Sub. Code	**:** EC6001	**Branch / year / Sem:**	ECE / III/ VI
Sub. Name	**:** Medical Electronics	**Batch**	**:**2015-2019
Staff Name	**:** Mrs.B.Karthiga	**Academic Year**	**:**2017-18(Even)

Unit-1

PART-A

1) State all or none law. NOV / DEC 2016

- Regardless of the method by which a cell is excited or the intensity of the stimulus which is assumed to greater than the threshold of stimulus.
- The action potential is always the same for any given cell.
- This is known as all or nothing law.

2) What is meant by conduction velocity? NOV / DEC 2016

- 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.
- It is otherwise called as propagation rate or conduction velocity.

3)List the important characteristics required for bio amplifier. APRIL/MAY 2016

- Bio amplifiers must have
  - High input impedance
  - Isolation and protection circuit
  - High voltage gain
  - Constant gain throughout required bandwidth
  - Low output impedance
  - High CMRR

4) Mention the electrodes used to record Biopotential from a single muscle fiber. APRIL/MAY 2016

- The types of electrodes used to record biopotential are
  - Micro electrode
  - Depth electrode
  - Needle electrode

5)Define absolute and relative refractory period. APRIL/MAY 2017

- A bsolute refractory period-Time duration of the cell non response to further stimuli.It is about 1 milli second in nerve cell.
- Relative refractory period-Following the absolute refractory period there is a brief period of time during which another action potential can be triggered but a much stronger stimulation is required.This period is called a relative refractory period.

6)Mention the cause of first and second heart sounds. APRIL/MAY 2017

- First heart sound-It is produced by the sudden closure of the mitral and tricuspid valves associated with myocardial contraction.
- Second heart sound-It is due to the vibration set up by the closure of semi lunar valves ie., closure of arotic and pulmonary valves.

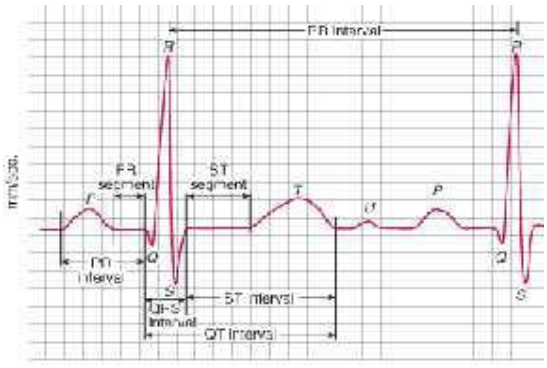
7) Describe the bioelectric potential. NOV / DEC 2015, APRIL/MAY 2012

- The membrane potential caused by the different concentration of ions is called resting potential. It is caused by very rapid change of membrane Permeability to sodium ions followed by recovery period.
- The positive potential of the cell membrane during excitation is called action 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.

8) What is PCG? May/June- 2012, Nov/Dec -2012

- A Phonocardiogram or PCG is a graphic display of the sounds generated by the heart and picked up by a microphone at the surface of the body.
- Frequency response required is 5 to 2000 Hz.
- It is measured by special transducer or microphone.

9) Give the ECG signal characteristics? APRIL/MAY 2015



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

10) Define latency in EMG. NOV / DEC 2015

- 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

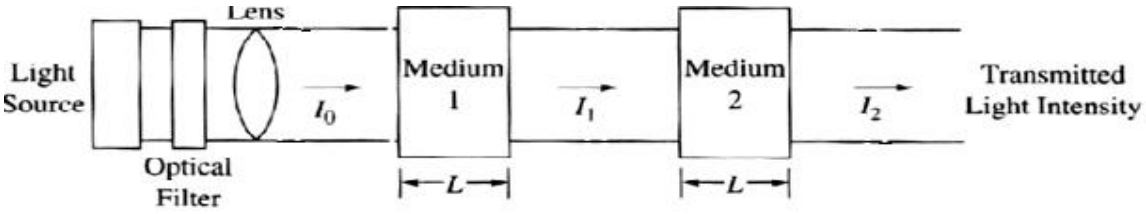
Unit 2

PART-A

1) *Define cardiac output. NOV / DEC 2016*

Cardiac output is defined as the amount of blood delivered by the heart to the aorta per minute. In case of adults during each beat, the amount of blood pumped ranges from 70 to 100 ml. for normal adults the cardiac output is about 4- 6 liters/ minute.

2) *State Beer's law. NOV / DEC 2016*



- **Transmittance**

  $T = I_1/I_0 * 100\%$

- **Absorbance**

  $A = - \log I_1/ I_0$

  $A = \log 1/T$

- If the path length or concentration increases, the transmittance decreases and absorbance increases, a phenomenon expressed by Beer's Law.

3) *Which flow meters are used to measure pulsatile flow of blood? APRIL/MAY 2016*

- Ultra sonic blood flowmeter is used to measure pulsatile flow of blood.
- In this flow meter,velocity of the flowing blood s determined with a beam of ultrasonic energy.

4) State the different types of test performed using auto analyzer? APRIL/MAY 2016

- An auto analyser sequentially measures the blood chemistry,through a series of steps of mixing,reagent reaction and colorimetric measurements.
- It consists of sampler,proportioning pumb,dialyser,healthing bath and colorimeter.

5)What is blood pressure.State the normal value of blood pressure. APRIL/MAY 2017

- Blood pressure is a measure of the force being exerted on the walls of arteries as blood is pumped out of the heart.
- Systolic (maximum) blood pressure in the normal adult is in the range of 95 to145 mm Hg, with 120 mm Hg being average.
- Diastolic (lowest pressure between beats) blood pressure ranges from60 to 90 mm Hg, 80 mm Hg being average.

6)Find the cardiac output of a person if his heart rate is 70bpm and stroke volume is 70 ml.MAY/JUNE 2016

- Cardiac output=heart rate x stroke volume
  =70 bpm x 70 ml
  =4900

7) Mention the basic principle behind electro chemical pH determination. Nov/Dec 2013

- Electrochemical measurement of pH utilizes devices that transducer the chemical activity of the hydrogen ion into an electronic signal,such as an electrical potential difference or a change in electrical conductance.
- Methods
  - Glass membrane electrode.
  - pH-FET
  - Metal/Metal Oxide electrode
  - Liquid membrane electrode.

8) What is auto analyzer? What are the essential units in it. Nov/Dec 2012

- Auto analyser is an automated analyser using the flow technique called continuous flow analysis.
- This sequentially measures blood chemistry through a series of steps of mixing,reagent action and colorimetric measurements.
- It consists of
  - Sampler
  - Proportioning Pump
  - Dialyser
  - Heating bath
  - Colorimeter

9) What are korotkoff sounds? (Nov/Dec 2008)

- In the Blood pressure (BP) measurement, when the systolic pressure exceeds the cuff pressure, then the doctor can hear some crashing, snapping sounds through the stethoscope.
- These sounds are called as korotkoff sounds.

10)What is Fick's Principle? Give its disadvantages. Nov/Dec 2014

- Fick's Principle-Q=M/(V-A)

Q-Volume of blood flowing through a organ in a minute.
M-number of moles of a substance added to the blood by an organ in one minute.
V and A-Venos and Arterial concentrations

- This principle can be used to measure the blood flow through any organ that adds substances to or remove substances from the blood.

UNIT-3

PART-A

1) What is demand Pacemaker. NOV / DEC 2013

- The pacemaker which provide the impulses based on the patients need is known a demand pacemaker.

2) Mention the importance of defibrillator protection circuit in ECG recorder NOV / DEC 2011

- The defibrillation protection circuit in ECG recorder has buffer amplifiers for each lead electrode and over voltage protection circuits to protect pr amplifier and power amplifier.

3) Why are asynchronous pacemaker no longer used? APRIL/MAY 2016

- Artrial and ventricular are not synchronized.
- The circuit is more sensitive to external electromagnetic interferences such as electric sharers,microwave ovens and ignition systems.

4) When do you need heart lung machine? APRIL/MAY 2016

- Heart lung machine is a device that maintains the circulation of the blood and the oxygen content of the body when connected with the arteriovenos system.
- It is also called pump oxygenator.
- The machine is used in open heart surgery when it is necessary to effect by pass of the circulatory system of the heart and lungs

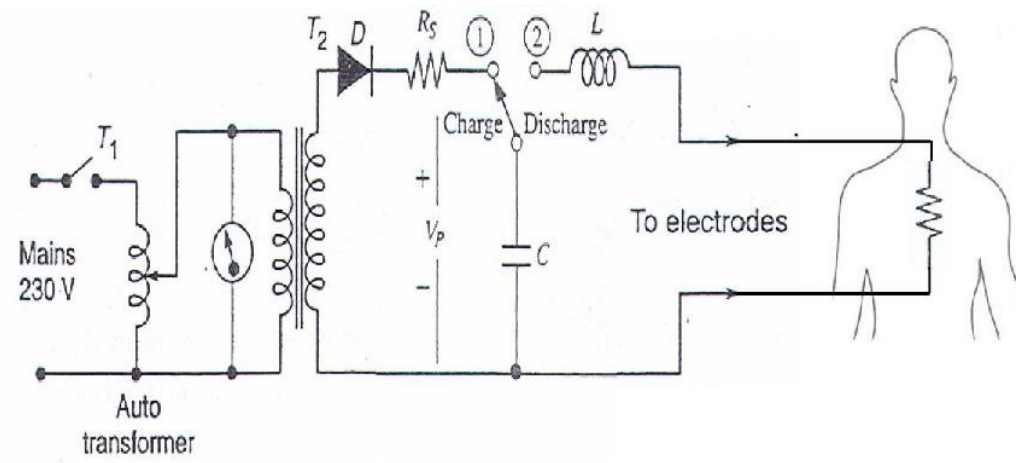
5) Differentiate internal and external pacemakers. APRIL/MAY 2008

S.No	Internal Pacemakers	External Pacemakers
1.	The pacemaker is a surgically implanted when if the skin near the chest or abdomen, with its output's leads is connected directly to the heart muscle.	The pacemaker is placed outside the body. It may be in the form of wrist watch or in the pocket, from that one terminal will go in the heart through the vein
2.	It requires open chest minor surgery to place the pacemaker	It does not require open chest surgery
3.	It is used for temporary heart regularity	It is used for permanent heart regularity
4.	There is no safety for the pacemaker, particularly in case of child carrying the pacemaker	There is 100% safety for circuit from the external disturbances.

6)Give the different types of oxygenators used in heart lung machine.

- 1.Bubble oxygenator
- 2.Film oxygenator
- 3.Membrane type oxygenator
- 4.Liquid liquid oxygenator

7) Draw the circuit of DC Defibrillator and give its output specifications. Apr/May 2011



- I rises rapidly to app. 20 A.Then I decays to 0 with 5 ms
- A negative pulse is produced for 1 to 2 ms
- The pulse width defined as the time that elapses between the start of the impulse and the moment that the current intensity passes the zero line for the first time and changes direction (5 ms or 2.5 ms)

8)When does the need for pacemaker arise? What is its function? Nov/Dec 2015

- Doctors recommend pacemakers for many reasons such as bradycardia and heart block.
- Bradycardia is a slower than normal heart beat.
- Heart block is a problem that occurs with the heart electrical's system.
- Pacemakers uses low energy electrical pulses to control abnormal heart rhythms.

9)List the typical ranges of pacemaker parameters. Nov/Dec 2014

- Weight :33-98 grams
- Reliability:3.5-18 yrs
- Pulse rate:25-155 pulse per minute
- Pulse amplitude:2.5 to 10 volts.

10) What is the pacemaker? Apr/May 2013

- Pacemaker is an electrical pulse generator for starting and maintaining the normal heart beat.
- The primary purpose of a pacemaker is to maintain the adequate heart rate either because the heart's natural pacemaker is not fast enough,or there is a block in the heart electrical conduction system.

UNIT-4

PART-A

1) *List the two types of multiplexing involved in multichannel wireless telemetry.NOV / DEC 2013*
    - Frequency division multiplexing
    - Time division Multiplexing

2) Define let go current. NOV / DEC 2016
- Let – go current is the minimum current to produce muscular contraction.
- For men—about 16mA
- For Women—about 10.5 mA

3)List the devices used to safeguard against electric hazards. APRIL/MAY 2016
- Ground fault interrupter
- Isolation transformer
- Line isolation monitor

4)What is radio pill? Mention the application of radio pill. APRIL/MAY 2016
- A capsule containing miniature radio transmitter that can be swallowed by a patient.
- During its passage through the digestive track a radio pill transmits information about the internal condition.
- Example:
    - Heidelberg Capsule

5)List the applications of bio telemetry. APRIL/MAY 2017
- Monitoring of astronauts during flight.
- Monitring of patients in ambulance while transmit to hospital.
- Monitoring of animals in their natural habitat.
- Monitoring of patients while exercising ECG.

6) Bring out the needs of patient plate in surgical diathermy. Nov/Dec 2013
- The patient lies on the couch which can be raised or lowered or moved sideways so that the tumor is positioned on the axis such that for any angle of the gantry, the beam will pass through tumor.

7)What is the principle of diathermy? Nov/Dec 2015

- Diathermy is the treatment process by which cutting,coagulation of tissues are obtained.
- Its various types are:
    - Surgical diathermy
    - Microwave diathermy
    - Ultrasonic diathermy
    - Surgical diathermy

8) Write the physiological effects of electricity? Apr/May 2015

- An electrical shock is a physiological response to current.The two types of shock are micro and macro shock.
- Macro shock-Physiological response to a current applied to the surface of body.
- Micro shock-Physiological response to a current applied to the surface of heart.

9)What is the use of ultrasonic diathermy?NOV/DEC 2011

- It is used for curing the diseases of periphera nervous system,skeletal muscle system and skin ulcers.

10) What is meant by single channel telemetry?NOV/DEC 2011

- It is used for the measurement of biological parameters over long distance.A miniature battery operated radio transmitter and receiver is used.

UNIT-5

PART-A

1) What is macro shock.MAY/JUNE 2013.

- A physiological response to a current applied to the surface of the body that produces unnecessary stimulation like muscle contractions or tissue injury is called macro shock.

2) Mention few applications of lasers in medicine. NOV / DEC 2016

- The types of lasers used in medical fields are i). Pulsed Nd-YaG laser ii). Continuous laser. Co_2 laser iii). Continuous wave organ ion laser

Applications:

- Angioplasty
- Cancer diagnosis
- Laser Mammography.

3) State the applications of telemedicine. APRIL/MAY 2016

- Information exchange between hospitals and physician.
- Networking of group of hospitals,research centres.
- Linking rural clinics to a central hospital.
- Remote Medical technology.

4)List the type of pumping sources used in LASERS. APRIL/MAY 2016

- Optical pumping-RUBY LASER
- Electron excitation-ARGON,HE-NE LASER
- Thermal excitation-CO2 LASER
- Chemical Pumping-CHEMICAL LASER

5)What makes thermograph useful APRIL/MAY 2017

- Get a visual picture so that you can compare temperatures over large area.
- It is real time capable of catching moving targets.
- Able to find deteriorating components prior to failure.
- Measurement in area inaccessible or hazaradous for other methods.

6)List the properties of LASER beam. APRIL/MAY 2017

- Monochromatic
- Directional
- Coherent
- Higher brightness operated in continuous or pulsed mode.

7) Define the term thermography. Nov/Dec 2015, Apr/May 2012

- Thermograph, thermal imaging, or thermal video, is a type of infrared imaging.
- Thermo graphic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 900–14,000 nanometers or 0.9–14 μm) and produce images of that radiation.

- Since infrared radiation is emitted by all objects based on their temperatures, according to the black body radiation law, thermograph makes it possible to see one's environment with or without visible illumination.

8)List the part of endoscope unit. Apr/May 2013

An endoscope can consist of

- A rigid or flexible tube
- A light delivery system to illuminate the organ or object under inspection. The light source is normally outside the body and the light is typically directed via an optical fiber system A lens system transmitting the image to the viewer from the fiberscope
- An additional channel to allow entry of medical instruments or manipulators

9)Bring out the clinical applications of endoscopy Nov/Dec 2015

- Endoscopy enables the physician to look inside the esophagus, stomach, and duodenum (first part of the small intestine).
- The procedure might be used to discover the reason for swallowing difficulties, nausea, vomiting, reflux, bleeding, indigestion, abdominal pain, or chest pain.

10)Which Laser is used for surgery?Apr/May 2011

Types of surgical lasers: CO2, argon,ND-YAG laser, Potassium titanyl phosphate and excimer laser.

UNIT I

ELECTRO-PHYSIOLOGY AND BIO-POTENTIAL RECORDING

1.Discuss in detail about the origin of action potential and resting potential with necessary equations. Also draw the action potential waveform. APRIL/MAY 2011, NOV / DEC 2012, APRIL/MAY 2012, NOV /DEC 2014.

THE ORIGIN OF BIO-POTENTIALS:

- Bioelectric phenomenon is of immense importance to biomedical engineers because these potentials are routinely recorded in modern clinical practice.
- ECG (Electrocardiogram), EMG (Electromyogram), EEG (Electroencephalogram), ENG (Electroneurogram), EOG (Electro-oculogram), ERG (Electroretinogram), etc. are some examples of biopotentials. We will briefly look at origin of ENG, EMG and ECG in this talk.

- As engineers, we should have a good physical insight into the nature of electromagnetic fields generated by bioelectric sources. Therefore we could contribute to quantitative solution of biological problems.

To understand the origin of biopotentials we need to focus on:

- Bioelectric phenomena at the cellular level
- Volume conductor fields of simple bioelectric sources
- Volume conductor fields of complex bioelectric sources
- Volume conductor fields as a necessary link between cellular activity and gross externally recorded biological signals

ELECTRICAL ACTIVITY OF EXCITABLE CELLS

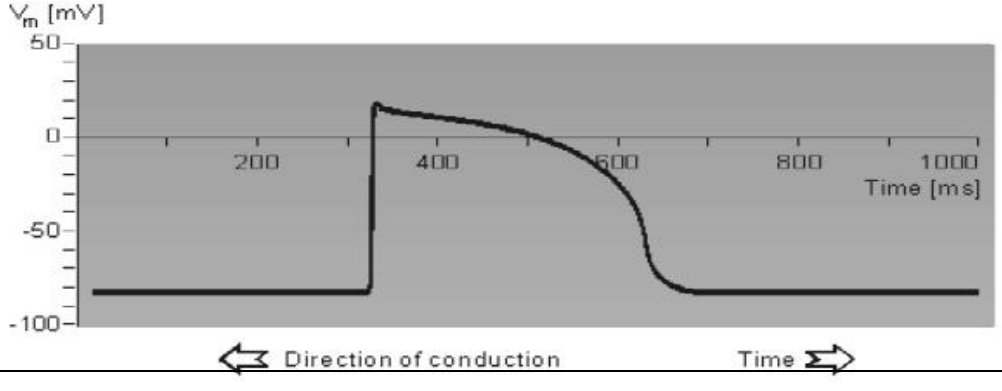
- Biopotentials are produced as a result of electrochemical activity of excitable cells: i.e., nervous, muscular (cardiac and smooth) and glandular cells

Factors influencing the flow of ions across the cell membrane

- Diffusion gradients
- Inwardly directed electric field (inside negative, outside positive)
- Membrane structure (availability of pores; K^+, $Na^+$and permeability of membrane to different ions)
- Active transport of ions across membrane against established electrochemical gradients
- When appropriately stimulated, they generate an action potential (flow of ions across the cell membrane and generation of a propagating wave of depolarization along the

  membrane)

BIOELECTRIC PHENOMENA AT THE CELLULAR



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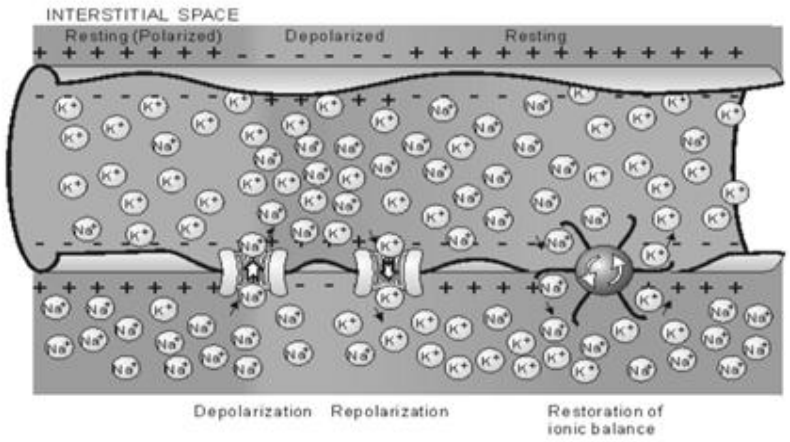


Figure Recording of action potential

A very important topic in electrophysiology is the relationship between intracellular and extracellular potentials, especially in nerve or muscle fibres .

