DEFINITION

"Bioelectric potential are actually ionic voltage produced as a result of electrochemical activity of certain special type of cells."

TYPICAL CELL POTENTIAL WAVEFORM:

Depolarization:

- ✓ When cell membrane is excited Na^+ions tends to move inside. Hence an imbalance of potential is created and the cell is said to be depolarized .
- ✓ Thus the process of changing from resulting state to action potential is called depolarization. Action potential is approximately +20 mv.

Polarization:

- ✓ After complete travel of Na^+ions a new state of equilibrium is established where movement of na^+ from outside to inside is blocked via ionic current barrier. Thus with the help of sodium pump the Na^+ions are pumped quickly. Therefore causing polarization.

Action potential:

- ✓ The net height of action potential is defined as difference between potential of depolarized membrane at peak of action and resting potential.
- ✓ Different cell have similar action potential.

Absolute refractory period:

- ✓ Following the generation of action potential there is brief period of time during which cell cannot respond to anynew stimulus called absolute refractory period. It last for 1 millisecond.

Relative refractory period:

- ✓ The period during which another action potential can be triggered but a much stronger stimulation is required called relative refractory period.

HALF CELL POTENTIAL

CONCEPT OF HALF CELL POTENTIAL

- ❖ Let us consider a metal placed into a solution containing ions of those metals.

  "Thus the electrolyte surrounding the metal is at different electrical potential from the rest of solution.This potential difference is called as the "half cell potential".
- ❖ The half cell potentialis determined by the Metal involved, concentration of ions in solution and temperature of the solution.
- ❖ Half cell potential is important for the understanding the behavior of the bio potential electrode.

- ❖ Half cell potential is important for the understanding the behavior of biopotential electrode.
- ❖ This charge distribution at electrode –electrolyte interface can affect electrode performance of the device in biosignal acquisitionlike ECG, EEG, EMG etc.,

IMPEDANCE

Bioelectric impedance analysis [BIA] is commonly used method for estimating body composition and particular body fat.

The electrical impedance can be denoted by Z,and can be calculated as :

Where,

- Z=impedance
- $\rho = resistivity$
- L=length
- A=area.

Example:

In lung model, the electrical impedance "Z"will increase during inspiration, as lung have a higher resistivity when filled with air.

Here in above equation, the length"L" and area "A" also change when we breath.

POLARIZATION OF ELECTRODE

Polarization of electrode is also termed as "Over potential of electrode",denoted by $V_P$the net over potential of an electrode is given by,

Where,

V_p= Total polarization of electrode or over potential.

V_r= Ohmic over potential.

V_c= Concentration over potential

V_a= Activation over potential

OVER POTENTIAL OR POLARIZATION OF ELECTRODE

Definition:

The difference between the observed half-cell potential and equilibrium zero current half cell potential is known as overpotential.

Three mechanism contribute to overpotential are,

- ✓ Ohmic over potential
- ✓ Concentration over potential
- ✓ Activation over potential

<u>Ohmic over potential</u>

Definition: "Ohmic over potential can be defined as the result of theresistance of electrolytes."

- ❖ When current passes between two electrodes in electrolyte, there is voltage drop along the path of the current in electrolyte as a result of resistance.

❖ The drop in voltage is proportional to the current and the resistivity of electrolyte.

Concentration over potential

Definition: "The concentration over potential results from change in distribution of ions in the electrolyte in Electrode to Electrolyte interface"

Activation over potential

In third mechanism of polarization results in activationover potential.

Definition: "When there is current between electrode and electrolyte,either oxidation or reduction takes place and hence the height of energy barrier depends direction of the current."

"The difference in energy appears as difference in voltage between electrode and electrolyte, which is known as activation over potential."

POLARIZABLE AND NON POLARIZABLE ELECTRODE

Theoretically two types of electrode are possible theyare,

1. Perfectly polarizable
2. Perfectly non polarizable

This classification refers to whathappensto an electrodewhen current passes between it and electrolyte.

Perfectly polarizable

"Perfectly polarizable electrodes are those in which no actual charge crosses the electrode electrolyte interface when a current is applied."Of course, there has to be current across the interface, but the current is the displacement current, which is negligible.

Perfectly non polarizable

"Perfectly non polarizable electrode is those in which current passess freely across the Electrode-Electrolyte interface,requiring no energy to make the transition. Thus,for perfectly non polarizable electrode there are no over potential."

Eg: Silver- Silver Chloride Electrode

TYPES OF ELECTRODE

Over the years different types of electrodes for recording various potential on the body surface are developed all the electrodes classified under three categories. They are,

1. Surface electrode
2. Needle electrode
3. Micro electrode

RECORDING PROBLEM IN ELECTRODES

INTRODUCTION

In observing the measurement of bio signal it require measurement of electrode in the surface of the body. Efficient measurement of biosignal can be acquired with proper design of electrodes. Few problems will occur during recording or fabricating in the electrodes. Those recording problems are,

- **MEASURAND ERROR**
- **MATERIAL USED FOR MANUFACTURE TRANSDUCER/SENSOR**
- **SIGNAL CONDITIONER**

- **DISPLAY SYSTEM**
- **ENERGY SOURCES**
- **CALIBRATION UNIT**
- **Z - CONTACT IMPEDANCE :**

UNIT –II

ELECTRODE CONFIGURATIONS

BIOSIGNAL CARACTERISTICS

There are various biosignal found in the physiological system

The term Biosignalreferes to all the signals that are being generated in all living organisms .they can also be described as the spaces , time or the space - time records of a biological event inside the body such as the heart beating or the contraction of the muscles so all the electrical , chemical and mechanical activites that happenes during these events produce signals which can be measured and analysed .these signals are so useful to understand the biological events of the body which can help in medical diagnosis

Bioelectric signal

Are generated by nerves and muscles tissues as the result of the changes in the electric currents which are produced by the sum potential differences across the tissues and organs.
Best known example is the Electrocardiography

Biochemical signal

Signals contain information about the changes in concentration of various chemical agents in the body. For example it determines the level of glucose.