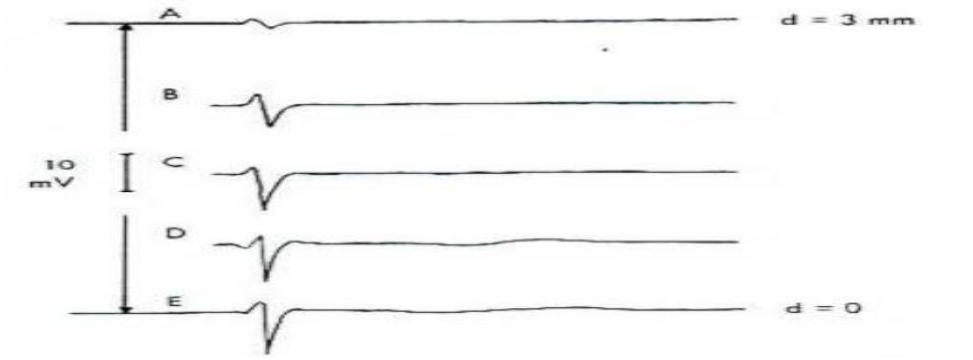


Figure Waveforms of intracellular action potential

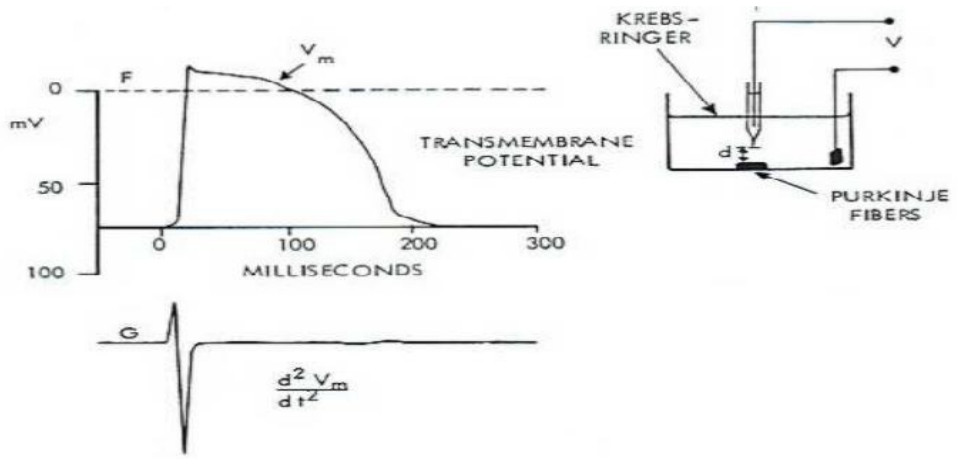
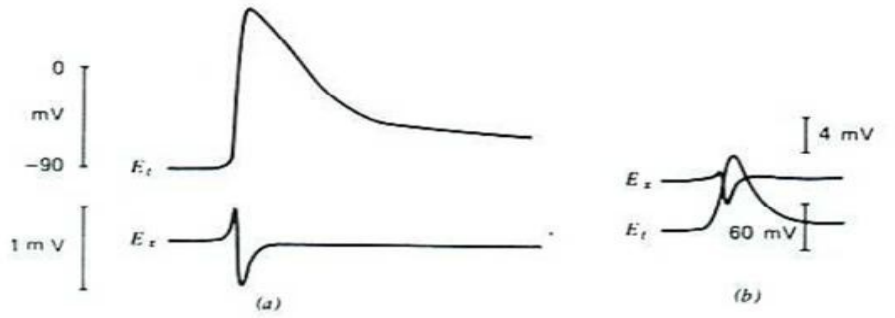


Figure Waveforms of Extracellular action potential

The relation between extracellular potentials (A-E), transmembrane potential Vm(part F) and the second derivative of Vm(part G).

Note:

The relationship between trans membrane (action potential) Vm (monophasic) and volume conductor (extracellular field) potential d2Vm/dt2(triphasic). Students interested in the biophysics of this topic should refer to: Bioelectic Phenomena by Robert Plonsey



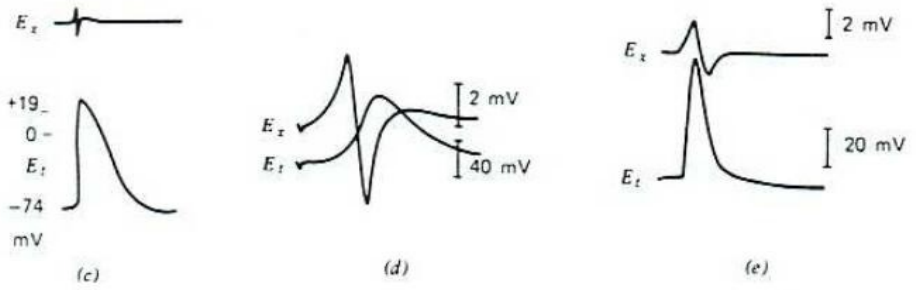


Figure Volume conductor fields of simple bioelectric sources

Trans membrane (Et= Vm) and extracellular action potentials (Ex) obtained from different excitable tissues. Note the monophasic and triphasic shapes.

a. Frog semitendinous muscle
b. Toad sartorius muscle

c. Rabbit atrium

d .Squid giant axon.

What is known as Biopotential electrodes? Draw its equivalent circuit. Explain various types of Biopotential electrodes with suitable diagram. NOV / DEC 2016

BIOPOTENTIAL ELECTRODES

Electrode – Electrolyte Interface

General Ionic Equations

$C <-> C^{n+} + ne^-$

$A^{m-} <-> A + me^-$

- If electrode has same material as cation, then this material gets oxidized and enters the electrolyte as a cation and electrons remain at the electrode and circuit.

flow in the external

- If anion can be oxidized at the electrode to form a neutral atom, one or two electrons are given to the electrode

The dominating reaction can be inferred from the following :

- Current flow from electrode to electrolyte : Oxidation (Loss of e-)
- Current flow from electrolyte to electrode : Reduction (Gain of e-)

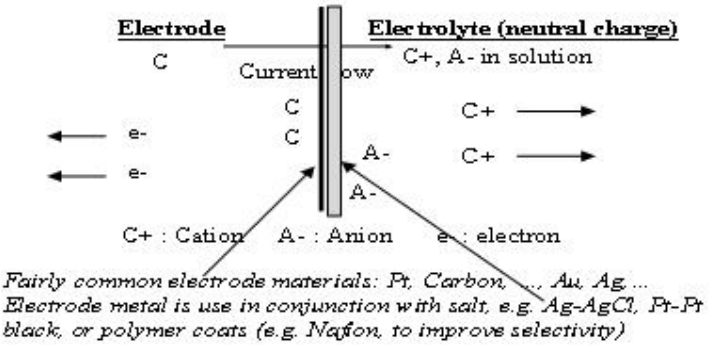


Figure Electrolyte Interface

Half Cell Potential

- A characteristic potential difference established by the electrode and its surrounding electrolyte which depends on the metal, concentration of ions in solution and temperature.

Half cell potential cannot be measured without a second electrode.

- The half cell potential of the standard hydrogen electrode has been arbitrarily set to zero.

Other half cell potentials are expressed as a potential difference with this electrode.

Reason for Half Cell Potential : Charge Separation at Interface

- Oxidation or reduction reactions at the electrode-electrolyte interface lead to a double- charge layer, similar to that which exists along electrically active biological cell membranes.

Measuring Half Cell Potential

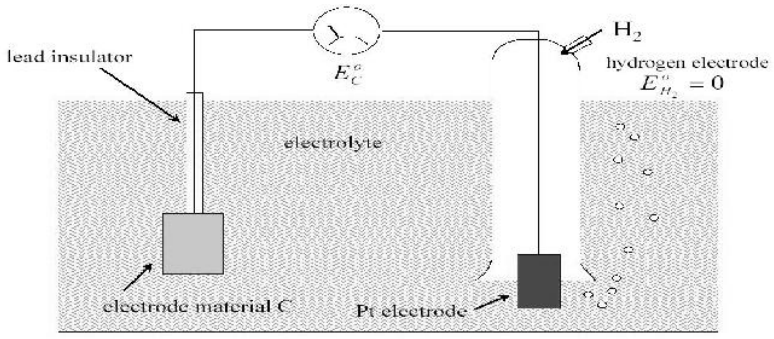


Figure Half Cell Potential

Polarization

- If there is a current between the electrode and electrolyte, the observed half cell potential is often altered due to polarization.

Nernst Equation

- When two aqueous ionic solutions of different concentration are separated by an ion- selective semi-permeable membrane, an electric potential exists across the membrane.

The Nernst equation for half cell potential is

$$E=E^0 + RT/n[a_c^{\alpha y} a_d^{\beta} / a_A a_B]$$

where E0 : Standard Half Cell Potential

E : Half Cell Potential

a : Ionic Activity (generally same as concentration)

n : Number of valence electrons involved

Polarizable and Non-Polarizable Electrodes

- **Perfectly Polarizable Electrodes:** These are electrodes in which no actual charge crosses the electrode-electrolyte interface when a current is applied. The current across the interface is a displacement current and the electrode behaves like a capacitor. Example : Ag/AgCl Electrode
- **Perfectly Non-Polarizable Electrode:** These are electrodes where current passes freely across the electrode-electrolyte interface, requiring no energy to make the transition.

Over potentials. Example : Platinum electrode

Example: Ag-AgCl is used in recording while Pt is use in stimulation

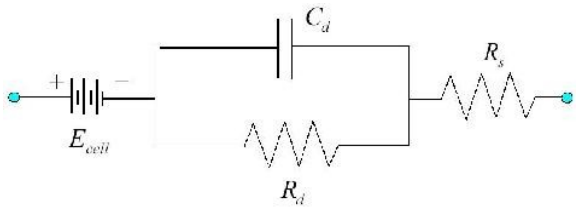


Figure Equivalent Circuit

Cd : capacitance of electrode-eletrolyte interface *Rd* : resistance of electrode-eletrolyte interface *Rs* : resistance of electrode lead wire

Ecell : cell potential for electrode

Electrode Skin Interface

Motion Artifact

- When the electrode moves with respect to the electrolyte, the distribution of the double layer of charge on polarizable electrode interface changes. This changes the half cell potential temporarily.
- If a pair of electrodes is in an electrolyte and one moves with respect to the other, a potential difference appears across the electrodes known as the ***motion artifact.*** This is

a source of noise and interference in biopotential measurements.Motion artifact is minimal

for non-polarizable electrodes

Body Surface Recording Electrodes

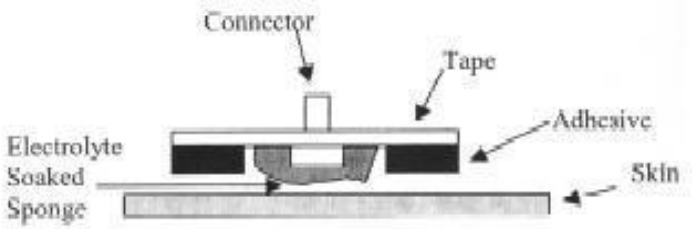


Figure Body surface Recording Electrodes

Commonly Used Biopotential Electrodes

Metal Plate Electrodes are

1. Suction Electrodes
2. Floating Electrodes
3. Flexible Electrodes

Metal plate electrodes

- Large surface: Ancient, therefore still used, ECG
- Metal disk with stainless steel; platinum or gold coated
- EMG, EEG
- smaller diameters
- motion artifacts
- Disposable foam-pad: Cheap!

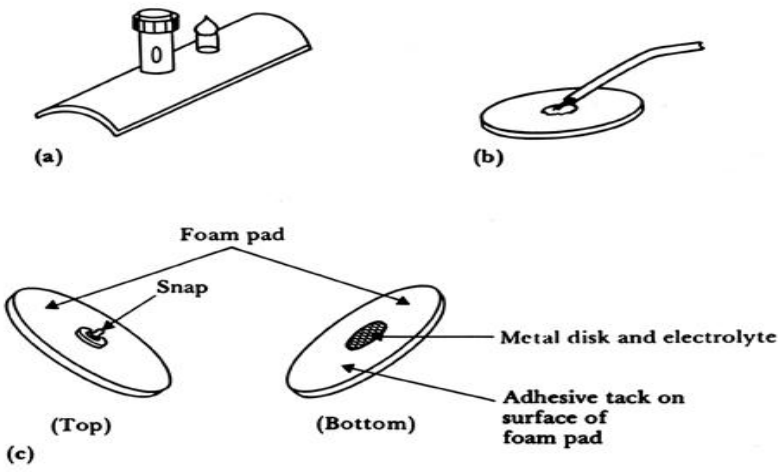


Figure Metal plate Electrode

Suction electrodes

- No straps or adhesives required
- precordial (chest) ECG
- can only be used for short periods

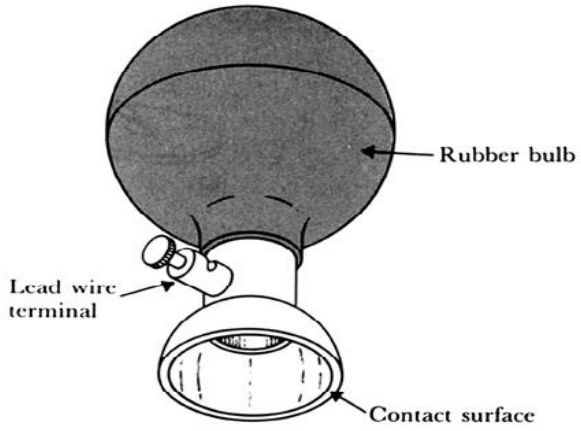


Figure Suction Electrode

- metal disk is recessed
- swimming in the electrolyte gel
- not in contact with the skin
- reduces motion artifact

Flexible electrodes

- Body contours are often irregular
- Regularly shaped rigid electrodes may not always work.
- Special case : infants
- Material :
  - Polymer or nylon with silver
  - Carbon filled silicon rubber (Mylar film)

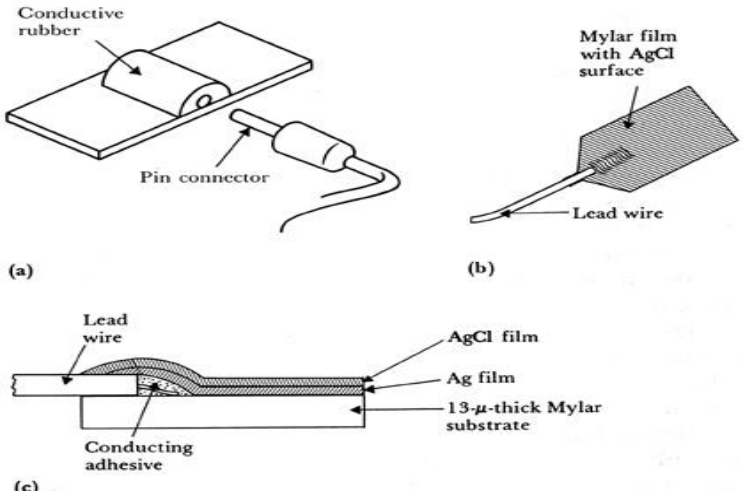


Figure Flexible Electrodes

(a)Carbon-filledsiliconerubberelectrode.
(b)Flexiblethin-filmneonatalelectrode.

(c) Cross-sectional view of the thin-film electrode in (b).

Electrodes in Biopotential Measurements

- to make the electrode cheaper
- more suitable for lower noise measurement for EEG
- circumvent patents that are based on plastic/foam electrode body
- attractive to consumers for use with their ECG machines at home
- reduce artifact (minimize the motion of skin/electrode) in ambulatory recording

In a research laboratory, scientists want to record from single cells in a culture dish. They want to record action potentials from single, isolated heart cells. What kind of electrode would they need to use (describe material and design)? Give a simplified schematic (circuit model of the electrode) described in the notes given to you.

Neural electrodes/microelectrodes

It is used to measure potential within asingla cell.It is small in diameter and during insertion of microelectrode into cell will not damage to human cell.

- It is classified into

    1. Metallic
    2. Non metallic(Micropipet)

Metallic Electrode

- It is formed by electrolytically etching the tip of fine tungsten filament stainless wire into a minute structure.
    - Potential within the cell can be measured by using two electrodes

    1. Micro electrode, 2. Reference electrode.

Non Metallic (Micropipet)

- It is used to measure the potential within the single cell using non metallic material is used.
- It is filled within an electrolyte ,that is compatible with the cellular fluids.

Distinguish biological amplifier from a conventional amplifier with suitable equations and circuits APR/MAY 2014

BIOPOTENTIAL AMPLIFIERS

- These are very important part of modern medical instrumentation. We need to amplify biopotentials which are generated in the body at low levels with high source impedance.
- Biopotentials amplifiers are required to increase signal strength while maintaining fidelity

Basic Requirements of Biopotential Amplifiers

Essential functions of a bioamplifier are:

• To take a weak biopotential and increase its amplitude so that it can be processed,

recorded or displayed

• To amplify voltage, but it could be considered as a power amplifier as well.To amplify current since in some cases a biopotential amplifier is used to isolate the load from the source current gain only

Input Impedance (Zin)

• All biopotential amplifiers must have **high input impedance** minimize loading (remember the characteristics of biopotential electrodes resulting into loading and distortion if input impedance of the amplifier is not high enough) – typical values of Zin over the frequency range of the measure and = 10 MΩ (remember the loading rule)

• Any potential or current at amplifier's input terminals can affect

Electric currents produced by the biopotential amplifier can result in microshock and macro shock

• The bioamplifier must have isolation and protection circuitry so that the current through the electrodes can be kept at safe levels and any artifact generated by such current can be minimized

Output Impedance (Zout)

- The output circuit does not present any critical problems, all it needs to do is to drive the load
- Output impedance must be low with respect to the load impedance and it must be capable of satisfying the power requirements of the load

Bandwidth (BW)

Frequency response

• The biopotential amplifier must be sensitive to important frequency components of the

biosignal

• Since biopotentials are low level signals, it is important to limit bandwidth

optimize signal-to-noise ratio

Gain (G)

• Biopotential amplifiers have a gain of **1000** or greater

Mode of Operation

• Very frequently biosignals are obtained from bipolar electrodes

• Electrodes symmetrically located with respect to ground need differential amplification

• High CMRR required because:

1. Common mode signals much greater than the biosignal appear on bipolar electrodes

2. Symmetry with respect to ground is not perfect (mismatch between electrode impedances) –

more on this later

Calibration Signal

- Medical and clinical equipment require quick calibration. The gain of the biopotential amplifier must be calibrated to provide us with an accurate indication of the signal's amplitude
- Push button to apply standard signal to the input of the biopotential amplifier
- Adjustable gain switch carefully selects calibrated fixed gains.

**.Discuss the genesis of ECG and explain the working of ECG machine with suitable block diagram along with its various lead configurations. NOV / DEC 2016*

ELECTROCARDIOGRAPHY (ECG)

- A very widely used medical instrument, which is utilized to diagnose and monitor cardiac beat abnormalities, is the electrocardiograph.
- It measures the electrical activity of the heart (more precisely biopotential differences arising from the electrical activity of myocardium). We've already talked about the genesis of the ECG signal.
- The ECG machine uses surface electrodes and high input impedance
- Differential amplifiers with good common mode rejection ratio to record the electrocardiogram
- Normal ECG amplitude ranges between 0.5-4 mV. Normal frequency content of ECG (for diagnostic purposes) is 0.05-100 Hz. A typical ECG waveform is shown below:

Significant diagnostic features of the ECG signal are:

- Duration of component parts of the signal
- Polarities and magnitudes
- The details of the ECG signal and the degree of variability in different parts of the ECG signal is shown below:

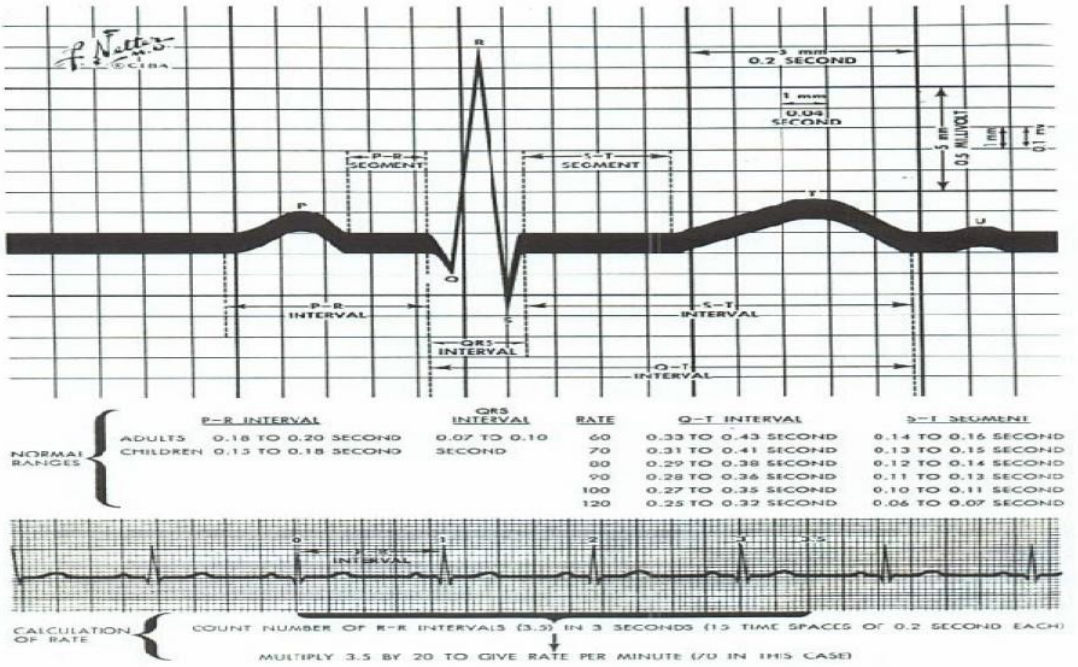


Figure ECG Signal

- The QRS amplitude, polarity, time duration, the RR interval (indicator of heartbeat per min.) and the T-wave amplitude are some very important and distinctive features of the ECG signal.
- The heart rate in BPM = Beats Per Minute) is simply = 60 (RR interval in seconds)

Some ECG waveform abnormalities that may indicate illness are:

- An extended PR interval may be diagnosed as AV node block
- A widening of the QRS complex may indicate conduction problems in the bundle of His
- An elevated ST segment may indicate occurrence of myocardial Infarction (MI)
- A negative polarity in the T wave may be due to coronary insufficiency

ECG Leads

A Normal ECG recording for the standard lead connections leads I, II and III (Lead II provides the strongest signal)

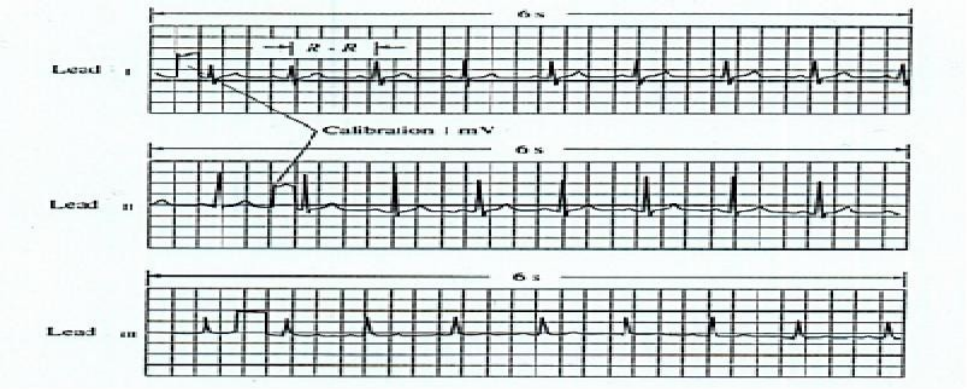


Figure Normal ECG waveforms

Obviously, all human hearts are not the same and this results into a high degree of **variability.**

Some abnormalities that may indicate illness:

- An extended P-R interval may be diagnosed as AV node block
- Widening of the QRS complex conduction problems in the bundle of His
- Elevated ST segment may indicate occurrence of MI
- Negative polarity T wave may be due to coronary insufficiency QRS amplitude, polarity, time domain, PR interval (indicator of heat beat per min. & T-wave amplitude are some very important.
- **Distinctive features**.