Biomechanical signal

produced by the mechanical functions of biological signals such as motion and displacement , pressure. Example: blood pressure measurements.

Bioacoustics Signal

They are special subset of biomechanical signals that involve in vibration basically motion. Example: respiratory system and muscles generates this kind of signals.

Biooptical signal

They are generated by the optical or light induced attributes of biological systems. They may occur naturally or induced.

Biosignal characteristics

1.Wave form shape

2.statistical structure of the signal

3.Temporal properties

Amplitude and frequency:

Amplitude is an important parameter of waves and is the maximum displacement of points on a wave. Stated another way, **amplitude** is the vertical distance between a peak or a valley and the equilibrium point. **Frequency** is the number of wave cycles passing a point per unit time.

Amplitude and frequency ranges were differentiated in Particular Measurement.

2.ELECTROENCEPALOGRAM : (EEG)

In brain chemical neurotransmitter released by presynaptic here produces postsynaptic potential.these potential are responsible for most of electrical activity of brain. Recordingof these potential using a surface electrode positioned over scalp is called EEG[electroencephalogram]

ELECROMYOGRAM:[EMG]

The electrical activity produced by muscle can be recorded using surface electrode called EMG.

It useful in bio feedback training of muscles

ELECTROGASTROGRAM[EGG]:

These patters associated with peristalic movements of gastrointestinal tract.It help to diagnose disease of stomach

ELECTRORETINOGRAPH:[ERG]

The electrical potential exist between cornea and back of the eye and potential change are called ERG

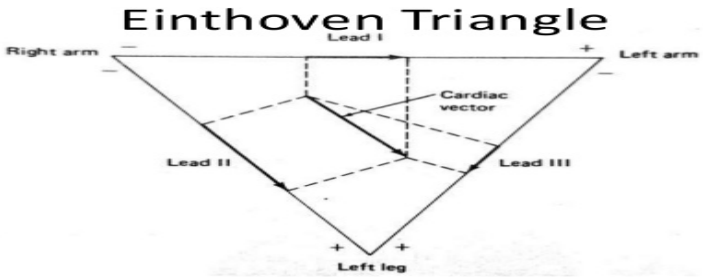
ELECTRO –OCULOGRAPH:[EOG]

EOG is recording of bio potential generated by the movement of the eyeball

EINTHOVEN TRIANGLE

12 lead standard ECG leads are used to acquire ECG.First 3 are introduced by Einthoven

Here,



The vector sum of the frontal plane Cardiac Vector at any instant onto the three axes of the Einthoven Triangle will be zero.

- Lead 1: Potential between the Right Arm (RA) and the Left Arm (LA)
- Lead 2: Potential between the Right Arm and the Left Leg
- Lead 3: Potential between the Left Arm and the Left Leg

ELECTROENCEPHALOGRAM[EEG]

Overview ; electroencephalogram

- Origin of EEG
- Anatomy of brain
- Placement of 10/20 electrode system
- Recording setup
- Analysis of EEG

ORIGIN OF EEG:

- EEG deals with recording & study of electrical activity of brain . by means of electrodes attached to skull of patient brain waves are picked up & recorded
- Therefore during the recording , electrodes are placed around the frontal , parietal, temporal & occipital lobes of brain
- Electrodes are placed on the scalp,
- Several type of electrodes are used for recording
  They are
  1. Peel & stick electrodes
  2. Silver plated cup electrodes
  3. Needle electrode
- The electrodes are small in size .the electrolyte gel is used to improve the electrical contact . it reduce the artifacts in o/p signal.

Modes of recording:

EEG offers 2 modes of recording EEG signal they are

- Monopolar mode
- Bipolar mode

ANATOMY OF BRAIN

The brain consists of three parts such as

Cerebrum
Cerebellum
Brain stem

Cerebrum consists of two hemisphere which separated by deep fissure

- Hemisphere divided into 4 lobes
    - Frontal lobe
    - Parietal lobe
    - Occipital lobe
    - Temporal lobe
- Frontal lobe is for intelligence.the upper side of temporal lobe consists of hearing center
- In posterior part of occipital lobe, the vision center is located
- In anterior part of parietal lobe sensory center and motor center are located
- The temporal lobe are the storage process in long term memory

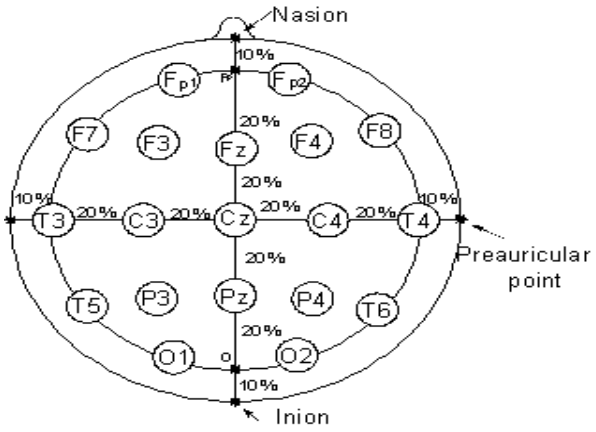
PLACEMENT OF 10-20 ELECTRODE SYESTEM

In EEG electrodes are placed in standards positions on the skull. This ar**r**angement is called 10-20 electrode system , a placement is devised by international federation of societies of EEG . placement

The electrodes in this arrangements are,

1.Draw a line on a skull from Nasion [NOSE] To inion(centre of occipital lobe).

2.electrode identification according to their position on head are described as:

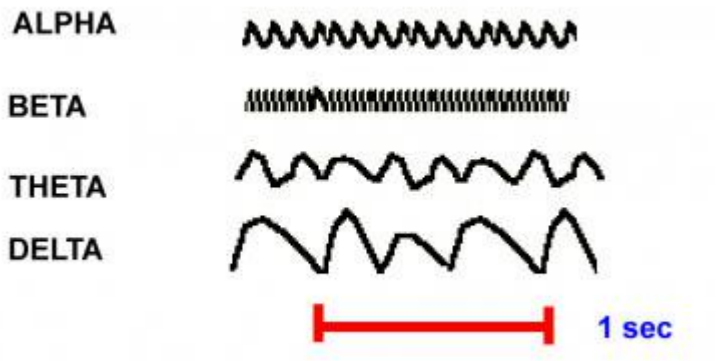


Montage

"A pattern of electrodes on the head and the channels they are connected to is called as Montage"

ANALYSIS OF EEG

EEG helps physicians to diagnosis the level of consciousness,sleep disorder , brain death,braintumor,epilepsy&multiple



sclerosis

ELECTROMYOGRAPHY[EMG]

- Electromyograpy is an instrument used for the recording the electrical activity of muscle to determine whether the muscle is contracting(or)not
- The instrument is useful for making a study of several aspects of neuromuscular function
- EMG measurements are also important for myoelectric control of prosthetic device ex :artificial limb
- **Electromyography** (**EMG**) is an electrodiagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles.[1]
- EMG is performed using an instrument called an **electromyograph** to produce a record called an **electromyogram**. An electromyograph detects the electric potential generated by muscle cells
- when these cells are electrically or neurologically activated. The signals can be analyzed to detect medical abnormalities, activation level, or recruitment order, or to analyze the biomechanics of human or animal movement.

MONOPOLAR LEAD SYSTEM:

Electromyograhic or EMG signal is the muscle electrical activity. It is the superposition of the evoked action potentials of all the active motor units in a muscle.
It can be recorded either in **Monopolar** or **Bipolar** configuration.

BIPOLAR LEAD SYSTEM:

In **Bipolar** configuration two electrodes are placed over the belly of the muscle within 1-2 cm from each other and one electrode some where farther as the reference and the signal between the two electrodes over the belly of the muscle is amplified differentially respect to the reference electrode. The advantage in this configuration is the common noise between the two electrodes is eliminated and hence we'll have a cleaner EMG signal. The the signal-to-noise ratio will be much better.

UNIT-III BIO AMPLIFIER

NEED FOR BIO AMPLIFIER

AMPLIFIER

An **amplifier**, **electronic amplifier** or (informally) **amp** is an electronic device that can increase the power of a signal (a time-varying voltage or current). It is a two-port electronic circuit that uses electric power from a power supply to increase the amplitude of a signal applied to its input terminals, producing a proportionally greater amplitude signal at its output. The amount of amplification provided by an amplifier is measured by its gain: the ratio of output voltage, current, or power to input. An amplifier is a circuit that has a power gain greater than one.

An amplifier can either be a separate piece of equipment or an electrical circuit contained within another device. Amplification is fundamental to modern electronics, and amplifiers are widely used in almost all electronic equipment. Amplifiers can be categorized in different ways. One is by the frequency of the electronic signal being amplified. For example, audio amplifiers amplify signals in the audio (sound) range of less than 20 kHz, RF amplifiers amplify frequencies in the radio frequency range between 20 kHz and 300 GHz, and servo amplifiers and instrumentation amplifiers may work with very low frequencies down to direct current. Amplifiers can also be categorized by their physical placement in the signal chain; a preamplifier may precede other signal processing stages, for example.[4] The first practical electrical device which could amplify was the triode vacuum tube, invented in 1906 by Lee De Forest, which led to the first amplifiers around 1912.

WHY WE NEED BIO AMPLIFIER?

Bio signals are having low amplitude and low frequency,so amplifiers are needed to boost the amplitude level of the bio signal. The output of the amplifiers is displayed as EEG or ECG waveform. These amplifiers are known as bio amplifiers are biomedical amplifier.

NEED FOR LOW-NOISE BIO-AMPLIFIERS:

Bio signal acquisition is difficult because it is in the low amplitude and low frequency regions. Particularly EEG pre-amplifiers are required to detect signals as low as amplitude.

Physiological signal amplifiers require enormous skill. Since, it should satisfy the following conditions:

(a) The voltage gain of the amplifiers should more than 100db.
(b) It should have low frequency response of particular bio signal.
(c) The gain and frequency response should be uniform throughout the required bandwidth.
(d) There is no drift in the amplifier. Amplifiers are also used for interfacing sensor/transducer that sense body motion, temperature etc.
(e) The output impedance of amplifier should be very small.

(f) Common Mode Rejection Ratio (CMRR) should be more than 80db. So it eliminates 50Hz interference from the mains.
(g) The gain of the amplifiers must be correctly calibrated.
(h) Bio amplifiers circuit must be isolated to protect patients from micro shock.