  1.Loss

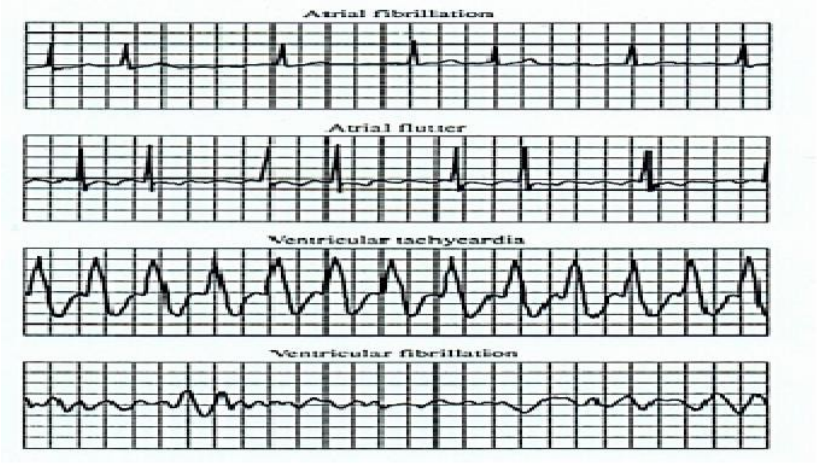


Figure ECG Abnormal waveforms

2. Origin of the ECG signal

Standard Limb Leads (I, II, III)

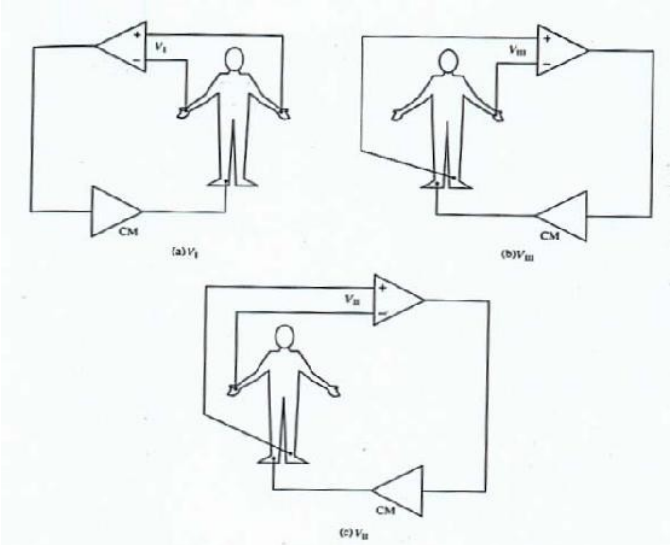


Figure origin of ECG Signal

- The lead wires are color-coded according to some conventions. One example is: White – RA (Right Arm), Black – LA (Left Arm), Green – RL (Right Leg), Red – LL (Left Leg), and Brown – C (Chest)

Augmented Limb Leads

- These leads offer a free 50% increase over leads VR, VL, and VF connections (unipolar leads) with respect to Wilson terminal AVR = -I – III/2, AVL = I – II/2, aVF = II – I/2

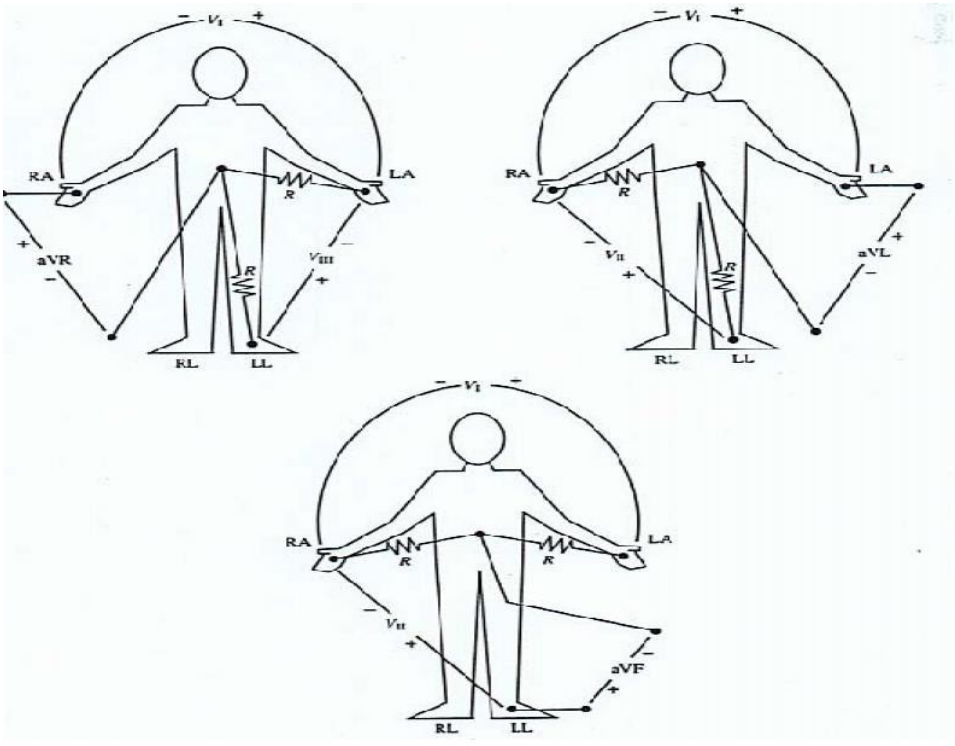


Figure Augmented Limb Leads

Each measurement is made from the reflected limb and the average of the other two limbs.

The ECG Machine

Most representative Specs:

- Zin = 10 MΩ
- Frequency response = 0.05 –100 Hz

- Strip Chart Recorder Speed = 25 mm/sec.
- Fast Speed = 100 mm/sec.

For detailed Specs. Refer to the Table in your text “Summary of performance requirements for electrocardiographs”

Location of the Heart

- The heart is located between the lungs behind the sternum and above the diaphragm.
- It is surrounded by the pericardium.
- Its size is about that of a fist, and its weight is about 250-300 g.
- Its center is located about 1.5 cm to the left of the midsagittal plane.

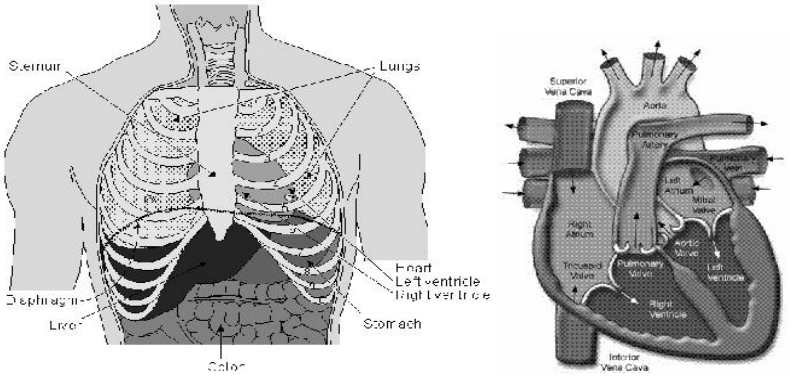


Figure 1.18 Location of Heart

Anatomy of the heart

- The walls of the heart are composed of cardiac muscle, called myocardium.

- It consists of four compartments:
  - the right and left atria and ventricles

The Heart Valves

- The tricuspid valve regulates blood flow between the right atrium and right ventricle.
- The pulmonary valve controls blood flow from the right ventricle into the pulmonary arteries

- The mitral valve lets oxygen-rich blood from your lungs pass from the left atrium into the left ventricle.
- The aortic valve lets oxygen-rich blood pass from the left ventricle into the aorta, then to the body.

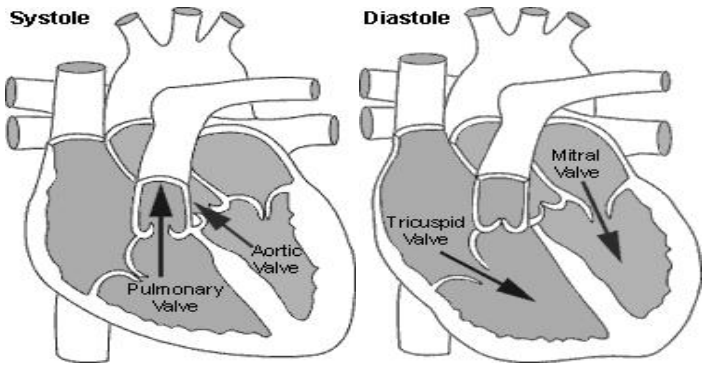


Figure Heart Valves

Blood circulation via heart

- The blood returns from the systemic circulation to the right atrium and from there goes through the tricuspid valve to the right ventricle.
- It is ejected from the right ventricle through the pulmonary valve to the lungs.
- Oxygenated blood returns from the lungs to the left atrium, and from there through the mitral valve to the left ventricle.
- Finally blood is pumped through the aortic valve to the aorta and the systemic circulation.

Electrical activation of the heart

- In the heart muscle cell, or *myocyte*, electric activation takes place by means of the same mechanism as in the nerve cell, i.e., from the inflow of Na ions across the cell membrane.
- The amplitude of the action potential is also similar, being 100 mV for both nerve and muscle
- The duration of the cardiac impulse is, however, two orders of magnitude longer than in either nerve cell or sceletal muscle cell.
- As in the nerve cell, repolarization is a consequence of the outflow of K ions.
- The duration of the action impulse is about 300 ms

Mechanical contraction of Cardiac Muscle

- Associated with the electric activation of cardiac muscle cell is its mechanical contraction, which occurs a little later.

- An important distinction between cardiac muscle tissue and skeletal muscle is that in cardiac muscle, activation can propagate from one cell to another in any direction.
- Electrical signal begins in the sinoatrial (SA) node: "natural pacemaker." causes the atria to contract.
- The signal then passes through the atrioventricular (AV) node.
  - sends the signal to the ventricles via the “bundle of His”
  - Causes the ventricles to contract.

The Conduction System

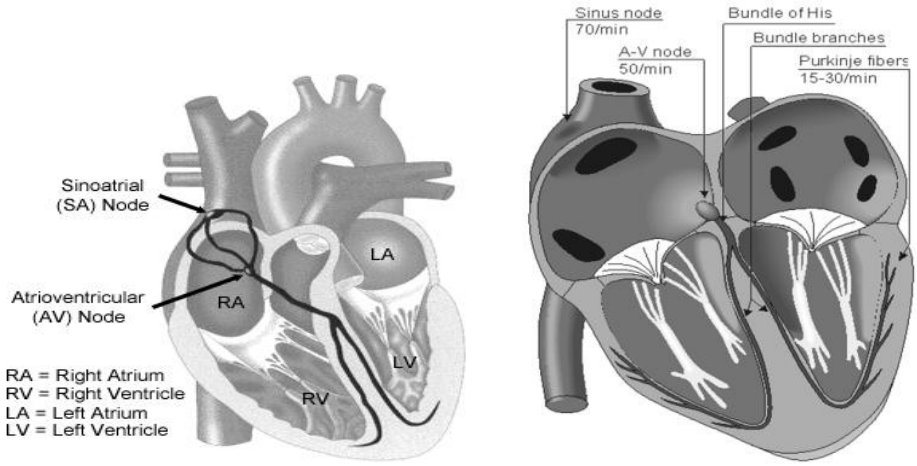


Figure Conduction System

The Action Potential

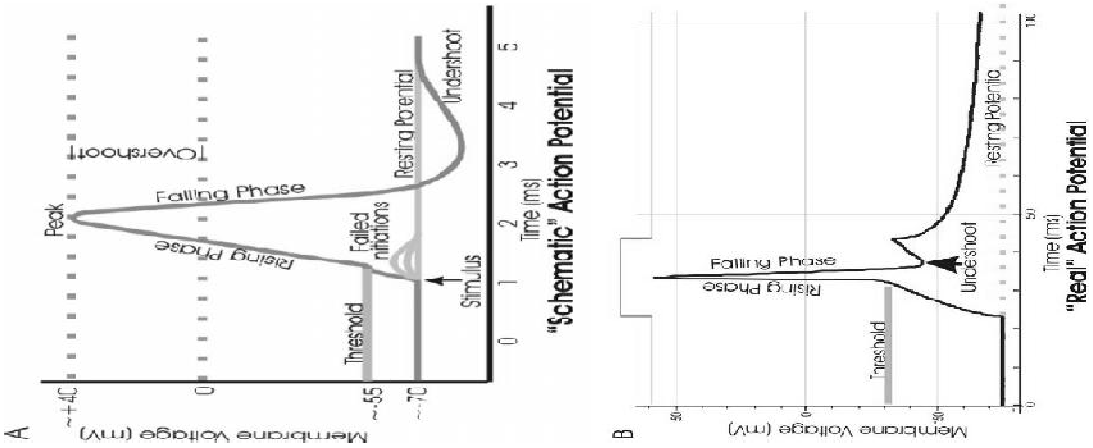


Figure 1.21 Action Potential

Recording an AP requires the isolation of a single cell.

- Microelectrodes (with tips a few µm across) are used to stimulate and record the response. A typical AP is 2-4ms long with an amplitude of about 100Mv

ELECTROENCEPHALOGRAM (EEG)

- EEG is the recorded representation of bioelectric potentials generated by the neuronal activity of the brain.
- Basically, the brain is a gelatinous mass suspend in the meanings, the cerebrospinal fluid, skull and scalp.
- The brain is composed of three major subdivisions:

    1. Cerebellum,
    2. Brainstem
    3. (Medulla, pons, midbrain, diencephalon) and
    4. Cerebrum

The cerebellum is mainly involved with skeletal muscle functions and maintenance of balance. It coordinates smooth and directed movements.

- The brain stemis the stalk of the brain and serves as a relay station for all afferent (sensory) and efferent (motor) nerve fibers between the spinal cord and higher brain canters. It also gives rise to ten of the twelve cranial nerves, which supply the muscles and glands of the head and major organs in the thoracic and abdominal cavities
- Throughout the entire brainstem runs a core of tissue called the reticular formation, which serves as a highly complex cluster of neurons involved in integration of information from many afferent pathways as well as from numerous other parts of the brain.

- The cerebrum consists of the right and left hemispheres. The outer part of the cerebral hemispheres, the cerebral cortex, is a cellular shell 1.5 – 4 mm thick of grey matter.
- The cerebral cortex is highly convoluted and is the most complex integrating center of the nervous system. It brings together basic sensory information into meaningful perceptual images and formulates ultimate decisions for control over the motor systems of the body.
- The cerebral cortex is comprised of two layers: the pale cortex and the neocortex.
- The pale cortex is located on the median surface and the base of the brain and the neocortex is present on the superior and lateral aspects of the cerebral hemispheres.
- The neocortex is composed of six layers and its cells can be categorized as pyramidal and non-pyramidal cells. There are approximately 1010 neurons in the human cerebral cortex, about 75% of, which is pyramidal.
- Pyramidal cells, named originally after their shape, have several

  characteristics. Their cell bodies are commonly triangular in shape, with the base down and the apex directed toward the cortical (superficial) surface.
- The cell bodies vary in size, from axial dimensions of 15 x 10 µm up to 120 x 90 µm. A typical pyramidal cell consists of a long apical dendrite, about 2 mm long, that ascends from the apex of the cell body and enters the overlaying layers and terminally branches

  within the outermost layer of the neocortex.
- There is a dominant apical dendrites tree, looking like a forest of

  similarly oriented, densely packed units in the superficial layers of the neocortex, where extensive branching occurs.

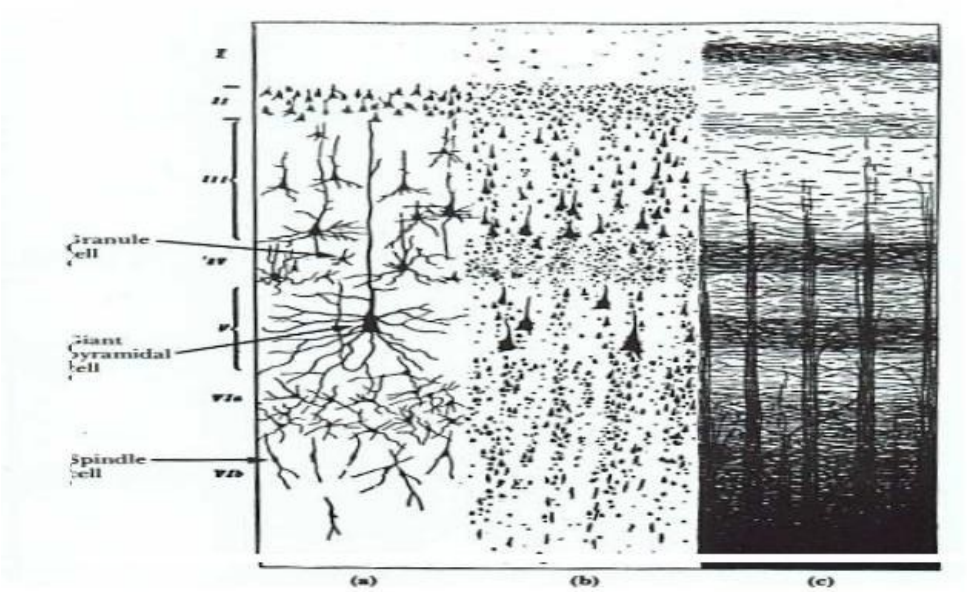


Figure EEG

- There is also a basilar dendritic system that extends out spherically from the cell body.
- Pyramidal cells also have an axon that emerges from the cell body and enters the sub cortical white matter.
- The axons of all pyramidal cells terminate in excitatory synapses. The initial segment of pyramidal cells is unmyelinated, as their recurrent branches

- Axons of some pyramidal cells turn back toward the cortical surface to end via their many dendritic branches on the dendrites of other cells.
- It has been shown by electrophysiological studies that under normal circumstances, propagating action potentials in axons do not contribute significantly to surface cortical recordings.
- There reason being that action potentials travel in large number of axons (running in many different directions relative to the surface) in a temporally a synchronized way. Therefore, their net contribution to the surface EEG is minimal and negligible.
- It has been shown that the vertically oriented pyramidal cells with their long apical dendrites running parallel to one another are the major contributors to the electro genesis of the cortical field potentials (EEG signal).

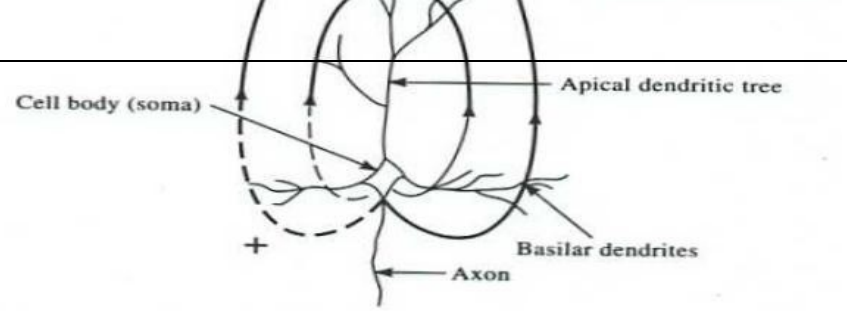


Figure Cerebrum

A highly schematic representation of a pyramidal cell and its role in the generation of surface EEG signal. Let's consider a single pyramidal cell, and explain how potential changes in one part of the cell relative to other parts could generate the EEG signal.