TITLE: TYPES OF AMPLIFIERS

Major classifications are,

- Differential amplifiers
- Operational amplifiers
- Instrumentation amplifier
- Chopper amplifier
- Isolation amplifier

CHARACTERISTIC OF OP-AMP

S.NO	CHARACTERS	IDEAL AMPLIFIER	TYPICAL IC OP-AMP
1.	Voltage gain	∞ (infinite open loop voltage gain)	100dB
2.	Bandwidth	∞ (infinite input)	few MHz
3.	R_{in}	∞ (infinite inputs)	few MΩs
4.	R_{out}	0 (zero outputs)	few Ωs
5.	CMRR	∞	80dB
6.	Offset voltage and current	0	few μvs- few μAs

POWER LINE INTERFERENCE

OVERVIEW:

- Introduction
- Origin of Interference
- Interference Reduction
- Reduction of Interference in measuring cable

INTRODUCTION:

- Power line interference is a serious issue while recording the bio signals in biomedical instrumentation.
- Bio electric recording are often disturbed by an excessive level of interference.
- The interference should be significantly reduced in the whole measurement situation and it should be analyzed.

ORIGIN OF INTERFERENCE:

- The capacitance between the patient, power line and ground cause a small interference current to flow through the body.
- In the modeling of measurement situation the capacitance between the body ground is taken to be 300pF.
- The capacitance between the body and the main power (C_{pow}) is taken to be 3pF.
- It should be assumed that C_{pow} and C_{body} show large variation and interference current ten times.
- Measurement without the use of a neutral electrode are possible but are not treated here.
- There should be galvanic connection between the amplifier common and grounded.

INTERFERENCE REDUCTION:

These are two ways by which a high common mode voltage may cause interference.

First way is when the Common Mode Rejection Ratio [CMRR] of amplifier is limited.The second, the high common mode voltage may cause interference is when there are difference in electrode impedance in input voltage.

The interference reduction can be done by "Driven right leg circuit ". If the gain of the driven right leg circuit is high and CMRR is much smaller than voltage.

A proper driven right leg offers a large reduction of common mode voltage magnitude in both isolated and non-isolated measurement.

A driven right leg circuit is most practical way to reduce the common mode voltage if a reduction of interference is not feasible.

This feature can be used to omit isolation amplifier in which safety standards are not critical in clinical situations.

Main drawback of driven right leg circuit is being potentially unstable.

Power link interference can also be reduced when leakage current does not exceeds the safety regulations even if the patient touches ground or mains.

REDUCED OF INTERFERENCE CURRENT IN MEASUREMENT CABLES

There is only one practical way to reduce interference current in the wires:

SHIELDING:

The different possible shielding technique are treated in following,

1)Shield connected to amplifier common 2)Simply connecting the shield to the amplifier eliminates interference current in wires.3)However, it usually does not reduce the total level of interference.

GUARDING:

When shield is driven with the signal at inner wire, there is virtually no cable capacitance and its contribution to the input impedance of circuit is negligible. This technique is usually known as Guarding.

GUARDING WITH AVERAGE OF INPUT SIGNAL:

If all shields are driven with average of input signal, the input capacitance is virtually small because there exists no potential difference between shield and inner wire for these signal.

This method is good compromise between the other two shielding technique.

However in normal ECG and EEG recording which have a restricted frequency content.

So, extremely long measuring cables are avoided.

CHOPPER AMPLIFIER

Chopper amplifier is used in the biomedical measurement because bio signals have the frequency range from d.c.to few hundred Hertz. Chopper amplifiers are available in the form of mechanical choppers and non-mechanical choppers. The chopper is used to convert the d.c. or low frequency signal into a high frequency signal. Then this modulated high frequency signal is amplified by conventional a.c. amplifier. Finally the amplified signal is demodulated and filtered to get amplified d.c. or low frequency signal. It is well known that the chopper amplifier has no drift.

- **MECHANICAL CHOPPER AMPLIFIER**
- **NONMECHANICAL CHOPPER AMPLIFIER**

OPTICAL ISOLATION

Isolation could also be achieved by optical means in which the patient is electrically connected with either hospital nor the ground line .A separate battery operator circuit supplies power to the patient circuit & the signal of interact is converted into like by a light source.

This light falls on the o/p side, which converts the light signal again into an electrical signal having it's original frequency , amplitude & linearity. No modulator/demodulator is needed because the signal is transmitted optically all the way

UNIT 4 MEASUREMENT OF NON ELECTRICAL PARAMETER.

TEMPERATURE RATE MEASUREMENT:

THERMISTORS:

- Thermal+resistor.
- It generally composed of semiconductor material .
- Most thermistor have a negative temperature co efficient of temperature resistance

Thermistor circuit are used to detect very small change in temperature .the resistance of conductor changes with change in the temperature.

CONSTRUCTION:

They are available in variety of sizes and shapes . it may in form of beads , rods and discs shaped structure .

MEASUREMENT OF RESPIRATION RATE:

The primary function of respiratory system are to supply oxygen and remove co_2 from the tissue.the action of breathing controlled by a muscular action cause volume of lung to increase and decrease effect of co_2 in arterial blood .

- ✓ The several methods has been developed to measure respiration rate.
- ✓ The choice of the particular method depend mostly on application of transducer and their acceptance by the subject under test.
- ✓ Various methods are ,
    i. Displacement method
    ii. Thermistor method
    iii. Impedance pneumography
    iv. Co_2 method of respiration rate measurement.

DISPLACEMENT METHOD:

- ➢ The respiratory cycle is accompanied by change in thoracic volume.
- ➢ These changes can be sensed by means of displacement transducer incorporating a strain gauge or variable resistance element.
- ➢ The transducer is held by an elastic band ,which goes around the chest .
- ➢ The respiratory movement results in resistance change of strain gauge ,connected as one arm of wheatstone bridge .

THERMISTOR METHOD:

- ➢ Since air is warmed during its passage through the lungs and the respiratory tract,there is detectable difference of temperature between inspired and expired air .
- ➢ This difference of the temperature can be best sensed by thermistor placed infront of nostrils by means of holding device.
- ➢ In case of difference in temperature of outside air is small,thermistor can be heated and variation of its resistance.
- ➢ In the case of suffocated patients no spontaneous respiration will pass through the cannula are sufficient to drive the breath rate meter .

IMPEDANCE PNEUMOGRAPHY:

- ▪ Its is a indirect technique for measuring of respiration rate .
- ▪ Externally applied electrode is placed in a throx, the impedance pneumograph are measured between thoracic impedance and respiratory depth.

- This technique avoid a subject with masks ,tubes ,flowmeter or spirometers.
- Contact with skin is made through electrode cream layer for minimizing motion artifacts.
- Impedance based respiration rate is implemented mostly in patient monitoring system.
- The electrode used for this purpose are the same as those used for ECG measurement.

MEASUREMENT OF PULSE RATE:

- The pulse can be felt by placing the finger tip over the radial artery in the wrist or some other location.
- Bio medical instrument used to detect the arterial pulse and pulse pressure waveform are called "plethymographs".
- Most of the technique respond to the change in volume of blood as a measure of blood pressure.
- The velocity of pulse is 10-15 times faster than blood flow.
- The method used for detection of pulse change due to blood flow are:
  1.electrical impedance change.
  2. strain gauge or microphone
  3.optical change (change in density).

PHOTOELECTRIC METHOD:

Most commonly used method to measure pulsatile blood volume change is called as photoelectric method. In this method most commonly used technique are:

1.TRANSMITTANCE METHOD

2.REFLECTANCE METHOD

TRANSMITTANCE METHOD:

- In this method light-Emitting Diode[LED] and phototransistor are mounted in an enclose that fits over tip of patient's finger

REFLECTANCE METHOD:

- In this method the phototransistor is placed adjacent to the exciter lamp.
- The part of the light rays emitted by the LED is reflected and scatterd from the skin and tissue and falls on the phototransistor.
- The quantity of light reflected is been determined by blood saturation of the capillaries.
- Then the voltage drop is across the phototransistor ,connected to the voltage divider.

MEASUREMENT OF BLOOD PRESSURE:

- Blood pressure [BP] is most often measured and most intensively studied parameter in medical field.
- The tremendous research and development for automatic BP monitor has carried out.
- The maximum pressure reached during cardiac ejection is called "systolic pressure".

- The minimum pressure occurring at the end of a ventricular relaxation is termed as “Diastolic pressure”.
- The mean arterial pressure over one cardiac cycle is aprox. One-third of pulse pressure to diastolic pressure.

TYPES OF BP MEASUREMENT:

There are 2 basic method for measuring blood pressure .They are,

1.Direct BP measurement

2.Indirect BP measurement

DIRECT METHOD OF MONITORING BP:

- ✓ The direct method of BP monitoring system have various advantages like,
  - Absolute accuracy
  - Dynamic response
  - Continuous real-time data acquired.
  - Can also measure BP in deep regions.
- ✓ For direct measurement, a catheter (or) needle type probe is used and inserted through vein (or) artery to ROI [Region of interest].
- ✓ Direct measurement is a INVASIVE TECHNIQUE.
- ✓ In direct measurement 2 type of probe can be used. they are,
  1.Catheter Tip probe
  2.Fluid- Filled catheter type.

OSCILLOMETRIC MEASUREMENT METHOD:

- The automated oscillometric method of non invasive blood pressure measurement has distinct advantage over the ausculatory method.
- Since sound is not used to measure blood pressure in the oscillometric technique.
- This technique does not require a microphone or transducer in cuff .
- Placement of the cuff is not as critical as it is with ausculatory or Doppler methods.
- As the pressure in cuff further decreases ,the oscillations increases to a maximum amplitude.
- Then decreases until the cuff fully deflates and blood flow returns to the normal.

PRESSURE AMPLIFIER:

The pressure amplifier includes systolic ,diastolic and mean detector used for processing the electrical signals received from pressure transducer for the measurement of arterial pressure .

The transducer is exited with 5 volt dc excitation.

OPERATION:

SYSTOLIC:

- When a positive pressure pulse appears at "A"→diode d_3 conducts and charges "c_3" to the peak value of input signal.
- If corresponds to systolic pressure .
- Then time constants R_3C_3 is choosen in such a way that it gives steddy output to indicating meter (M_1).

DIASTOLIC:

- The value of diastolic pressure is devired in an indirect way.
- A clamping circuit consisting of $C_1$and D_1 is used to develop a voltage equal to peak-peak value of pulse pressure
- This appears across R_1 and diode D_2 would then conduct and charge capacitor C_2 to the peak value of pulse signal.
- The diastolic pressure is indicated by the second meter M_2which shows the difference between peak systolic minus(-) the peak –to-peak pulse pressure signal.
- The mean pressure can also be read by using a smoothing circuit when required.

REQUIREMENT OF BP SYSTEM:

- Transducer should be of higher sensitivity.
- Should give more accurate results ,at lower pressure .
- A correction of 7.8 mmhg is applied for every 10cm probe .
- A site of measurement is below the height of the heart.

CARDIAC OUTPUT MEASUREMENT:

- "cardiac output is the quantity of blood delivered by the heart to the aorta per minute"
- The problem many occur when supply of O_2 is less in demand to heart .
- A fall in cardiac output [co] may result in low blood pressure, reduced tissue oxygenation, acidosis, poor renal failure and shock.
- Normally cardiac output can measured as,
  CO=stroke volume X heart rate.

TYPES OF CO MEASUREMENT:

Few types of CO measurement are,

1.Indicator dilution method

2.Dye dilution method

3.Thermal dilution method.

INDICATOR DILUTION METHOD :

PRINCIPLE :

" If we introduce a known indicator into a stream of fluid the concentration difference of upstream and downstream of indicator site are estimated to find the volume flow of fluid".