- Excitatory synaptic inputs to the branches in the apical dendritic tree of the pyramidal cells cause depolarization of the dendritic membrane.
- This leads into generation of an excitatory postsynaptic potential (EPSP)
- As a result, a radially oriented dipole is set up and sub threshold current flows in a closed path through the cytoplasmic core of the dendrites and cell body of the cell, returning to the synaptic sites via the conducting extracellular medium
- The lines of current flow make the extracellular medium close to the cell body act as a source with + polarity and the upper part of the apical dendritic tree to act as a sink with – polarity.
- This leads into recording a negative potential at the cortical surface
- In case of inhibitory synaptic inputs to the branches in the apical

dendritic tree, an inhibitory postsynaptic potential (IPSP) is generated with a reversal in the polarity of the current dipole, which leads into a generation of a positive cortical recording.

- Therefore, the influence of a particular dendritic postsynaptic potential on the cortical recording depends on its net excitatory or inhibitory effect and on its location relative to the measurement site.

The EEG (electroencephalogram) signal is a recording of the electrical activity of the brain. The EEG signal recorded at the cortex or the scalp is generated by the polled activity of billions of cortical and sub cortical regions. The origin of the EEG signal is based on the electrical activity of the pyramidal cells. The EEG potentials primarily reflect the summated fluctuations of excitatory and inhibitory postsynaptic potentials in the pyramidal cells of the upper layers of the cerebral cortex. For reasons of geometry as well as because of extreme extracellular attenuation, action potentials from firings of pyramidal cells contribute only minimally or not all to the generation of the EEG signal.

- All we need to contend ourselves with at this stages that the EEG or brain waves are summation of neural depolarization sin the brain due to the stimuli from the five senses as well as from thought processes (indeed a very complex source). More on this in physiology in the Nervous System topic.
- EEG potentials have random-appearing waveforms with peak-to-peak amplitudes ranging from less than 10 mV to over 100mV. Required bandwidth is from below 1 Hz to over

  100 Hz.

EEG is recorded with 3 types of electrodes:

1. Scalp
2. Cortical Electrocardiogram (recording from surface of cortex)
3. Depth Electrodes recording from depth of brain (thin insulated needles of various designs)

- No matter where the recording is obtained from (scalp, cortex or depth of the brain), the fluctuating potentials represent a superposition of the volume conductor fields produced by a huge variety of active neuronal current-generators.
- On the surface of the brain (i.e. Electrocardiogram), we can record voltages on the order of 10 mV! But, typical EEG electrodes measure the electrical activity propagated through skull bone and is attenuated from 1 to 100 μV.

- EEG potentials vary as a function of position over the surface of the skull, making it necessary to select sets of electrodes grouped around Frontal, Parietal, Temporal and Occipital lobes.

The EEG Signal

- The character of the EEG signal is highly dependent on the degree of the activity of the cerebral cortex, i.e. waves change markedly between states of wakefulness and sleep.
- Much of the time, EEGs are irregular and no general pattern can be observed. Other times, distinct patterns emerge
- The EEG waveform is divided into four wave groups:

    1. The Alpha Waves (α) 8-13 Hz
    2. The Beta Waves (β) 14-30 Hz (The Gamma Waves (γ) 22-30 Hz or higher)
    3. The Theta Waves (θ) 4-7 Hz
    4. The Delta Waves (δ) <3.5 Hz

Note: During periods of mental activity, the waves usually become asynchronous rather than synchronous, so the magnitude of summed potentials decreases in spite of cortical activity.

- In general there is a relationship between cerebral activity and the frequency of the EEG rhythm
- Frequency increases progressively with higher degrees of activity

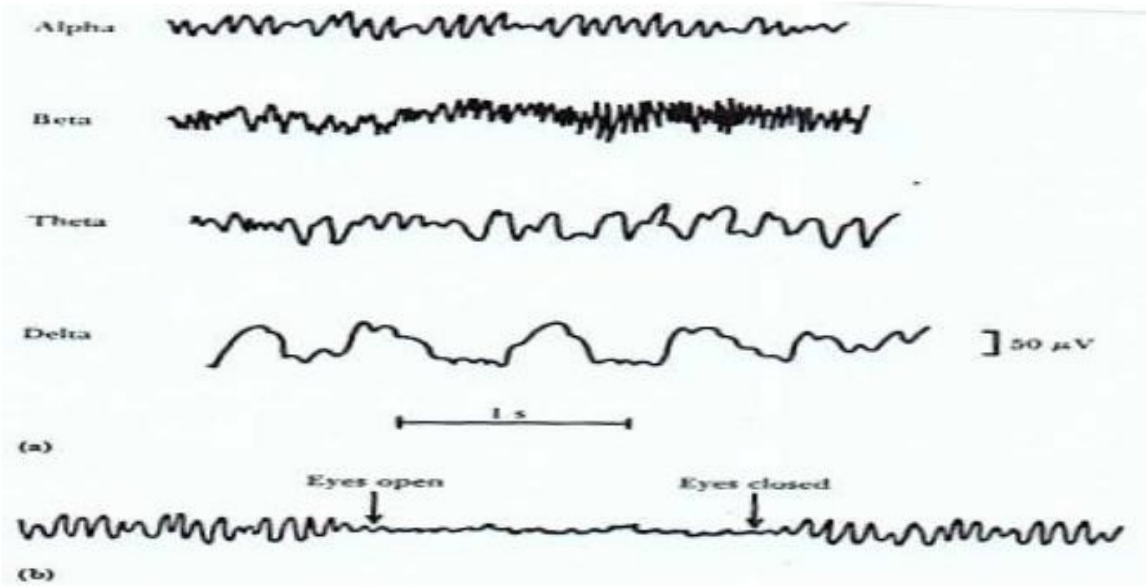
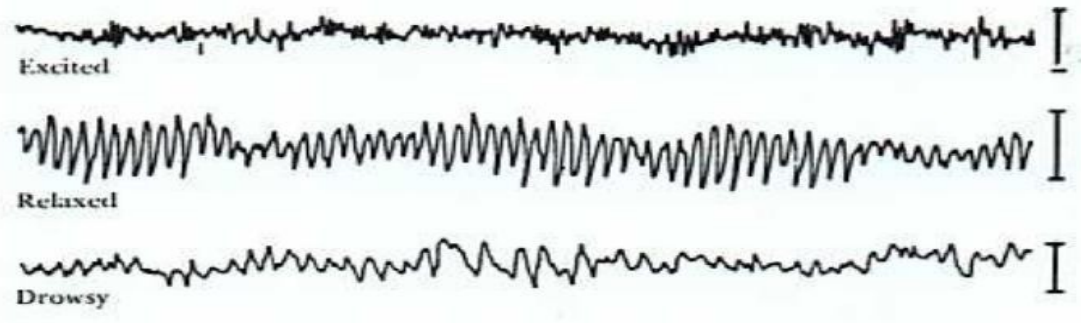


Figure EEG waveform

Examples:

- δ-Waves(<3.5 Hz) occur in surgical anesthesia and sleep
- θ-Waves(4-7 Hz) occur in emotional stress and frustration
- α-Waves(8-13 Hz) occur during relaxed states
- β-Waves(14-30 Hz)occur during intense mental activity



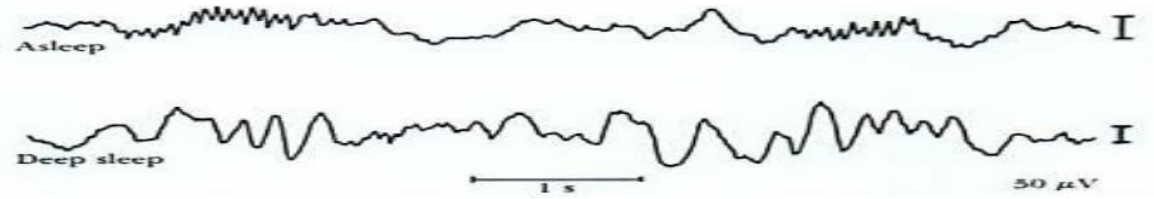


Figure Different EEG waveforms

The EEG changes that occur as a human subject goes to sleep.

EEGs in Diagnosis

The purpose of the clinical EEG is to help neurologists diagnose disease. The pathological states most commonly diagnosed using EEG are:

- Brain death (legal death)
- Brain tumors
- Epilepsy
- Multiple Sclerosis
- Sleep Disorder
- Evoked responses (diseases of the audio, visual and tactile senses)
- Modern life sustaining equipment like respirators, kidney dialyzers, ventilators, artificial heart pumps have changes the definition of death
- A sustained absence of EEG signal is a clinical measure of brain death and can be used in deciding whether to transplant a heart, liver, or lung or whether to shut down the life

  sustaining equipment

Some Representative Abnormal EEGS

Petit mal epilepsy– Minor for of seizure, clouding of consciousness and loss of contact with the environment

Grand mal epilepsy– Sudden loss of consciousness, falling down, tonic contractions (stiffening of muscles) followed by twitching and jerking movements of the limbs

Psychomotor seizures are parietal seizures characterized by: semi-purposeful movements, changes in consciousness, hallucinations and illusions.

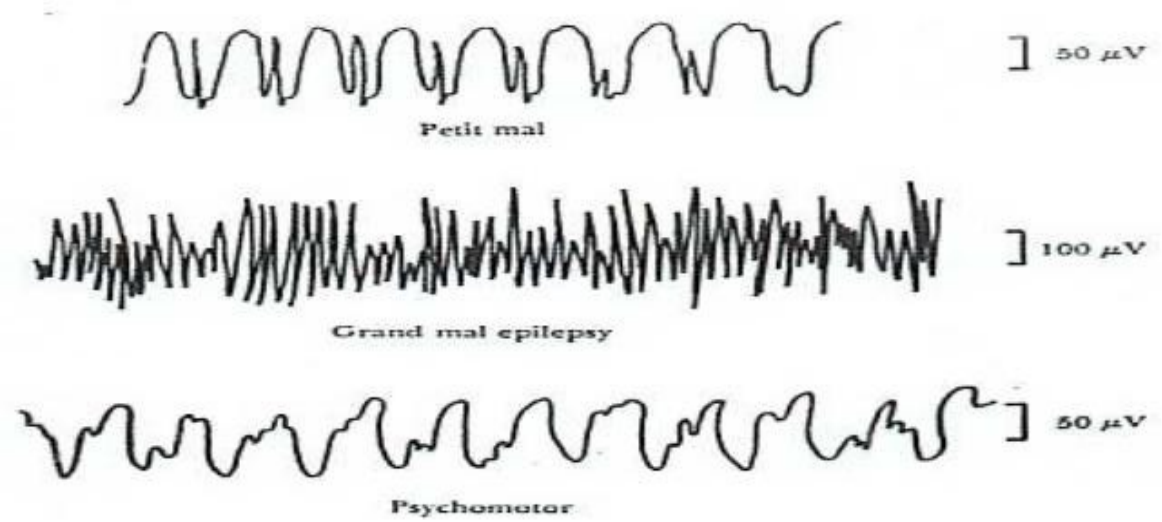


Figure Abnormal EEGs

EEG Electrode Positions

- In electroencephalography, the electrodes are placed in an arrangement referred to as the

  10-20 system

- This is a placement scheme devised by the International Federation of Societies of

Electroencephalography

- The electrodes are placed along a line drawn on the skull from the root of the nose, the nasion, to the classification (bump on the occipital lobe)
- The first mark is placed 10% of the distance along this line and others are arranged at 20% intervals

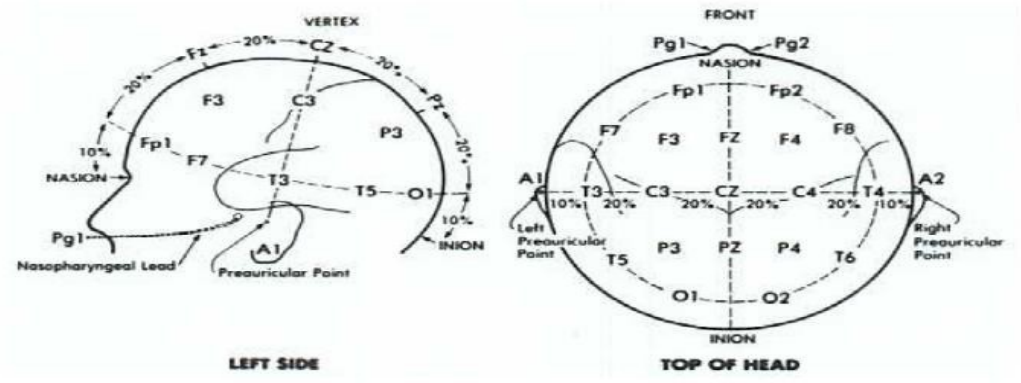


Figure EEG Electrode position

Electroencephalograph Signal Path

The EEG signal path is comprised of: Scalp (biosignal source) EEG electrodes , Junction box ,channel selector , differential amplifier, bank filters, display .

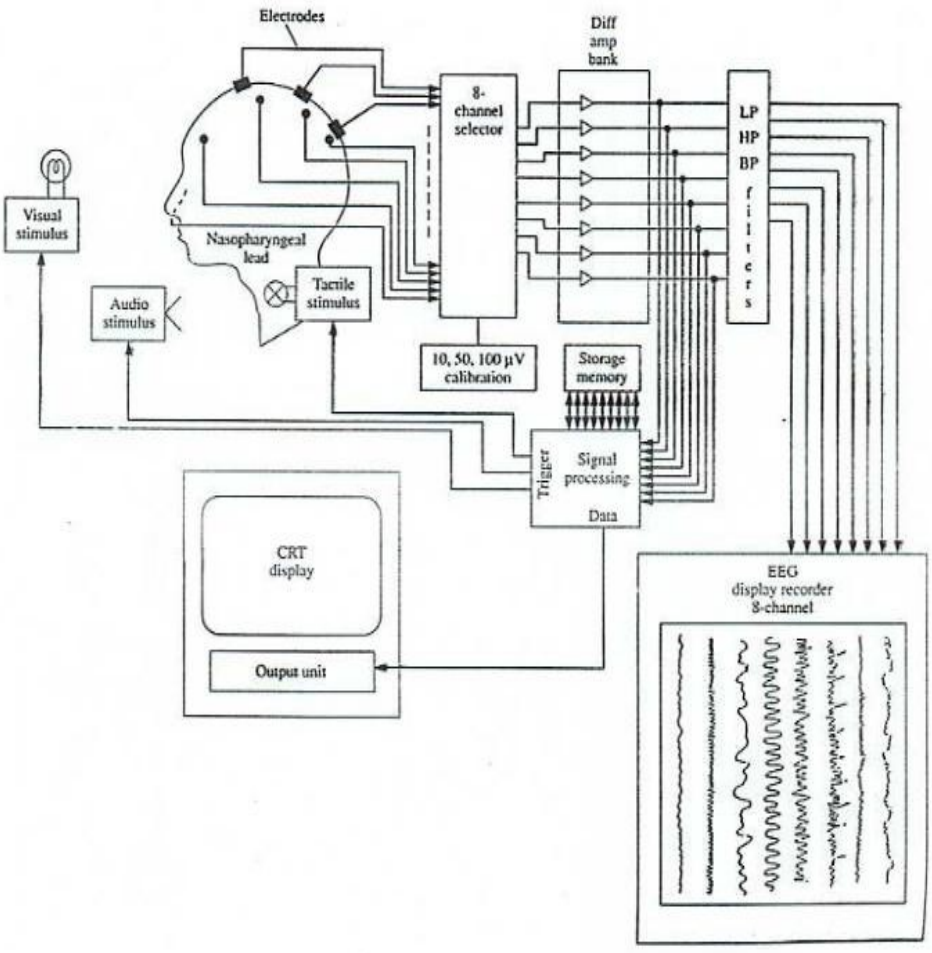


Figure Block diagram of Electroencephalograph Signal Path

- It shows the modern 8 channel EEG recorder. The patient cable consists of 21 electrodes and is connected to the 8 channel selector.
- The electrodes are attached to the channel selector in groups of 8 called a montage of electrodes.
- The right ear electrode acts as reference electrode for the right brain electrodes and left ear electrode act as reference electrode for left brain electrodes.
- The 50 Hz interference is reduced by employing differential amplifiers as preamplifiers with more than 80 dB CMRR and by use of 50 Hz notch filters.
- The effect of notch filter on signal distortion is not so much because important EEG signals have frequencies below 30 Hz.

- The output voltage from the amplifier may either be applied directly to the eight channel display through the filter bank or it may be stored as data on a tape recorder or in a computer memory for further processing.

Describe the typical EMG waveform and its characteristics. APRIL/MAY 2017,APR/MAY 2016.

EMG (ELECTRO MYOGRAPH)

It is an instrument used for recording the electrical activity of the muscles to determine whether the muscle is contracting or not. Study of neuromuscular function is also possible by using EMG. Muscular contractions are caused by the depolarization of muscle fibers. Similarly the recording of peripheral nerves action potentials is called as electro neurography.

ELECTRODES USED FOR EMG Two

types of electrodes:

Surface electrodes- Usually this electrode is used for EMG. But by using this electrode, it is not possible to take the deeper potential.

Needle electrodes – These are inserted into tissue or closer to tissue to measure the electrical activity of muscle.

EMG RECORDING SYSTEM

EMG potentials are taken from the tissue by using electrodes. These EMG potentials are given to differential amplifier. This is the high gain amplifier. Its frequency range is given as 10 Hz to 10 KHz.

Bandwidth of EMG is large. CMRR (Common mode Rejection Ratio) of this differential amplifier is 80 to 100 db.Input Impedance of this amplifier is 10 MΩ. Here there is no lead selector switch. Because only two electrodes are available. The output of the differential amplifier is given to loudspeaker system, tape recorder and CRO.

Before giving the output of differential amplifier to loudspeaker, it is given to power amplifier. Power amplifier amplifies the signal that is received by loudspeaker.

The amplified signal from the output of the differential amplifier is displayed by using CRO. Here storage oscilloscope is used. Output cab be displayed and the same can be stored in the CRO. The signal from the differential amplifier is recorded by using tape recorder. It is used for the future purpose.

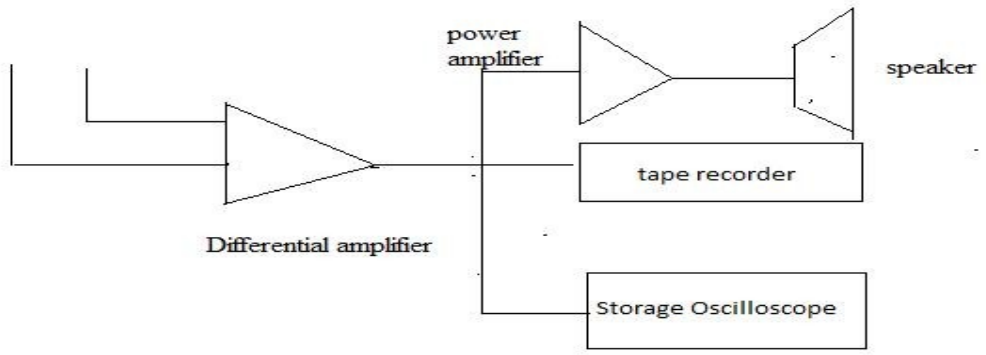


Figure EMG Recording System

MEASUREMENT OF CONDUCTION VELOCITY IN MOTOR NERVES

In modern EMG systems, nerve conduction time and nerve velocity are measured. For this measurement, initially nerve is stimulated and EMG is measured.This conduction velocity measurement is used to indicate the location and type of nerve lesion.

Steps involved in measurement of conduction velocity

- Stimulte is applied at point A
- Electrical activity of muscle is measured at point B
- The space between A and B is noted as l_1 meters.
- The time delay between applying stimulus and receiving action potential is known as latency. This time delay is detoned as t_1 second.
- Now change the position of A into C. Now the space is reduced. It is noted as l_2 meters.
- The time delay noted is t_2 second.
- Usually, $l_2 < l_1$ and $t_2 < t_1$.
- Now , the conduction velocity is given as , $V = l_1.l_2/t_1.t_2$.
- Usually V= 50 m/sec.
- If V<40 m/s. It means there is some disorder in nerve conduction.
- Thus conduction velocity is measured in motor nerves.

- Skeletal muscle is organized functionally on the basis of the motor unit.

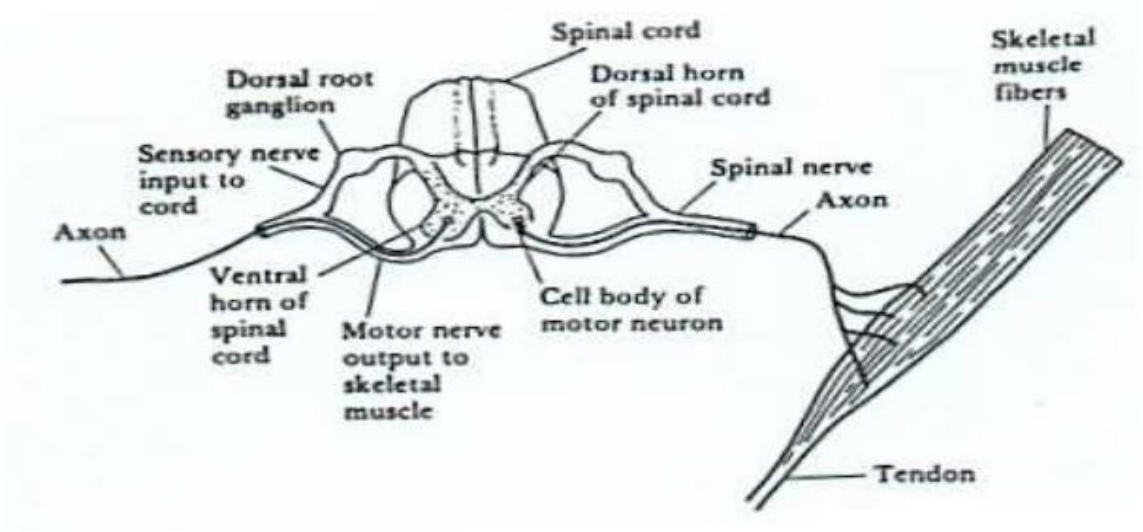


Figure Conduction Velocity In Motor Nerves

Single Motor Unit (SMU)

- The motor unit is the smallest unit that can be activated by a volitional effort (all constituent muscle fibers are activated synchronously)
- Single motor unit (SMU) consists of a single motor neuron and the group of skeletal muscles that it innervates
- SMU is a distributed unit bioelectric source in a volume conductor consisting of all other muscle fibers, both active and inactive.
- The evoked extracellular field potential from the active fibers of an SMU has a triphasic form of 3-15 ms duration and 20-2000 μV amplitude depending on the size of SMU
- The figure below shows motor unit potentials from normal muscle under graded levels of contraction. At high levels of activity, many sophisticated motor unit responses give rise

  to a complicated response (interference pattern)

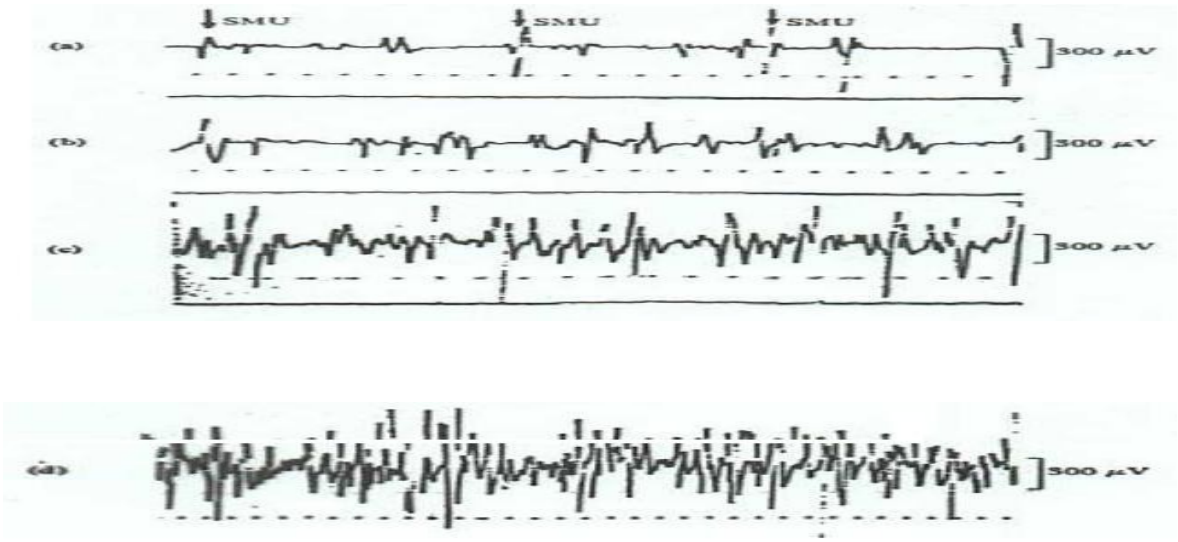


Figure EMG Recording

- A variety of electrodes have been developed for EMG recording
- The figure below shows the needle and wire electrodes used in recording the EMG signal
- The EMG is also of considerable clinical value
- The shape of SMU potentials is modified by disease

The figure below shows the EMG response for a normal subject and one with neuropathy

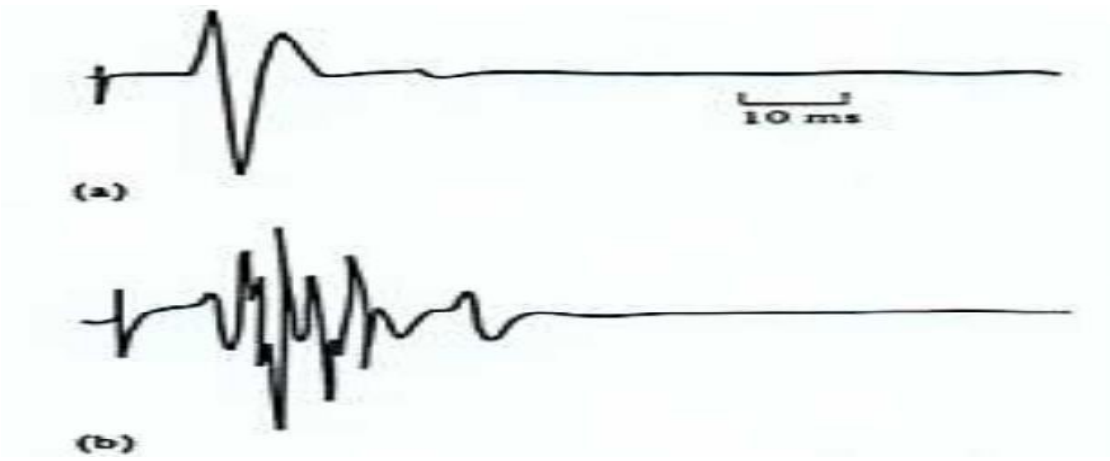


Figure EMG response of a normal and an abnormal waveforms

Applications of EMG:

EMG is used in the field of:

- Electrophysiological testing.
- Clinical neurophysiology.
- Neurology.
- Psychiatry.

Write Short notes on measurement of PCG. APR/MAY 2014

PCG (PHONO CARDIOGRAM)

The graphical record of heart sound is known as Phono Cardiogram. Here Cardio means the heart. The device which is used to measure heart sound is known as phonocardiograph. Auscultation: The technique of listening sound produced by organs and vessels of the body is known as auscultation.

In PCG, different types of heart sounds are measured. These heart sounds are due to the vibrations set up in the blood inside the heart by the sudden closure of valves. In abnormal heart additional sounds are heard between the normal heart sound. These additional sounds are known as murmurs.Murmers is generally caused by improper opening of the valves or by regurgitation.

CLASSIFICATION OF HEART SOUND

It is divided into four types

- ✓ Valve closure sound
- ✓ Ventricular filling sound
- ✓ Valve opening sound

- ✓ Extra cardiac sound

Valve closure sound

This sound occurs at the beginning of systole and at the beginning of diastole.

Ventricular filling sound

This sound is occurred at the time of filling of the ventricles.

Valve opening sound

This sound occurs at the time of opening of atrio- ventricular valves and semi lunar valves.

Extra cardiac sound

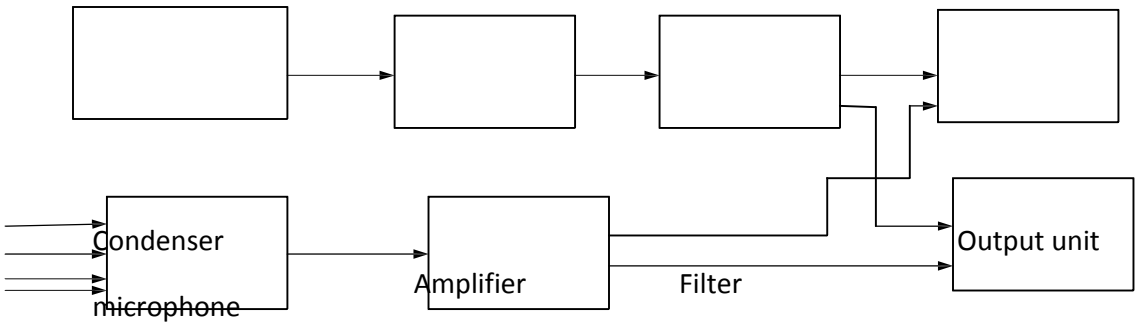
This sound occur in mid systole or late systole or early diastole

Systole: The contraction of the heart muscle. The systolic pressure is 120mm of Hg.

Diastole: The relaxation of the heart muscle. The diastolic pressure is 80 mm of Hg.

PCG RECORDING SYSTEM

Microphone is used to convert heart sound into the electrical signals. Certain positions are recommended to pick up the heart sound by using microphone. The electrical signal picked up by the microphone is amplified by the amplifier block. The amplified output is given to filter block.



ECG electrode

ECG amplifier

recorder

Figure Block Diagram of PCG Recording System

TYPES OF MICROPHONES USED IN PCG

1. Air coupled microphone- Movement of chest is transferred through the air cushion. It provides low mechanical impedance to the chest.
2. Contact microphone – it is directly coupled to the chest wall and provides high impedance, high sensitivity, and low noise. Its light weight is also one of the advantageous factor.

The first heart sound is developed during the opening of aortic valve and during the closing of mitral valve.

PCG waveform

Frequency of first heart sound consists of 30 to 45 Hz. Second heart sound is usually higher in pitch than the first. Its frequency range is 50Hz to 70 Hz. Third heart sound is extremely weak vibrate sound is extremely weak vibration. Its frequency is below 600 Hz.

Aortic stenos are murmur occurred when the blood is ejected from the left ventricle through aortic valve due to resistance to ejection, the pressure in the left ventricle increased. So turbulent blood flow occur.This turbulent blood impinging the aortic valve. So intense vibration is produced. It produces loud murmur.

Mitral regurgitation murmur- In this murmur, blood flows in backward direction through the mitral valve during systole.

Aortic regurgitation murmur – During diastole, sound is heard. In diastole blood flows in the backward direction from aorta to left ventricles when valves are damaged, then this sound is heard.

Mitral stenosis murmur – This murmur is produced when blood is passed from left atrium to left ventricle. This sound is very weak.

Explain the international standard 12 lead system used to record ECG. APRIL/MAY 2016 ,APR/MAY 2017

LEAD SYSTEMS AND RECORDING METHODS

Leads

Graphic showing the relationship between positive electrodes, depolarization wavefronts (or mean electrical vectors), and complexes displayed on the ECG.

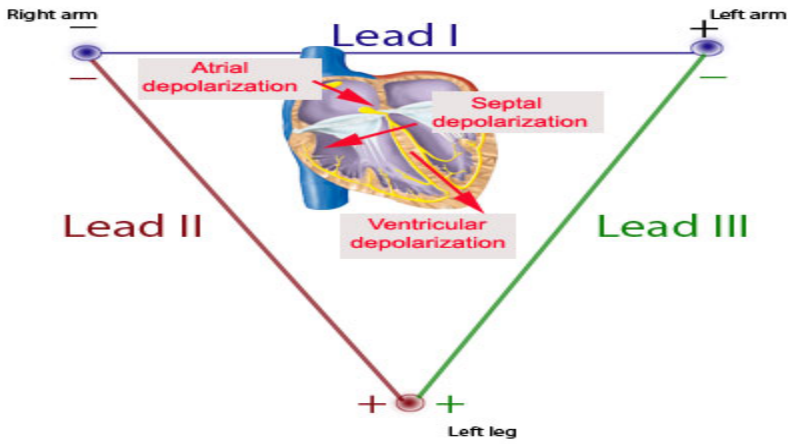
In electrocardiography, the word, "lead" (rhymes with 'speed') refers to the signal that goes between two electrodes. These electrodes are attached to the patient's body, usually with very sticky circles of thick tape-like material (the electrode is embedded in the center of this circle).

Unipolar vs. bipolar leads

There are two types of leads—*unipolar* and *bipolar*. Bipolar leads have one positive and one negative pole. In a 12-lead ECG, the limb leads (I, II and III) are bipolar leads. Unipolar leads have only one true pole (the positive pole). The negative pole is a "composite" pole made up of signals from lots of other electrodes.In a 12-lead ECG, all leads besides the limb leads are unipolar (aVR, aVL, aVF, V1, V2, V3, V4, V5, and V6).

In both the 5- and 12-lead configuration, leads I, II and III are called **limb leads**. The electrodes that form these signals are located on the limbs—one on each arm and one on the left leg. The limb leads form the points of what is known as **Einthoven's triangle**.

Einthoven's triangle



P wave

During normal atrial depolarization, the main electrical vector is directed from the SA node towards the AV node, and spreads from the right atrium to the left atrium. This turns into the P wave on the ECG, which is upright in II, III, and aVF (since the general electrical activity is going toward the positive electrode in those leads), and inverted in aVR (since it is going away from the positive electrode for that lead). A P wave must be upright in leads II and aVF and inverted in lead aVR to designate a cardiac rhythm as Sinus Rhythm.

- The relationship between P waves and QRS complexes helps distinguish various cardiac arrhythmias.
- The shape and duration of the P waves may indicate atrial enlargement.

- Absence of the P wave may indicate atrial fibrillation.
- A saw tooth formed P wave may indicate atrial flutter.

The QRS complex is a structure on the ECG that corresponds to the depolarization of the ventricles. Because the ventricles contain more muscle mass than the atria, the QRS complex is larger than the P wave. In addition, because the **His/Purkinje system** coordinates the depolarization of the ventricles, the QRS complex tends to look "spiked" rather than rounded due to the increase in conduction velocity. A normal QRS complex is 0.08 to 0.12 sec (80 to 120 ms) in duration represented by three small squares or less, but any abnormality of conduction takes longer, and causes widened QRS complexes.

PR/PQ interval

The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. It is usually 120 to 200 ms long. On an ECG tracing, this corresponds to 3 to 5 small boxes. In case a Q wave was measured with a ECG the PR interval is also commonly named PQ interval instead.

ST segment

The ST segment connects the QRS complex and the T wave and has a duration of 0.08 to 0.12 sec (80 to 120 ms). It starts at the J point (junction between the QRS complex and ST segment) and ends at the beginning of the T wave. However, since it is usually difficult to determine exactly where the ST segment ends and the T wave begins, the relationship between the RT segment and T wave should be examined together. The typical ST segment duration is usually around 0.08 sec (80 ms). It should be essentially level with the PR and TP segment.

T wave

The T wave represents the repolarization (or recovery) of the ventricles. The interval from the beginning of the QRS complex to the apex of the T wave is referred to as the **absolute refractory period**. The last half of the T wave is referred to as the **relative refractory period** (or vulnerable period).

QT interval

The QT interval is measured from the beginning of the QRS complex to the end of the T wave. Normal values for the QT interval are between 0.30 and 0.44 seconds. The QT interval as well as the corrected QT interval are important in the diagnosis of long QT syndrome and short QT syndrome. Long QT intervals may also be induced by antiarrythmic agents that block potassium channels in the cardiac myocyte. The QT interval varies based on the heart rate, and various correction factors have been developed to correct the QT interval for the heart rate. The QT interval represents on an ECG the total time needed for the ventricles to depolarize and repolarize.

U wave

The U wave is not always seen. It is typically small, and, by definition, follows the T wave. U waves are thought to represent repolarization of the papillary muscles or Purkinje fibers. Prominent U waves are most often seen in hypokalemia, but may be present in hypercalcemia, thyrotoxicosis, or exposure to digitalis, epinephrine, and Class 1A and 3 antiarrhythmics, as well as in congenital long QT syndrome and in the setting of intracranial hemorrhage. An inverted U wave may represent myocardial ischemia or left ventricular volume overload.

BIO-CHEMICAL AND NON ELECTRICAL PARAMETER MEASUREMENT

Describe the measurement of PO2. APRIL/MAY 2017

pO_2 MEASUREMENT

The term po2 is defined as the partial pressure of oxygen respectively. The determination of po2 is one the most important physiological chemical measurement. The effective functioning of both respiratory and cardiovascular system can be by po2 measurement. The partial pressure of a gas is proportional to the quantity of that gas present in the blood.

The platinum wire, which is an active electrode, is embedded in glass for insulation and only its tip is exposed. It is kept in the electrolyte solution in which the oxygen is allowed to diffuse. The reference electrode is made up of silver-silver chloride (Ab/AgCl). A voltage of 0.7 is applied between the platinum wire and the reference electrode. The negative terminal is connected to the active electrode through a micro ammeter and the positive terminal is given to the reference electrode.

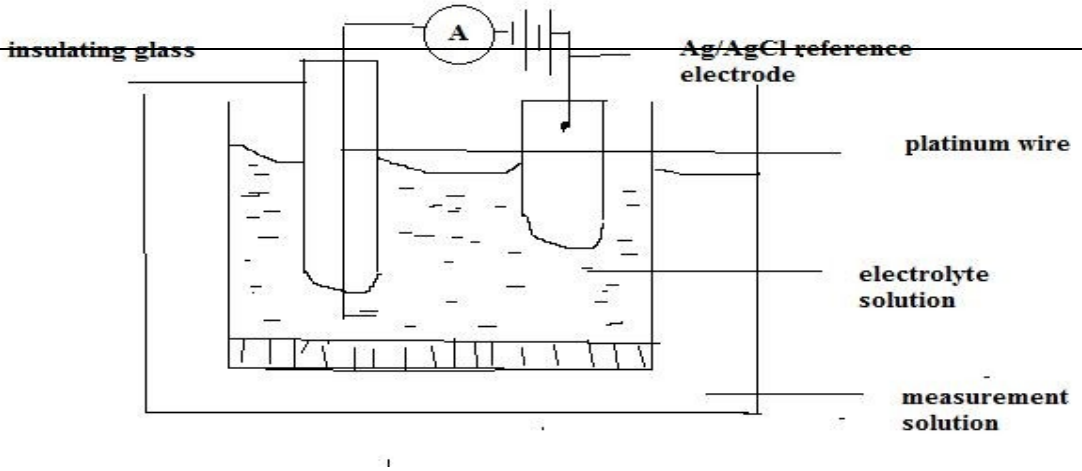


Figure pO_2 Electrode

Due to the negative terminal, the oxygen reduction takes place at the platinum cathode. Finally the oxidation reduction current proportional to the partial pressure of oxygen diffused into the electrolyte can be measured in the micro ammeter. The electrolyte is generally scaled in the electrode chamber by means of a membrane through which the oxygen can diffuse from the blood or sample solution.

There are two types of pO_2 measurement. They are

I) Vitro measurement

II) Vivo measurement

In case of dark electrode the platinum cathode and the reference electrode is present in a single unit. This electrode is used for vitro and vivo measurements.

In Vitro Measurements

In this method the blood sample is taken and the measurement for oxygen saturation is made in the laboratory. The electrode is placed in the sample blood solution and the pO_2 value is determined.

In Vivo Measurements

In this method the oxygen saturation is determined while the blood is flowing in the circulatory system. A micro version of the pO_2 electrode is placed at the tip of the catheter so that it can be inserted into various parts of the heart or circulatory system.

The pO_2 measurement also has some disadvantages in it. The reduction process in the platinum cathode removes a finite amount of the oxygen from the cathode. And there is a gradual reduction of current with respect to time. However careful design and proper procedures in modern pO_2 electrodes reduce the errors.

Explain the block diagram and working of colorimeter. APRIL/MAY 2017

COLORIMETER

- Measures the color concentration of a substance in a solution by detecting the color light intensity passing through a sample containing the substance and a reagent
- Optical color filters are used to detect the color wavelength of interest. E.g., urine passes yellow light and absorbs blue and green
- Laser LEDs are preferred if their wavelength is suitable due to purity of the monochromatic color.

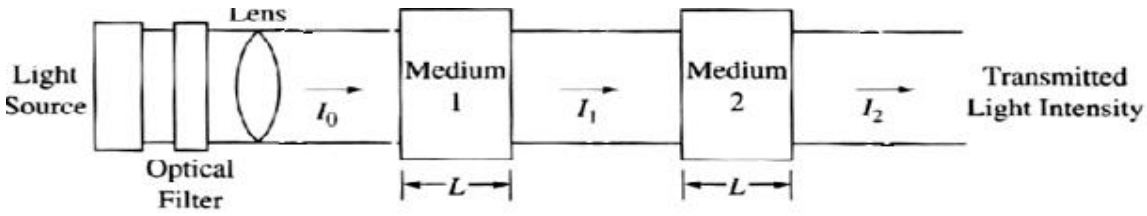


Figure Colorimeter

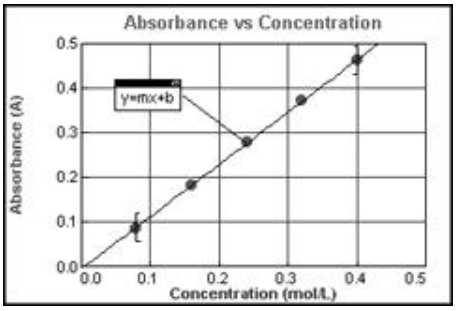


Figure Concentration vs Absorbance

Transmittance

$T = I_1/I_0 * 100\%$

Absorbance

$A = - \log I_1/ I_0$

$A = \log 1/T$

If the path length or concentration increases, the transmittance decreases and absorbance increases, a phenomenon expressed by Beer's Law.