OPERATION :

Generally 2 methods are followed,

- Introducing the indicator in blood stream at constant rate .
- This method suffers because of some disadvantages that most indicator recirculate in the blood .
- Second method is a known quantity of indicator such as dye or radioisotope administrated into the circulation.
- It is injected into large vein or into right heart itself .then the presence of indicator in artery is detected by suitable photoelectric transducer and recorded.

  For calculating cardiac output, assume,

  Q=M/Average conc .of indicator per liter of blood × curve duration in seconds. (lt/sec)

Where,

Q=Cardiac output

M=quantity of injection indicator in mg.

DYES DILUTION METHOD:

- Most commonly used dye is indocyanine green [cardiogreen] dyes which usually employed of recording dilution curve.
- Procedure was injecting a dye into right atrium by means of venous catheter.
- Usually 5mg of cardiogram dye is injected in 1ml volume .

THERMAL DILUTION TECHNIQUE:

PRINCIPLE:

"A thermal indicator of known volume is introduced into right or left atrium will produce a resultant temperature change in pulmonary artery which is inversely proportional to the cardiac output".

Cardiac output="a constant "x(BLOOD TEMP-INJECTED TEMP)/ area under dilution curve.

- Blood temperature is measured over the range of 30 to 40℃.

- System calibration is based on injection of 5% dextrose solution at a temperature range of 18-28°C.
- Thermistor is most commonly used sensor for the co measurement.

BLOOD FLOW MEASUREMENT:

INTRODUCTION:

- Blood flow is one of the important parameter and also most difficult to measure accurately.
- The measurement setup should have good sensitivity depends on magnitude of flow.
- Blood flow measurement is difficult engineering and clinical problem .
- They are many widely used technique for measuring the blood flow velocity.
- They are invasive and non invasive technique.
- The most accurate method, is to simplify server the vessel and time the blood flow into a calibrated beaker.
- Types of measuring setup are,
  1.electromagnetic bloodflow meter
  2.ultrasonic bloodflow meter.

1.ELECTRO MAGNETIC BLOOD FLOW METER:

- The most commonly used instrument for measuring blood flow is electromagnetic type.
- This method requires the blood vessel be exposed so that the flow head or measuring probe can be put across it.
- In this type blood flow can be measured without cannulation.
- The operating principles underlying all electromagnetic type flow meter is based on upon faraday's law of electromagnetic induction.
- In the assembly provides the magnetic field placed at right to blood vessel, in which is to measured.
- The blood stream which is conductor cuts the magnetic field and voltage is induced in blood stream.
- magnitude is called bye=CHVd.

Where,

e=induced voltage.
H=strength of magnetic field.
V= velocity of blood flow.
d=diameter of blood vessel.
C=constant.

2.ULTRASONIC BLOOD FLOW METERS:

- Doppler- shift –flow meter is used to measure blood velocity,volume flow, flow direction,flow profile to visualize the internal human of blood vessel.
- It is a non invasive technique to measure blood velocity in particular vessel from the surface of the body.
- Works on principles of Doppler effect .
- When there is frequency shift to measure the size and direction of flow velocity.

UNIT –V

BIOCHEMICAL TRANSDUCERS

An electrode potential is generalized either at a metal-electrolyte interface or across a semi permeable membrane separating 2 different concentrations if an ion that can diffuse through the membrane. The usual method of measuring concentration of ions or gases is to use one electrode that is sensitive to the substance or ion being measured and to choose a reference electrode, that is insensitive to the substance.

REFERENCE ELECTRODE

The hydrogen gas interface has been designated as the reference interface and was anti-trarily assigned an electrode potential of zero volts. These electrodes makes use of the principle that an inert metal rarely absorbs hydrogen gas. If a properly trealid piece of platinum is partially immersed in the solution containing hydrogen ions and is also exposed to hydrogen gas, which is passed through the electrode, an electrode potential is formed.

The hydrogen electrode is not sufficiently stable to serve as a good reference electrode. Two types of electrodes have interfaces sufficiently stable to serve as a reference electrode the silver-silver chloride electrode and calomel electrode.

The silver-silver chloride electrode utilizes for electrochemical measurements. The silver chloride side if the interface is connected to the solution by an electrolyte bridge, usually a dil.Kcl filling solution which forms a liquid junctionwith the sample solution. It's electrode potential depends on the concentration of the Kcl. For eg: with a 0.01 molc-solution ,the potential is 0.343v

In calomel electrode ,the interface between mercury and mercurous chloride generates the electrode potential. By planning the calomel side of the interface in a Kcl filling solution, an electrolyte bridge is formed to the sample solution from which the measurement is to be made. It's electrode potential depends on the concentration of Kcl. An electrode with a 0.01 molc solution of Kcl has an electrode with a 0.01 molc solution of Kcl has an electrode potential of 0.388v.

THE PH ELECTRODE

It is the logarithm of reciprocal of the H^+ion concentration.

$$pH = -\log_{10}[H^+] = \log_{10} 1/[H^+]$$

pH is a measure of the acid-base balance of a fluid. A neutral solution has a pH of 7, lower pH numbers indicates acidity , whereas higher pH values define a basic solution.

Because a thin glass membrane allows passage of only hydrogen ions in the form of H_3O^+, a glass electrode provides a "membrane" interface for hydrogen. Inside the glass bulb is a highly acidic buffer solution. Measurement of the potential across the glass interface is achieved by placing a silver-silver chloride electrode in the solution inside the glass bulb and a calomel reference electrode in the solution in which the pH is being measured. For pH measurement, the glass electrode with the silver-

silver chloride electrode inside the bulb is considered one half cell, while the calomel reference electrode constitutes the other half cell.