State and explain the working principle of electromagnetic blood flow meter. APRIL/MAY 2016, APRIL/MAY 2017

ELECTROMAGNETIC FLOWMETERS

- Electromagnetic blood flow meters measure blood flow in blood vessels
- Consists of a probe connected to a flow sensor box

Figure Blod flow meter

An Electromagnetic Flow Meter is a device capable of measuring the mass flow of a fluid. Unlike the common flow meter you can find on the market it has no moving parts, and for this reason it can be made to withstand any pressure (without leakage)and any fluid(corrosive and non corrosive). This kind of flow meter use a magnet and two electrodes to peek the voltage that appears across the fluid moving in the magnetic field.

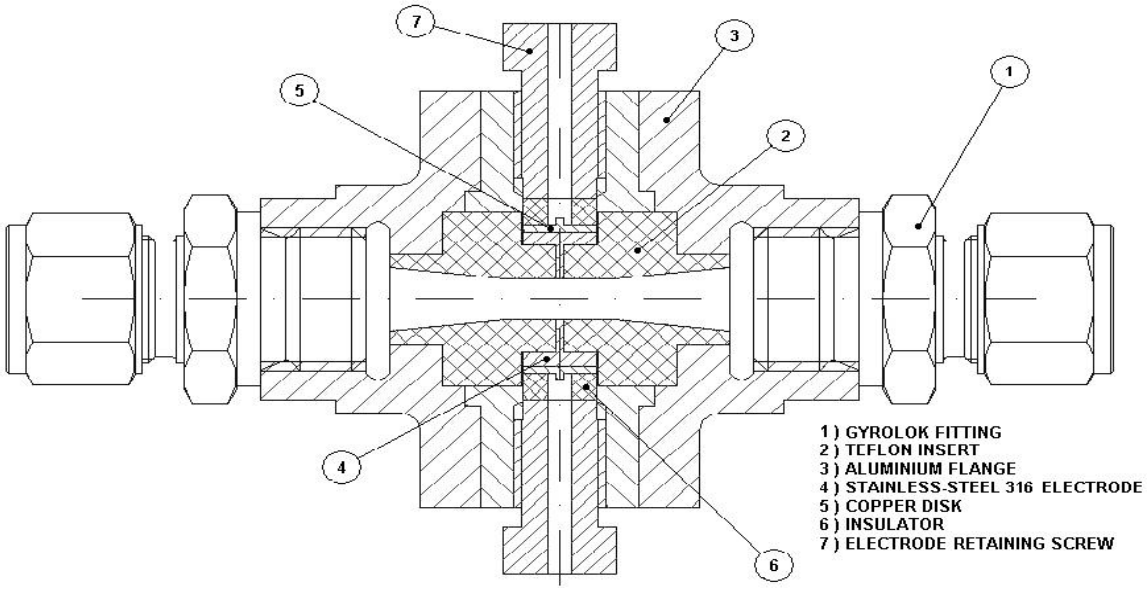


Figure Electromagnetic Flowmeter

The Neumann Law (or Lenz Law) states that if a conductive wire is moving at right angle through a magnetic field, a voltage ***E*** [Volts] will appear at the end of the conductor (Fig.1):

$$E=B*L*V$$

Where

B = Magnetic Induction [Weber/m2]

L = Length of the portion of the wire 'wetted' by the magnetic field [m]

V = Velocity of the wire [m/sec]

Fig.2

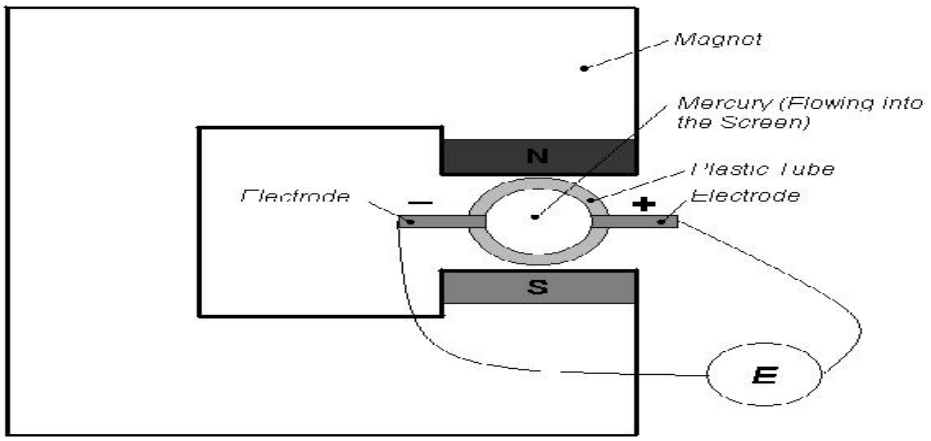


Figure Magnetic Blood flowmeter priciple

Now imagine you have a plastic tube with two electrodes on the diameter and Mercury flowing into it (fig.2.6.3). A voltage will appear on the electrodes and it will be

$$E=B*L*V$$

As in the previous example (***L*** in this case is the inner diameter of the tube).Mercury as tiny conductive wires next to each other: each wire, moving in the tube, will touch the two electrodes ,and thus you can measure their voltage.

An interesting fact is that if you reverse the flow, you still get a voltage but with reverse polarity (Fig.1). Till now we have talked about a conductive fluid ,Mercury, but this stuff will also work with non conductive fluid, provided that you use an alternating magnetic field. Two physicists, Middleman and Cushing, in an unpublished work, stated that when using a non conductive fluid, if the frequency of the alternating magnetic field is ***v*** the voltage at the electrodes will be attenuated by a factor ***α*** so that:

Measuring the flow

`A perfect axisimmetric construction cannot be achieved and thus some magnetic flux lines will 'wet' the connecting wires to the electrodes. The alternating magnetic field will create an offset voltage in this wire and even if the fluid is not moving, the measured voltage will not be zero.

With suitable diagram describe how ultra sound principles are used in measuring the flow of blood. NOV / DEC 2016

ULTRASONIC FLOWMETERS

The blood cells in the fluid scatter the Doppler signal diffusively.In the recent years ultrasound contrast agents have been used in order to increase the echoes.The ultrasound beam is focused by a suitable transducer geometry and a lens.

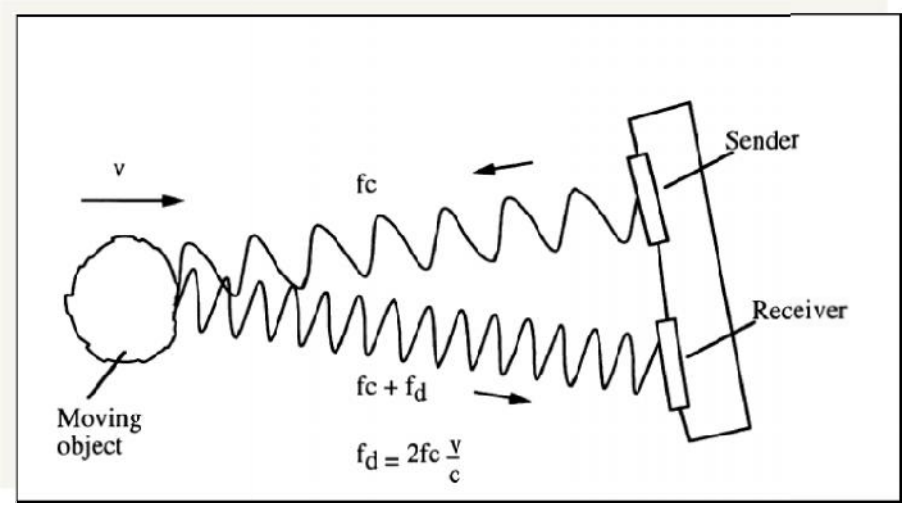


Figure Ultrasonic flowmeters

$f_d = 2f_cv/c$

f = 2- 10 MHz

c = 1500 - 1600 m/s (1540 m/s)

$f = 1,3 – 13\ kHz$

In order to know where along the beam the blood flow data is colledted, a pulsed Doppler must be used.The flow velocity is obtained from the spectral estimation of the received Doppler signalThe ultrasound Doppler device can be either *a continuous wave* or *a pulsed Doppler*

A Continuous Wave

No minimum range
Simpler hardware
Range ambiguity

Low flow cannot be detected

A Pulsed Doppler

Accuracy

No minimum flow

Minimum range

(Maximum flow) x (range)= limited the power decays exponentially because of the heating of the tissue. The absorption coefficient roportional to frequency the far field operation should be avoided due to beam divergence.

$$D_{nf} = D^2 / 4\lambda$$

D = Transducer diameter (e.g. 1 – 5 mm) .

Define the term "Cardiac Output".How is cardiac output measured by dye dilution technique.Explain? APRIL/MAY 2017

CARDIAC OUTPUT

Definition: Volume of blood pumped by the heart per min

CO = SV x HR
Norm ~ 5 l/min

Cardiac index – corrected for body surface area

Affected by :

Met. Rate – pregnancy, hyperthyroid, septic

Preload / contractility / afterload

Clinical indicators of CO imprecise

Affected by anaesthetic agents used in everyday practice

Provides estimate of:

- whole body perfusion
- oxygen delivery
- left ventricular function

Persistently low CO associated with poor outcome

Methods: Fick method

Dilution techniques – dye / thermal /
lithium Pulse contour analysis- LiDCO &
PiCCO Oesophageal doppler

TOE

Transthoracic impedance plethysmography

Inert gas through flow

Non-invasive cardiac output measurement

Fick Principle: Measure volume displacement 1st proposed 1870 -the total uptake or release of a substance by an organ is the product of the blood flow through that organ and the arteriovenous concentration difference of the substance. Limited by cumbersome equipment, sampling errors need for invasive monitoring and steady-state haemodynamic and metabolic conditions

Indicator dilution techniques

An indicator mixed into a unit volume of constantly flowing blood can be used to identify that volume of blood in time, provided the indicator remains in the system between injection and measurement and mixes completely in the blood.

Dye dilution

- Inert dye – indocyanin green
- Injected into pulmonary artery and arterial conc. measured using a calibrated cuvette densitometer
- Plot indicator dilution curve (see diagram) CO derived from area under curve.

Indicator Dilution Curve

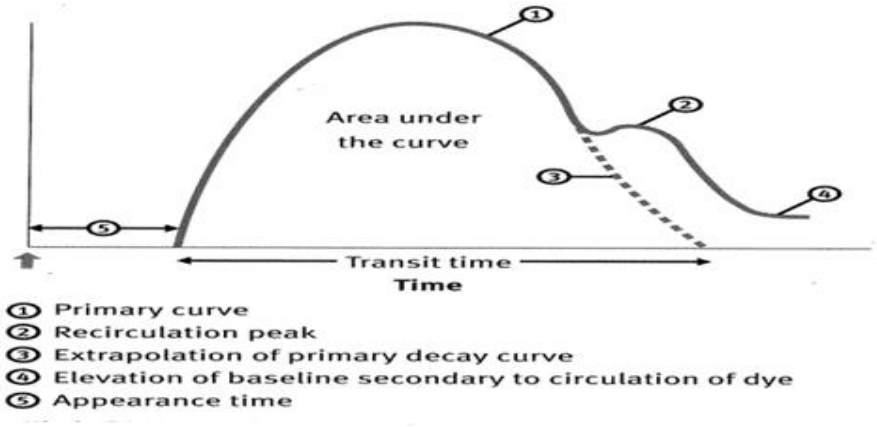


Figure Indicator dilution curve

Cardiac Output Measurement

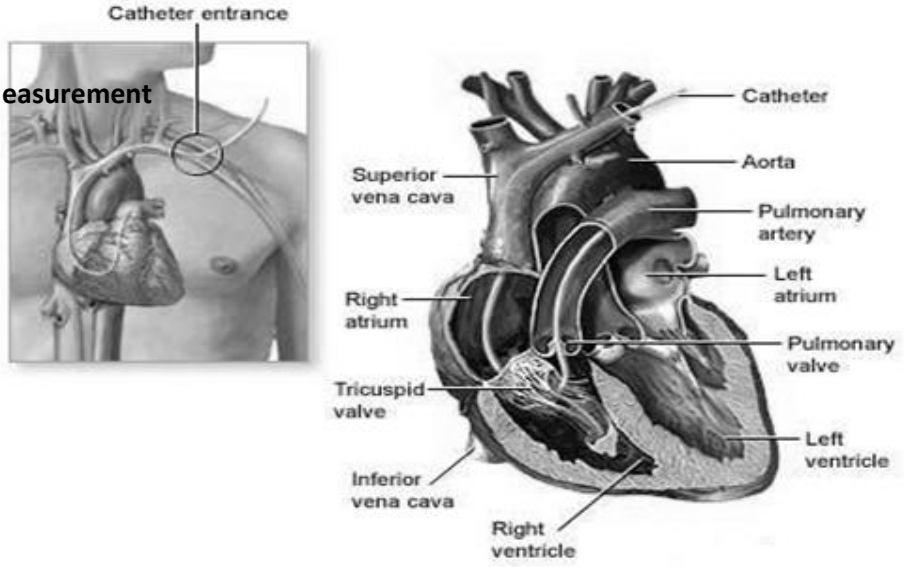


Figure Cardiac output measurement

Explain the measurement of respiration rate using impedance technique. APRIL/MAY 2016

RESPIRATORY RATE MEASUREMENT

Respiratory system provides a means of acquiring oxygen and eliminating CO_2. Various laws are involved in the understanding of respiratory functions.

Various Gas laws are given below:

1. **BOYLE'S LAW:** It states that at constant temperature, the volume of gas varies inversely with the pressure.

$V_2/V_1 = P_1/P2$ here temperature T= constant

V_2= Final volume

V_1 = Initial volume

P_1 = Original (initial) pressure

P_2 = Final pressure

2. **CHARLE'S LAW:** It states that, at constant pressure, the volume of gas isdirectly proportional to the absolute temperature.

$V_2/V_1 = T_2/T_1$ Here pressure P=constant

V_2, V1 =Final, initial volume

T_1 =original temperature

T_2 = Final temperature

3 . **HENRY'S LAW :** It states that, if the temperature is constant, the quantity of a gas that goes into a solution is directly proportional to the partial pressure of that gas . The gas with the greater partial pressure will have more mass in solution.

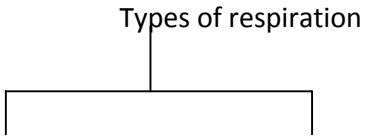
4. **DALTON'S LAW :** It states that, the total pressure exerted by a mixture of gases is equal to the sum of the partial pressures of various gases.

$P_T = P_1 + P_2 + \ldots\ldots\ldots\ldots + P_n$

P_T = total pressure

P_1, P_2, P_3 = partial pressure of various gases

TYPES OF RESPIRATION



Internal respiration External respiration

Respiration is nothing but the interchange of gases between an organism and the living medium

Internal respiration is the exchange of gases between the blood stream and nearby cells

.**External respiration** is the exchange of gases between the lungs and blood stream .

Lungs Volumes and Capacities (Respiration Parameters) Or (LVC)

Respiration parameters are used to indicate the state of respiratory function , including lung volumes and capacities , airway resistance , lung compliance , etc .

Dead Air

Only a portion of the air entering the respiratory system actually reaches the alveoli . The volume of air that is not available for gas exchange with the blood is known as dead air . The total dead space is less less than 30 percentage of the total volume .

Tidal Volume (TV)

Tidal volume is the depth of breathing or the volume of gas inspired or expired during each respiratory cycle. It is equal to 500 ml for a normal person .

Inspiratory Reserve Volume (IRV)

It is the maximal amount of gas that can be inspired from the end- inspiratory position (Extra inspiration from the high peak tidal volume . It is equal to 3600 ml for a normal person

Expiratory reserve volume (ERV)

It is the maximal amount of gas that can be end expiratory level. It is equal to 1200 ml.

Residual Volume(RV)

It is the amount of gas remaining in the lungs at the end of maximal expiration. It is equal to 1200 ml.

Minute Volume (MV)

It is the volume of air breathed normally for 1 minute.

Total Lung Capacity(TLC)

It is the amount of gas contained in the lungs at the end of maximal inspiration and it is the sum of inspiratory capacity(IC)and functional residual capacity (FRC)TLC is of 6000 ml for a normal person.

Vital Capacity(VC)

It is the maximum amount of gas that can be expelled from the lungs by forceful effort from maximal inspiration. It is 4800 ml for a normal person.

Inspiratory Capacity(IC)

It is the maximum amount of gas that can be inspired from the resting expiratory level and it is the sum of tidal volume and inspiratory reserve volume. It is equal to 3600 ml for a normal person.

Functional Residual Capacity(FRC)

It is the amount of gas remaining in the lungs at the resting expiratory level.

FRC = ERV + RV

Airway resistance

It relates to the ease with air flows through tubular respiratory structures. In smaller tubes,

airway resistance is high.

Lung Compliance

It is the ability of the alveoli and lung tissue to expand on inspiration**.**

Lung Elasticity

It is the ability of the lung's elastic tissues to recoil during expiration

Intra thoractic Pressure

It is the positive and negative pressure occur within the thoracic cavity

Types of respiration rate measurement

1. Displacement method
2. Thermistor method
3. Impedance pneumography
4. CO_2 method
5. Apnoea detectors

Displacement Method

In this method the transducer is hold by an elastic band which goes around the chest.The respiratory movements results in a corresponding resistance changes of the strain gauge. It is connected as one arm of a wheatstone bridge circuit. Its output varies with chest expansion. This output corresponds to the respiration activity.

Thermistor Method

Generally there is a temperature difference between inspired and expired air. This temperature is sensed by placing thermistor in front of nostrils. Thermistor is placed by using suitable stand. The thermistor is connected with the bridge circuit. So unbalance signal is amplified to get the respiratory activity.

Define blood pressure. How it can be measured using sphygmomanometer? NOV / DEC 2016

BLOOD PRESSURE

One of the oldest physiological measurements.Observation of blood pressure allows dynamic tracking of pathology and physiology affecting to the cardiovascular system, which has profound effects to all other organs of the body

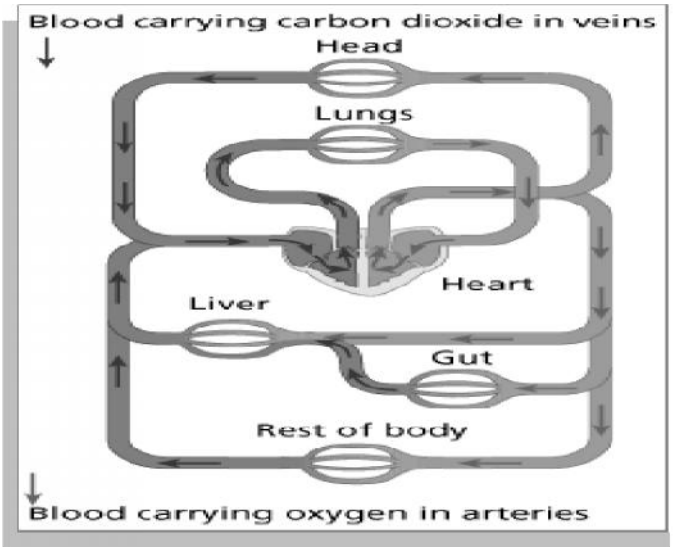


Figure Observation of blood pressure

- Originates from the heart
- Commonly refers to arterial blood pressure

Value depends on 3 factors:

- cardiac output diameter of arteries the quantity of blood
- Values should be lower than 120 / 80 mmHg(systolic pressure (SP) / diastolic pressure (DP))
- *High value* increases the risk of heart attack and strokes
- *Low value* increases the risk of lower oxygen perfusion e.g. in brains.

However, the 'normal values' differ from person to another

Pulse Pressure(PP) = SP - DP

Mean pressure (MP)

Average pressure during one cardiac cycle driving force of the peripheral perfusion. an estimate can be done by using an empirical formula:

MP = DP+PP/3

SP and DP may vary significantly throughout the arterial system but MP is quite uniform (in normal situations)

1. Non-Invasive

Palpatory Method(Riva-Rocci Method)
Auscultatory Method

Ultrasonic Method
Oscillometric Method
Tonometry

2. Invasive

Extravascular Sensor

Intravascular Sensor

General on System Parameters

INDIRECT METHODS IN BLOOD PRESSURE MEASUREMENTS

Indirect measurement = non-invasive measurement

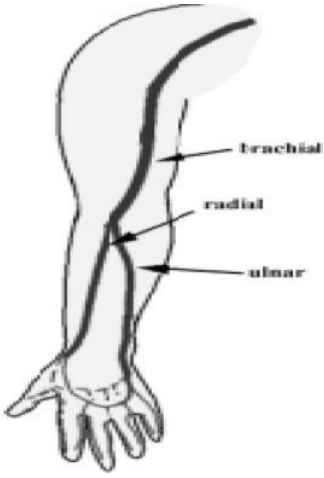


Figure Blood pressure measurements

Brachial artery is the most common measurement site

Close to heart

Convenient measurement

Other sites are e.g.:

forearm / radial artery wrist (tends to give much higher SP)

The most common indirect methods are auscultation and oscillometry an occlusive cuff is placed on arm and inflated to P > SP. Then the cuff is deflated gradually and the measurement of blood flow is done .

The occlusive cuff should be of a correct size in order to transmit the pressure to the artery evenly and thus to obtain accurate results .A short cuff requires special attention in placement. Longercuff reduces this problem. The cuff should be placed at the heart level in order to minimize the hydrostatic effects .

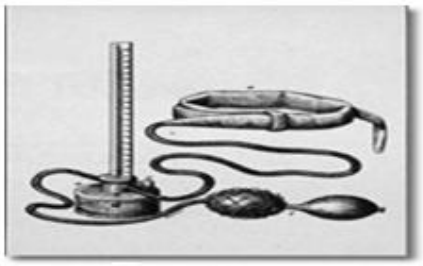


Figure Sphygmomanometro

2.9.2 DIRECT METHODS IN BLOOD PRESSURE MEASUREMENTS

Direct measurement = Invasive measurement

A vessel is punctured and a catheter (a flexible tube) is guided in The most common sites are brachial and radial arteries but also other sites can be used e.g. femoral artery A division is made into extravascular and intravascular sensor systems .This method is precise but it is also a

complex procedure involving many risks Used only when essential to determine the blood pressure continuously and accurately in dynamic circumstances

EXTRAVASCULAR SENSOR

The sensor is located behind the catheter and the vascular pressure is transmitted via this liquid-filled catheter.

The actual pressure sensor can be e.g. strain gage,variable inductance,variable capacitance

Optoelectronic,piezoelectric, etc

INTRAVASCULAR SENSOR

sensor is located in the tip of the catheter. This way the hydraulic connection is replaced with an electrical or optical connection .The dispacement of the diaphragm is measured .The frequency response is not limited by the hydraulic properties of the system.

No time delay.

Electrical safety and isolation when using fiber optics

Breaks easily

More expensive

Disposable Sensors

Disposable sensors decrease the risk of patient cross-contamination and reduce the amount of handling by hospital personnel

Cheaper and more reliable than reusable pressure sensors.

GENERAL ON SYSTEM PARAMETERS

Even minute air bubbles in catheter have a dramatic effect on frequency response

The natural frequency and the length of the catheter have a following relationship:

$$f_n = 1/\sqrt{L}$$

The catheter diameter has a linear relationship to natural frequency Stiffer catheters have a higher frequency response.

.

Briefly, describe the working of Counters? APRIL/MAY 2016

BLOOD CELL COUNTER

- The blood cell counter count the number of RBC or WBC per unit of volume of blood using either of two method:
  - Electrical method called aperture impedance change
  - Optical method called flow cytometry

Aperture impedance change

- When blood is diluted in the proper type of solution, the electrical resistivity of blood cells (ρ_c) is higher then the resistivity of the surrounding fluid (ρ_f)
- By contriving a situation in which these resistivities can be differentiated from each other, we can count cells

Blood cell sensing

- The sensor consist of a two-chamber vessel in which the dilute incoming blood is on one side of barrier, and the waste blood to be discarded is on the other
- A hole with a small diameter (50µm) is placed in the partition between the tow halves of the cell
- Ohmmeter measure the change on the resistance when the blood cell pass the aperture

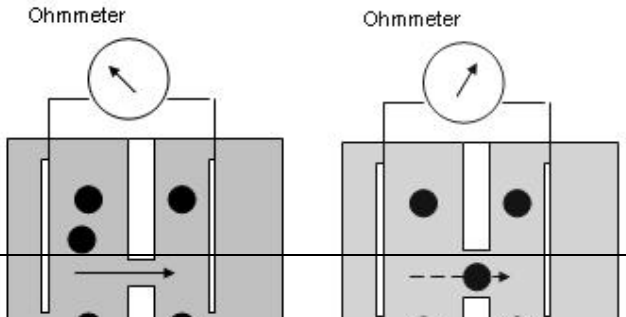


Figure Blood cell sensing

COULTER COUNTER

- Constant current source (CCS) and voltage amplifier replace the ohmmeter
- R_A is the resistance of the aperture and will be either high or low, depending on whether or not the blood cell is inside the aperture.
- Amplifier convert the current pulse to voltage pulse

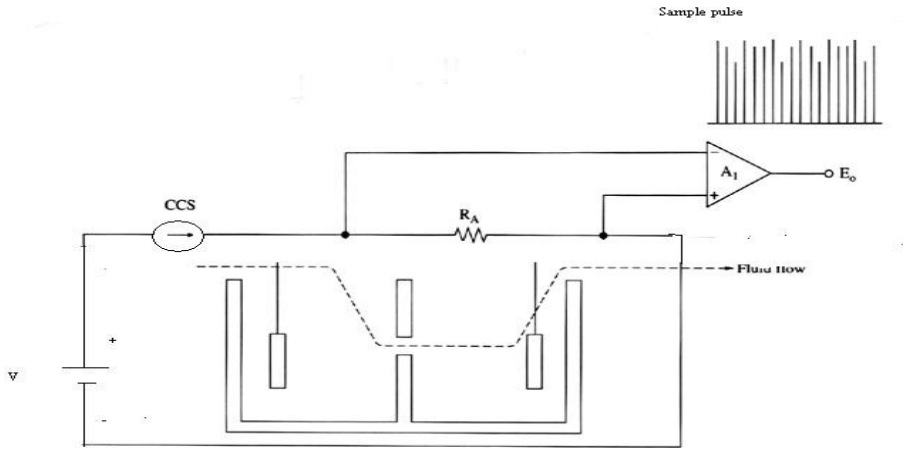


Figure Block diagram of Coulter Counter

FLOW CYTOMETRY CELL COUNTERS

Optical flow cytometry sensing

- The optical cytometry sensor consists of a quartz sensing sheath designed with a
  - hydrodynamic focusing region
  - cell path region that passes only a single cell at time.
- Focusing is done by decreasing the diameter of the aperture.
- Light source is (He-Ne) Laser
- Two Photodetectors (photosensors)
  - Photodetector A detects forward scatted light
  - Photodetector B detects orthogonal scatted light
- blood sample enters the analyzer
  - Optical counter → WBC count
  - Colorimeter → hemoglobin
  - Optical flow sensor → RBC count

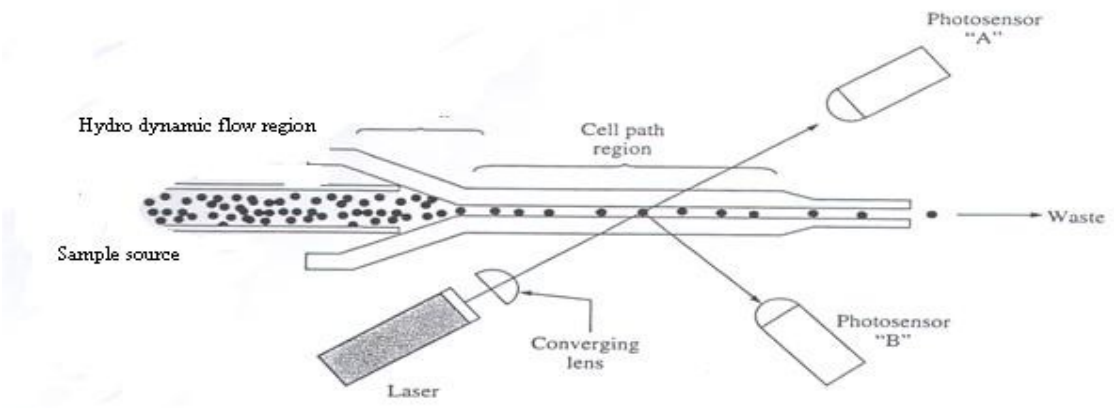


Figure Optical flow cytometry

The blood is actually split into different chambers, where in each chamber it is diluted / mixed to differentiate different cell types. WBC and RBC are separated (using lysing).

UNIT III

ASSIST DEVICES

*.H*ow pacemakers are classified based on the modes of operation? Draw the block diagram of stand by and demand pacemakers and explain its working principle. NOV / DEC 2016*

**.Describe the working of artrial synchronous pace maker APRIL/MAY 2017*

CARDIAC PACEMAKERS

Definition:

A device capable of generating artificial pacing impulses and delivering them to heart is known as pacemaker system or pacemaker. It consists of a pulse generator and electrodes. Sino Atrial node is responsible for the starting of heart beat, hence it is called as Natural Pacemaker.

Types of pacemakers:

- Internal pacemaker
- External pacemaker

INTERNAL PACEMAKER

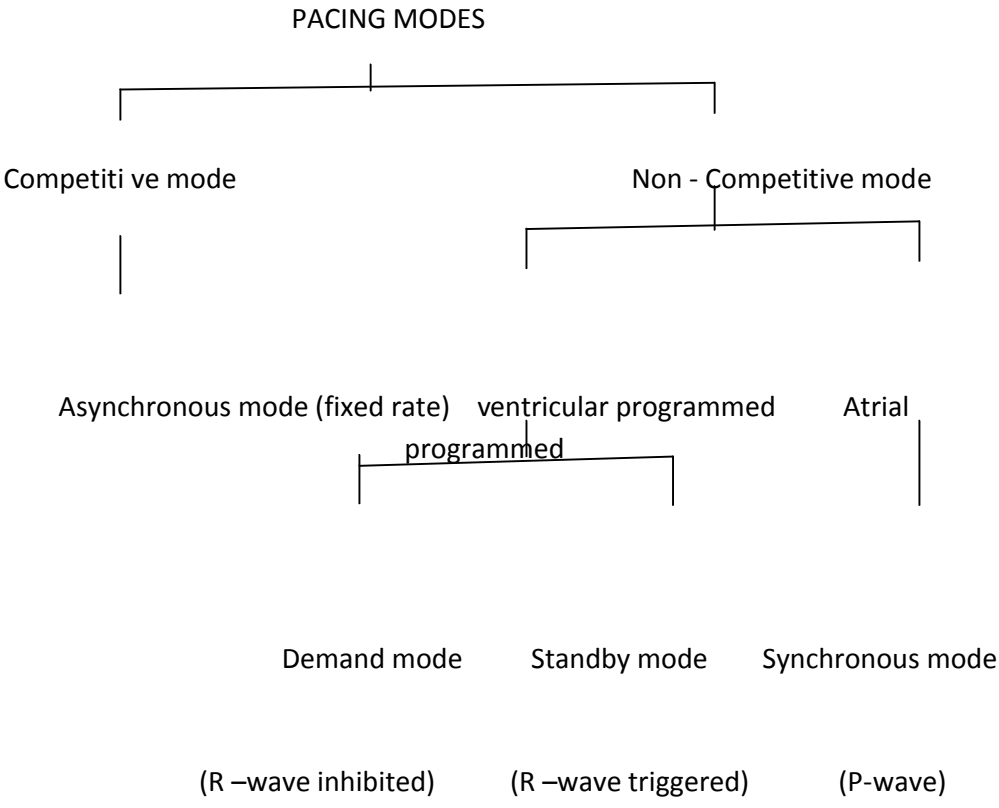
- It is placed inside the body. It may be permanently implanted on the patients whose SA nodes are failed to function or those who suffered from permanent heart block**.**
- Internal pacemaker systems are implanted with the pulse generator placed in a surgically developed pocket below the right or left clavicle, in left sub costal region.
- In case of women it is placed beneath the left or right major pectoral's muscle.
- Internal leads are connected to the electrodes that directly contact the surface of the myocardium**.**
- The exact location of the pulse generator used in the internal pacemaker system depends on the following factors.
  - Type and nature of the electrode used.
  - Nature of the cardiac problems.
  - Mode of operation of the pacemaker system.

EXTERNAL PACEMAKER

- It consists of an externally placed pulse generator circuit connected to the electrodes placed on the myocardium.

- Temporary heart irregularities or disorders.
- Treating the patient from arrhythmias.
- Treatment of coronary patient and during the cardiac surgery.
- It consists of pulse generators. They are placed m the body and connected normally to the electrode with the help of wires introduced into the right ventricle.
- The pulse generator may be strapped to the lower arm of the patient.

TYPES OF PACING MODES



VENTRICULAR ASYNCHRONOUS PACEMAKER (FIXED RATE PACEMAKER)

- It can be implemented in atrium or ventricle.
- Suitable for patients who are suffered by total AV block, atrial arrhythmia.
- It consists of square wave generator and monostable multivibrator circuit. The period square

Wave generator is given as T.

- $T=-2(RC)\ln\left(\frac{R3}{2R2+R3}\right)$

T can be modified by changing the R,C,R2,R3 values.

Pulse duration is given by

$$T_d = 5C_c\left(\frac{R5R6}{R5+R6}\right)$$

Disadvantages:

- Heart beat rate cannot be changed.
- If it is fixed in atrium, atrium beat at a fixed rate. If ventricle beat at a different rate, and then it leads to a severe problem. Ventricular fibrillation may be occurred.

With a neat diagram explain the block diagram of DC defibrillator. APRIL/MAY 2017

DC DEFIBRILLATION

- To overcome the disadvantage of defibrillation method In 1962,Bernard lawn from Harward school of public health and peter bent of Brigham hospital developed a new method known as dc defibrillation.
- In this dc defibrillation method , a capacitors charged to a high dc voltage and then rapidly discharged through electrodes across the chest of patient.
- DC defibrillation is capable of correcting both the atrial fibrillation and ventricular fibrillation.
- DC method produces some harm to the patient. Depending on the energy setting in the defibrillator , the amount of electrical energy discharged by the capacitor ranges between 100 to 400 joules. Discharge portion is approximately 5 ms.
- In discharge waveform ,the peak value ofs current is nearly20 A and the wave is monophasic in nature.
- Monophasic means most of the excursion of curve is above the base line.

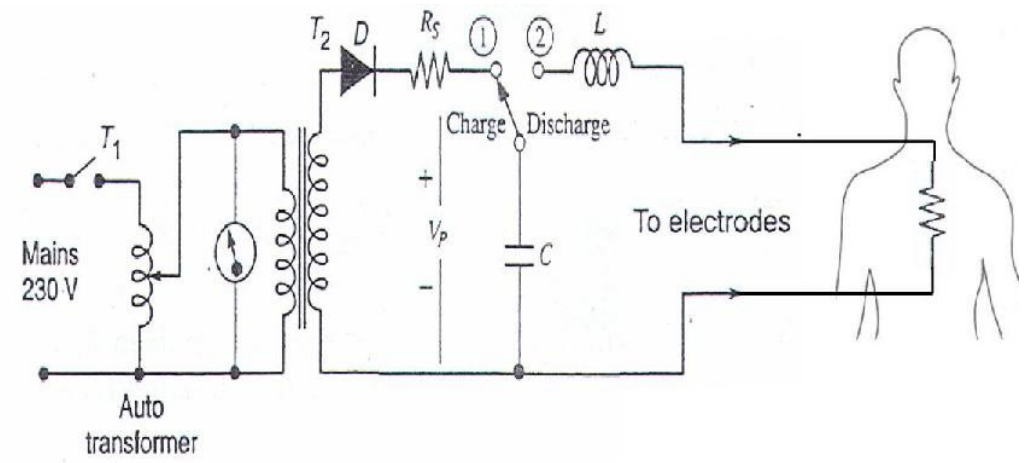


Figure DC defibrillator circuit

Energy level of a defibrillator can be controlling:The voltage amplitude*VP*of the defibrillator by varying the setting onthe varactor or Duration of the defibrillator pulse. The energy (W_A) stored in the capacitor *C* and available for the defibrillation is:

Lown waveform: *Curve 1* shows a typical discharge pulse of defibrillator which called -Lown waveform.

I rises rapidly to app. 20 A

Then I decays to 0 with 5 ms

A negative pulse is produced for 1 to 2 ms

The pulse width defined as the time that elapses between the start of the impulse and the moment that the current intensity passes the zero line for the first time and changes direction (5 ms or 2.5 ms)

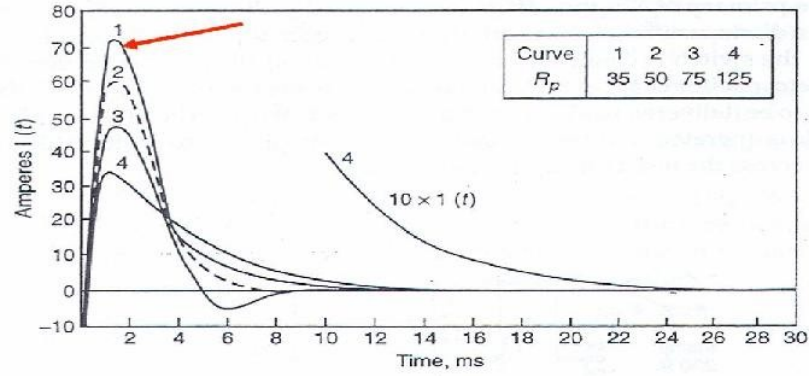


Fig DC defibrillator waveform

DUAL PEAK DC DEFIBRILLATOR

If peak voltage is as high as 6000V is used there is a possibility of damaging myocardium and the chest walls.

- Produce dual peak wavereform of longer duraoltation at lower voltage.
- Effective defibrillation is achieved in adults with lower level of delivered energy.
- Energy range is between 50 to 200W-sec or joules.
- Effective defibrillation at the desirable lower voltage levels is also possible with the truncated waveform.
- The amplitude of the waveform is relatively constant, but is varied to get required energy.
- Large electrodes are used for the proper delivery of large current through the surface of the skin.
- These electrodes are called as paddles .

EXTERNAL DEFIBRILLATOR:

- A unit based on computer technology and designed to analyze the heart rhythm itself, and then advise whether a shock is required.
- It is designed to be used by lay persons, who require little training.
- It is usually limited in their interventions to delivering high joule shocks for *VF* and *VT* rhythms
- The automatic units also take time (generally 10-20 seconds) to diagnose the rhythm, where a professional could diagnose and treat the condition far quicker with a manual unit.

- Automated external defibrillators are generally either held by trained personnel who will attend incidents, or are public access units which can be found in places including corporate and government offices, shopping centers, airports, restaurants,
- AEDS require self-adhesive electrodes instead of hand-held paddles for the two following reasons:
- The ECG signal acquired from self-adhesive electrodes usually contains less noise and has higherquality ⇒ allows faster and more accurate analysis of the ECG ⇒ better shock decisions. Hands off defibrillation is a safer procedure for

  the operator, especially if the operator has little or no training.

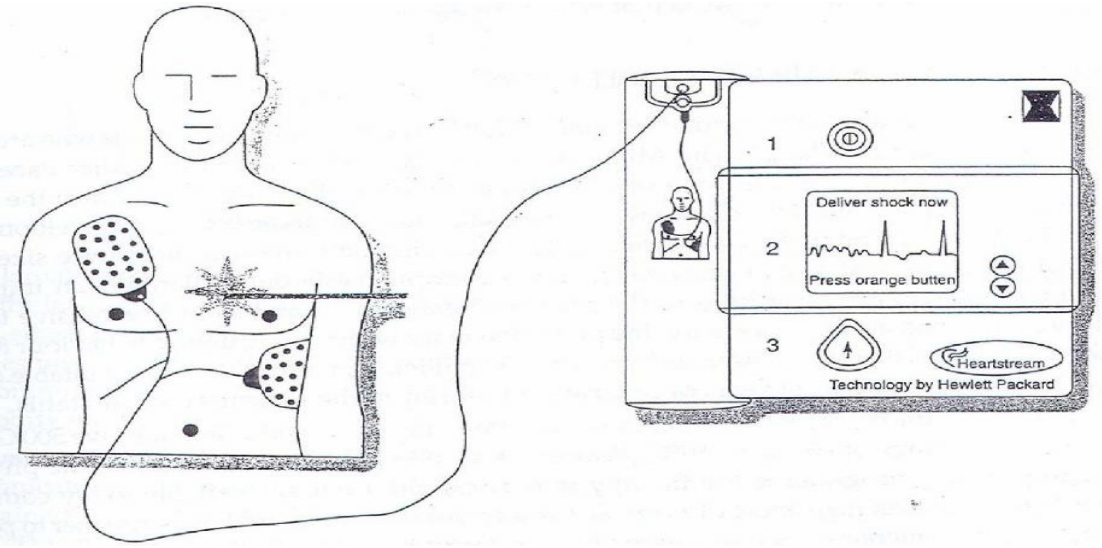


Fig External Defibrillator

DC DEFIBRILLATOR WITH SYNCHRONIZER

- Synchronization means, synchronized the working of the heart with the pacemaker. Synchronized DC defibrillator allows the electric shock at the right point on the ECG of the patient.
- Electric shock is delivered approximately 20 to 30 ms after the peak of R wave of patients ECG.

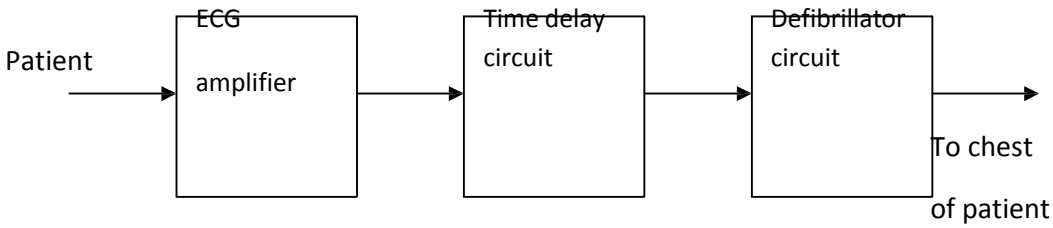


Figure Block diagram of DC Defibrillator With Synchronizer

Working

- ECG waveform is traced from the patient.
- R-wave in the output of ECG amplifier triggers the time delay circuit .It gives the delay of

30 ms approximately. After that, defibrillator circuit is switched ON. So that, the capacitor discharges the electric shock to the patient's heart.