Special type of pH electrodes where available for the extreme ranges. Special hydroscopic glass that readily absorbs water provides the best pH response. Modern pH electrodes have impedance ranging from 50-500 mega ohms. Most pH metres employ electrometric impulse.

BLOOD GAS ELECTRODES

The partial pressure of a dissolved gas is the contribution of that gas to the total pressure of all dissolved gases in the blood.

FLAME PHOTOMETERS

A photoelectric **flame photometer** is a device used in inorganic chemical analysis to determine the concentration of certain metal ions, among them sodium, potassium, lithium, and calcium. Group 1 and Group 2 metals are quite sensitive to **Flame Photometry** due to their low excitation energies.

- Flame photometer is one of the most useful instruments in clinical analysis.
- This is due to the suitability of the flame photometer for determining sodium , potassium and calcium which are of immerse importance.
- In the clinical analysis of Na ,K the flame photometer gives , rapidly and accurately numerous differential data for normal and pathological values.
- The method of flame photometric determination is simple.

PARTS OF FLAME PHOTOMETER

A flame photometer 3 essential parts. These are

1. Emission system.
2. Optical system.
3. Recording system.

EMISSION SYSTEM

Consist of the following

Fuel gases

It comprises of fuel reservoir, compressor ,pressure, regulators ,pressure gauges.

Atomizer

It consist of sprayer and atomization chamber.In the atomization chamber the aersol is produced and fed into the flame.

Burner

The burner receives the mixhire of the combustion gases .

Flame

Flame acts as the true source of the emission.

Optical system

It consist of optical system for wavelength selection , lenses diaphragms, slits,etc… The wavelength selection is done by filters or monochromators.

Recording system

It includes detectors like photo cells ,photo tubes, photo multipliers…etc And the electronic means of amplification ,measuring and recording.

BLOOD GAS ANALYZER

Introduction

- Blood gas analyzers are mainly used to measure partial pressure of hydrogen , carbon di oxide, oxygen present in human blood.
- It is very useful to determine the acid –base balance in the body.
- Blood pH below 7.35 indicates respiratory acidosis which indicates respiratory failure.
- Meanwhile the PCo_2 of atrial blood is increased to 90 mm/Hg.
- The respiratory failure can be corrected temporarily using a ventilator.

TYPES OF BLOOD MEASUREMENT

1.Blood pH measurement

- Acidity/alkalinity of solution depends on it's concentration of H^+ions.
- When concentration of H^+ions increase s solution make acidic, decreasing the concentration of H^+ makes it more alkaline.
- We know pH = - log [H^+].
- If the number 10^{-7} represents the concentration H^+ions in certain solution, pH would be 7.
- As H^+ions concentration rises pH falls because logarithm gets smaller and as H^+ions concentration falls pH rises because logarithm gets larger .
- For making pH measurement solution taken in a beakers.
- 2 electrodes, indicating electrode and a reference electrode dipped in solution.
- Voltage developed in solution across electrode is applied to an electronic amplifier.
- Error caused in pH measurement due t o temperature effects can be compensated either by manually or automatically.
- In manual adjustment the instrument is caliber at 25 degree celcius.

- By this adjustment,o/p current of amplifier get corrected to desired temperature.
- An automatic adjustment ,variable resistor which is usually a thermistor or wire would resistance that has an approximate desired resistance temperature coefficient is inserted in circuit.

Effect of blood on electrodes

- pH of blood is found to change linearly with temperature in range of [18-30] degree Celsius.
- The temperature coefficient for pH of blood 's 0.0147 pH unit /deg centigrade
- Glass electrode deteriorate if allowed to remain in contact with blood for along time.
- This results in change of emf pH slope.
- Poisoning effects appears to be due to protein deposition .

Blood PO_2 measurement

- PO_2 in blood indicates the extent of O_2 *exchange between lungs* and blood.
- *Usually* $PO_2$is measured with polarographic .
- *The measurement of* current developed at the PO_2 electrode due to partial pressure of oxygen present special problems.
- *Difficultly*arises because of extremely small size of the electrical signal.
- *Measurement of* oxygen electrode current is made by using high i/p impedance, low noise and low current amplifiers.
- *Field* effect transistor usually from the i/p stage of pre amplifier.

Measurement of *blood*PCo_2;

- The blood $PCo_2$is the partial pressure of CO_2 of blood taken anaerobically.
- It is expressed in mmHg and is related to the % of CO_2 as follows.
- **PCo_2= Barometric pressure – water vapour pressure * %CO_2/100.**
- All modern blood gas analyzers make use of PCo_2electrode of the type described by stowetal .
- Basically consist of pH sensitive glass electrode having a rubber membrane stretched over it with a thin layer of water separating the membrane from electrode surface.
- The technique is based on the fact that dissolved CO_2changes of the pH of an aqueous solution.
- The CO_2 from the blood sample diffuses through membrane to form H_2Co_3, which dissociate into H^+ and HCo_3^- ions.
- Use of PCo_2electrode for the measurement of blood or plasma of PCo_2 has been studied repeatedly and has been found to be accurate presice and expedient.

- EMF generated by a of PCo_2 electrode is a direct logarithm function of of PCo_2.

SPECTROPHOTOMETERS

DEFINITION:

Spectrophotometer is an instrument which isolates monochromatic radiation in a more efficient and vessalile manner .In these instruments Light from the source is made into a parallel beam and passed to a prism or diffraction graling ,where light of different wavelengths is dispersed at different angles.

Microprocessor based spectro photo meter:

In spectrophotometry, a microprocessor is used here.For processing of data from analytical instruments, but has also been performed conventionally by analog circuits.

Advantages:

- Results in improved performance, operability and reliability over purely analog instruments.
- A microprocessor, in a spectrometer could be used for following functions.
  - Control functions: wavelength scanning, automatic light source selection, control of slit width.
  - Signal processing function: baseline correction, signal smoothing, derivative etc.
  - Communication function: keyboard entry, menu drived operations, data presentations.

BLOOD CELL COUNTERS

A **complete blood count** (**CBC**), also known as a **complete blood cell count**, **full blood count** (**FBC**), or **full blood exam** (**FBE**), is a blood panel requested by a doctor or other medical professional that gives information about the cells in a patient's blood, such as the cell count for each blood cell type and the concentrations of hemoglobin. A scientist or lab technician performs the requested testing and provides the requesting medical professional with the results of the CBC.

Blood counts of various types have been used for clinical purposes since the 19th century. Automated equipment to carry out complete blood counts was developed in the 1950s and 1960s.[1] Most blood counts today include a CBC count (i.e.: complete blood count) and leukocyte differential count (LDC) that gives the percentage of each WBC type, such as neutrophils, eosinophils, basophils, monocytes, and lymphocytes).[2]

The cells that circulate in the bloodstream are generally divided into three types: white blood cells (leukocytes), red blood cells (erythrocytes), and platelets (thrombocytes). Abnormally high or low counts may indicate the presence of many forms of disease, and hence blood counts are among the most

commonly performed blood tests in medicine, as they can provide an overview of a patient's general health status. A CBC is routinely performed during annual physical examinations in some jurisdictions.

Types of blood cells

Changes in the normal functioning of an organism are often accompanied by changes in the blood cell count .Therefore the determine of the number and size of blood cells per unit volume provide valuable information for accruable diagnosis.

The blood constitutes 5-10% of vital body weight may average adult .

The % of cells in the blood is called haematocil value of packed cell volume [pcv].

Blood constitutes the corpuscles & plasma

- RBC [erythrocytes].
- WBC [leucocytes].
- PLATELETS [thrombocytes].

In element:

1. RBC

    - Biconcave disk shape.
    - Diameter 7.5 micro & thickness 1.7 micro.
    - Life period 120 days.
    - No nucleus.
    - Carry oxygen from lungs to tissue & co_2 from tissue to lungs.

2.WBC

    - Spherical shape,having nucleus.
    - Normally 8000-10000 white cells per cubic mm of blood and various the number during the day.
    - Life time 14 days.
    - Function – Defense mechanism against infection.
    - Two types – Neutrophil
      Lymphocytes [concerned with immunological response].

3. Thrombocytes
    - Tiny ,irregularly shaped cells.
    - Storage characteristic 2 micro.
    - 1 liter of blood contains 0.45 liters of red cells.

Method of cell counting

Microscopic method :

Here it is most commonly used in labs.

Here the diluted sample is visually examined & the cells are counted.

Several drawbacks:

- Having an inherent error of system
- Poor reproducibility of results.
- Lengthy procedure
- Poor time &labour utilization.
- The data gathered by the measurement of not directly suitable for storage / further processing/ evaluation.

By later observation instead of +/- 20% measuring accuracy in microscopic counting, the electronic counters can provide an accuracy of +/- 5% .

Automatical optical method;

- Here the collecting scatterd light form the blood cells &convrt it into electrical pulses for existing process .
- A sample of dilute blood is taken in a glass contains .This drawn through a counting chamber in which the blood stream is reduced in cross section by a concentric high velocity by liquid sheath. A sample optical system provides a dark field symmetrical zone on the stream & the light scatter in the forward direction is collected on the cathode of a photomultiplier tube pulses are produced in the photomultiplier tube corresponding to each cell. These signals are amplified in a high i/p impedance amplifies & fed to in adjustable amplitude disseminator . The disseminator provide pulses of equal amplitude.
- It takes about 30s for completing event.
- Accuracy of 2% atomable
- Instrument sequence about 1 mm of blood sample

Electrical conductivity method

Blood cell counter, operating in the principle of conductivity change, which across each time a cell passes through an surface aregenerallyknown ascountless counters. The method was partitioned by countler in 1956& it form the basis of several particle counted instruments manufactured by a number of firm throughout the world . This technique is mutual for determining the number & size of particle suspended in an technical conductive liquid .

Indicator dilution method

Indicator or dye dilution method are the only methods of blood flow measurement that really measure the blood flow & not the blood velocity .

Principle;

DYE DILUTION METHOD

- In dye dilution method,the indicator used in a dye .The indo cyanine green dye is employed for recording the dilution curve.
- **Necessity of indo cyanine green dye.**

  It process the full properties i.e
  - Absorption of light in 800 nm region [here both reduced of oxygenated H_b have the same optical obsorption.
  - Concentration of cardio green/ indo cyanine green can be measured using infrared photocell transducer .

THERMAL DILUTION TECHNIQUES

A thermal indicator of known volume is introduced into either right or left atrium will produce aeculient temperature change is the pulmonary artery or in the aorta.

Cardiac o/p = "a constant" * (blood temp – injective temp) / area under dilution curve.

ULTRASONIC BLOOD FLOW METER

In an ultrasonic blood flow meter a beam of ultrasonic energy is used to measure the velocity of flowing blood. This can be done in 2 different ways . In the transit time ultrasonic flow meter a pulsed beam is directed through a blood vessel at a shallow angle &it's transit time is then measured when the blood flows in the direction of the energy transmission. The transit time is shortened if it flows is opposite direction .The transit time is lengthened .

BIO SENSORS

It combines the equisite selectivity of biology with the processing power of modern microelectronics & upto electronics to offer powerful new analytical tool with major applications in medicine.Environmental studies,food & processing industries .

SMART SENSORS

They have a tight coupling between the sensing and computing elements .they have thedecision making capability .self-diagnostic capability and it can communicate interactively with the external circuits. The important role of smart sensor are :