- The moment at which electric shock occurs is noted by producing the marker pulse on monitoring display.
- This type of circuit is preferred in cardiac emergencies
- The sudden cardiac arrest can be treated using a defibrillator and 80 percent of the patients will be cured from the cardiac arrest if the is given within one minute of the attack.

Electrodes used for defibrillation

- These paddles have metal disks of 8 to 10 cm in diameter for external use.
- For internal use smaller paddles are used on infants and children.
- For external use, pair of electrodes are firmly pressed against the patients chest.

Need of Insulation Handle

- To prevent the person applying the electrodes from accidential electric shock specially insulated handles are provided in the paddles.
- When paddles are properly positioned , this prevents the patient from receiving a shock.
- In earlier equipment a foot switch is used instead of thumb switch.

Need of Thumb Switch

- There is a possibility of someone accidentally stepping on the foot switch in the excitement of an emergency before the paddles are placed. So thumb switches are mostly preferred.

Charging of Defibrillators

- In some defibrillators charging is done by means of a charge switch located in the front panel of the unit.
- The charge switch is located in the handle of one of its paddles.
- In few defibrillators the charging process begins automatically after discharge.

Types of Electrodes

Two electrodes are

- Anterior-anterior
- Anterior-posterior

- Anterior-anterior paddles are applied to the chest. Anterior-posterior paddles are applied to both the patients chest wall and back so that energy is delivered through the heart.
- Specially designed pediatric paddles are available with diameter ranging from 2 to 6 cm.
- Internal paddles can be either gas-sterilized or autoclaved.

Indication Meter

- Most of the defibrillators include a watt second meter to inducate the amount of energy stored in the capacitor before discharge.
- The energy indicated on the meter is lost or dissipated as heat in the components inside the unit.

Explain in detail the principle block diagram and working of haemodialyser. APRIL/MAY 2016

DIALYSER

- Dialyser is the use of high frequency electric current to produce heat.
- Used to either cut or destroy tissue or to produce coagulation.
- Mains electricity is 50 Hz and produces intense muscle and nerve activation.
- Electrical frequency used by diathermy is in the range of 300 kHz to 3 MHz.
- Patients body forms part of the electrical circuit .
- Current has no effect on muscles.

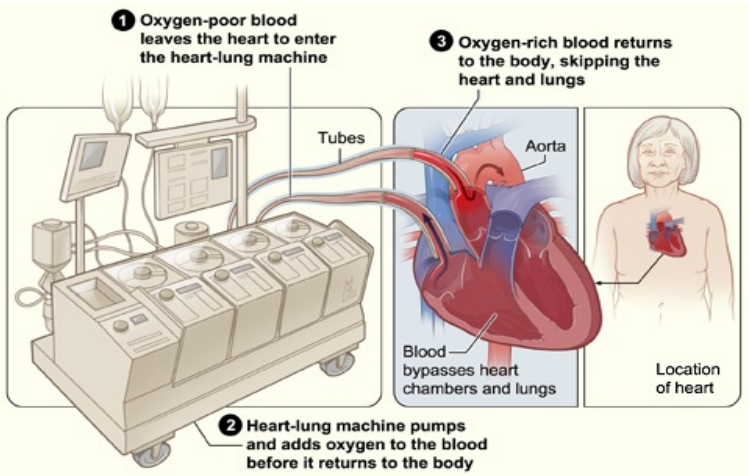
Effects of dialyser

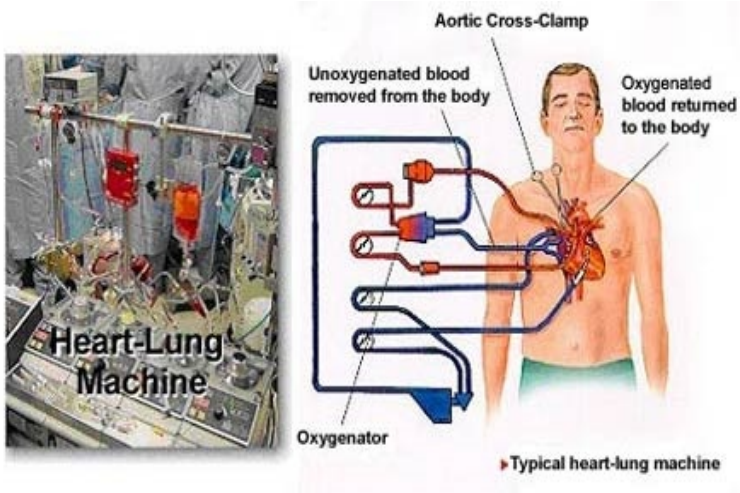
- The effects of diathermy depends on the current intensity and wave-form used
- Coagulation

- Produced by interrupted pulses of current (50-100 per second) Square wave-form
- Cutting
- Produced by continuous current
- Sinus wave-form

Explain in detail the different types of oxygenators and pumps used in heart lung machine.APRIL/MAY 2017

HEART – LUNG MACHINE





The principle of the heart-lung machine (also known as pump-oxygenator or cardiopulmonary bypass) is actually quite simple. Blue blood withdrawn from the upper heart chambers is drained (by gravity siphon) into a resevoir. From there, the blood is pumped through an artificial lung. This component is designed to expose the blood to oxygen. As the blood passes through the artificial lung (also known as an oxygenator), the blood comes into intimate contact with the fine surfaces of the

device itself. Oxygen gas is delivered to the interface between the blood and the device, permitting the blood cells to absorb oxygen molecules directly.

Now the blood is red in color, indicating its rich content of oxygen destined to be delivered to the various tissues of the body. Finally, the heart-lung machine actively pumps the red blood back into the patient through a tube connected to the arterial circulation. The heart-lung circuit is a continuous loop; as the red blood goes into the body, blue blood returns from the body and is drained into the pump completing the circuit.

UNIT IV

PHYSICAL MEDICINE AND BIOTELEMETRY

1. Define diathermy. Draw the circuit diagram of short-wave diathermy unit and discuss its impact on therapy purpose in detail. Also briefly describe how it can be applied to human subjects. NOV / DEC 2016

DIATHERMIES

In the natural sciences, the term **diathermy [di´ah-ther″me]** means "electrically induced heat" the use of high-frequency electromagnetic currents as a form of physical or occupational therapy and in surgical procedures. The term diathermy is derived from the Greek words dia and therma, and literally means "heating through." adj., adj diather´mal, diather´mic.

It is commonly used for muscle relaxation. It is also a method of heating tissue electromagnetically or ultrasonically for therapeutic purposes in medicine. Diathermy is used in physical therapy and occupational therapy to deliver moderate heat directly to pathologic lesions in the deeper tissues of the body.

Surgically, the extreme heat that can be produced by diathermy may be used to destroy neoplasms, warts, and infected tissues, and to cauterize blood vessels to prevent excessive bleeding. The technique is particularly valuable in neurosurgery and surgery of the eye.

The three forms of diathermy employed by physical and occupational therapists are ultrasound, short wave and microwave. The application of moderate heat by diathermy increases blood flow and speeds up metabolism and the rate of ion diffusion across cellular membranes. The fibrous tissues in tendons, joint capsules, and scars are more easily stretched when subjected to heat, thus facilitating the relief of stiffness of joints and promoting relaxation of the muscles and decrease of muscle spasms.

Ultrasound

Main article: Therapeutic ultrasound

Ultrasound diathermy employs high-frequency acoustic vibrations which, when propelled through the tissues, are converted into heat. This type of diathermy is especially useful in the delivery of heat to selected musculatures and structures because there is a difference in the sensitivity of various fibers to the acoustic vibrations; some are more absorptive and some are more reflective. For example, in subcutaneous fat, relatively little energy is converted into heat, but in muscle tissues there is a much higher rate of conversion to heat.

The therapeutic ultrasound apparatus generates a high-frequency alternating current, which is then converted into acoustic vibrations. The apparatus is moved slowly across the surface of the part being treated. Ultrasound is a very effective agent for the application of heat, but it should be used only by a therapist who is fully aware of its potential hazards and the contraindications for its use.

Explain the working and application techniques of shortwave diathermy. APRIL/MAY 2016

SHORT WAVE

Short wave diathermy machines use two condenser plates that are placed on either side of the body part to be treated. Another mode of application is by induction coils that are pliable and can be molded to fit the part of the body under treatment. As the high-frequency waves travel through the body tissues between the condensers or the coils, they are converted into heat. The degree of heat and depth of penetration depend in part on the absorptive and resistance properties of the tissues that the waves encounter.

Short wave diathermy operations use the ISM band frequencies of 13.56, 27.12, and 40.68 megahertz. Most commercial machines operate at a frequency of 27.12 MHz, a wavelength of approximately 11 meters.

Short wave diathermy usually is prescribed for treatment of deep muscles and joints that are covered with a heavy soft-tissue mass, for example, the hip. In some instances short wave diathermy may be applied to localize deep inflammatory processes, as in pelvic inflammatory disease.

MICROWAVE

Microwave diathermy uses microwaves, radio waves which are higher in frequency and shorter in wavelength than the short waves above. Microwaves, which are also used in radar, have a frequency above 300 MHz and a wavelength less than one meter. Most, if not all, of the therapeutic effects of microwave therapy are related to the conversion of energy into heat and its distribution throughout the body tissues. This mode of diathermy is considered to be the easiest to use, but the microwaves have a relatively poor depth of penetration.

Microwaves cannot be used in high dosage on edematous tissue, over wet dressings, or near metallic implants in the body because of the danger of local burns. Microwaves and short waves cannot be used on or near persons with implanted electronic cardiac pacemakers.

Microwave diathermy is used in the management of superficial tumours with conventional radiotherapy and chemotherapy. Hyperthermia has been used in oncology for more than 35 years, in addition to radiotherapy, in the management of different tumours. In 1994, hyperthermia has been introduced in several countries of the European Union as a modality for use in physical medicine and sports traumatology. its use has been successfully extended to physical medicine and sports traumatology in Central and Southern Europe.

Discuss the different operations performed using surgical diathermy. APRIL/MAY 2016

SURGICAL DIATHERMY

Surgery

Main article: Electrosurgery

Surgical diathermy is usually better known as "electrosurgery". (It is also referred to occasionally as "electrocautery", but see disambiguation below.) Electrosurgery and surgical diathermy involve the use of high frequency A.C. electric current in surgery as either a cutting modality, or else to cauterize small blood vessels to stop bleeding. This technique induces localized tissue burning and damage, the zone of which is controlled by the frequency and power of the device.

Some sources insist that electrosurgery be applied to surgery accomplished by high-frequency alternating current (AC) cutting, and that "electrocautery" be used only for the practice of cauterization with heated nichrome wires powered by direct current (DC), as in the handheld battery-operated portable cautery tools.

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Write short notes on frequency applications for telemetry applications. APRIL/MAY 2016

FREQUENCY SELECTION AND BIOTELEMETRY

Elements of biotelemetry

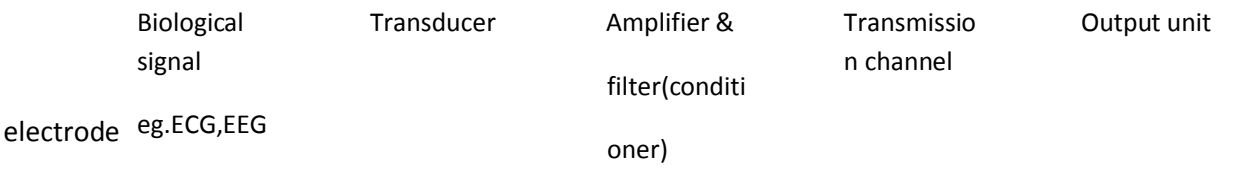

Figure Block diagram of bio telemetry system

ECG,EEG,EMG- Electrodes act as transducer

For measuring temperatures-Thermisto is used as transducer

For measuring blood pressure-strain gauge is used as transducer

For measuring stomach pH-glass electrode is used as transducer.

DESIGN OF BIO TELEMETRY

- Telemetry system should be selected to transmit the bio –electric Signal with maximum fidelity and simplicity.
- The system should not affect the living system by any interference.
- Smaller in size light in weight.
- It should have more stability and reliability.
- The power consumption at the transmitter and receiver should be small.
- It should reject common mode interference rejection.
- Miniatured radio telemetry system should be used to reduce noise.

With suitable diagram, explain how the ECG signal can be transmitted using single channel telemetry system. NOV / DEC 2016

RADIO TELEMETRY SYSTEMS

- Single channel telemetry system
- Multi channel telemetry system

SINGLE CHANNEL TELEMETRY SYSTEM

- For a single channel telemetry system, a miniature battery operated radio transmitter is connected to the electrodes of the patients.
- The transmitter broadcasts the biopotential to a remote place in which the receiver detects the radio signal and recovers signal for further processing.
- The receiving system can be located in a room separately from the patients.
- The only risk is shock to the patient.

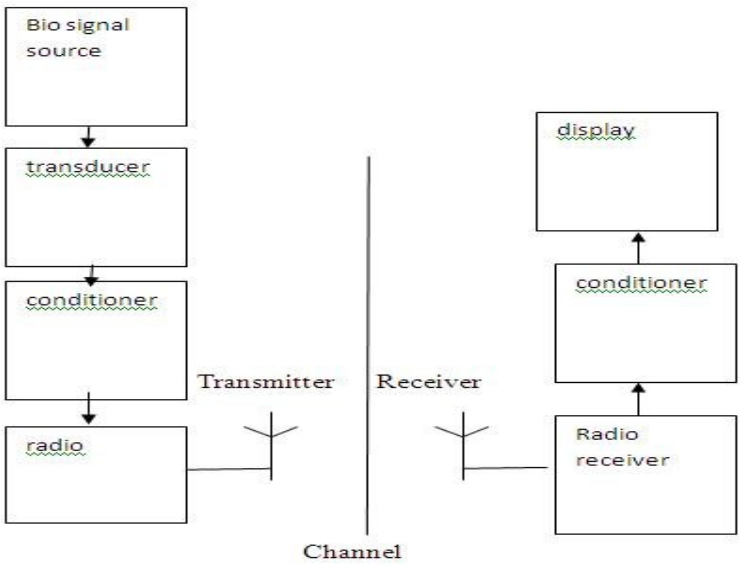

Fig Block diagram of Single Channel Telemetry System

- Biosignal from the patient is converted into electrical signals by the transducer.
- They are amplified and filtered at the conditioner. Further they are frequency modulated or pulse modulated.Frequency modulation provides the high noise interference rejection and high stability.
- The biosignals are amplified to radio frequency range of few hundred KHz to about 300 KHz and then they are transmitted by transmitter antenna.s
- At radio receiver the corresponding frequency are received and then they are demodulated, amplified and displayed.

Transmission of bioelectric variables:

- Active measurements
- Passive measurements

Tunnel diode FM transmitter

- The tunnel diodes exhibit a specific characteristics known as negative resistance. They have extremely low values of inductance an capacitance.
- It is used for the transmission of EMG,ECG, respiration rates.

- Tunnel diodes are used as active devices and this circuit has higher fidelity and sensitivity.
- Total weight is 1.44 gm with battery and the size is small.
- Varactor diode is basically a reverse biased PN junction which utilizes the inherent capacitance of depletion layer.
- Varactor diodes are voltage capacitors used for frequency modulation.
- The signal is transmitted through the inductor L of the tank circuit of RF oscillator.

Advantages:

- All the signal can be transmitted by using the circuit.
- No shielded room is needed.

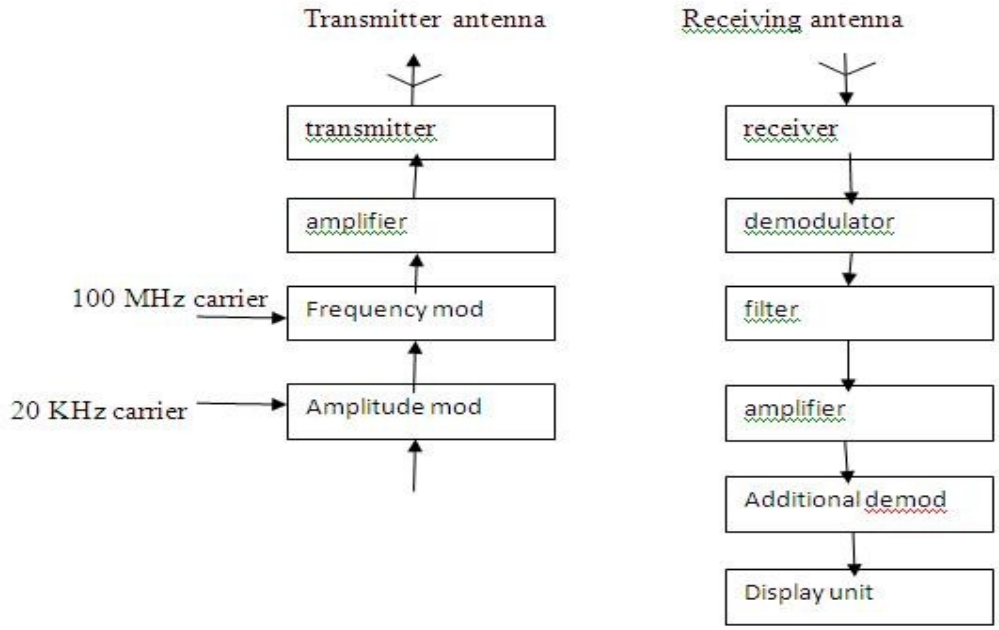

Fig 4.7.2 Bio telemetry using sub carrier system

Receiver side:

- At the receiver end the receiver detects the RF and recovers the sub carrier carrying the signal.
- At the receiver side, the signals are passed to demodulator, demodulated signal is filtered, amplified by amplifier and then they are given to additional demodulator. It is

used to convert the signal from the modulated sub carrier system an to get the original signal.

- Finally the signal is displayed**.**

Describe the physiological effects of electricity on humans. APRIL/MAY 2016

ELECTRICAL SAFETY OF MEDICAL EQUIPMENT

The patient in hospital is the center of care, but he is also helpless in the center of potential dangers, which are in the industry, long time ago, as such identified (i.e. chemicals, electricity, radiation).Safety in hospital means firstly patient safety, but it means also safety of operators and others. Electrical safety is a very important element in hospital safety. The electrical safety of the medical equipment in hospital is the most important of it.

Medical. Enggineering. & El. Safety

Assurance the highest possible level of med. Equipment safety in hospital is one of the most important tasks of the med. / clinical engineer.The med. / clinical engineer, therefore, must be aware of and very familiar with the issues of the electrical safety of the medical equipment in hospital. Electrical Safety means electrical shock protection.

The Mechanism of the El. Shock

El. Shock occurs when a victim is a part of an electrical circuit (an element closing it), in which an electrical current can flow and has the ability to harm the victim or even cause death (electrocution).That means consequently that there must be a simultaneous two-points contact of the victim with the electrical shock circuit.

El. Shock = Closing the El. Shock Circuit

El. Power Distribution System

For technical reasons, neutral point (and consequently the neutral line) is deliberately connected to earth. It is this connection that makes the electrical service a “grounded

system".Understanding this is the key for understanding the mechanism of electric shock and electrocution.The voltage between the two power-carrying wires (Phase (P) & Neutral (N) or "hot & cold") is also present between Phase and Ground (which is not considered as power-carrying wire) and everything connected to earth.

Two Kinds of Grounding / Earthing

Grounding of Electrical Systems:

Connecting N-line of the service side to earth due to technical reason and for protection of systems and plants (removing the floating high voltage in the secondary (service) side of the distribution transformer).

Protective Grounding:

Connecting conducting parts, which are not intended for carrying current in normal circumstances (enclosures; switch-, fuse-, outlet- metal boxes; etc.) via 3rd conductor (which, in normal situations, does not carry current) to earth.

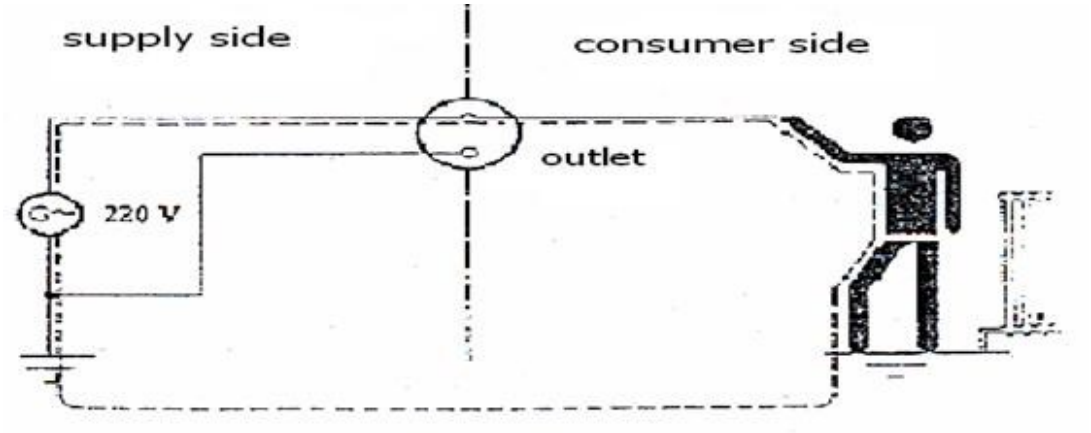

Fig Basic shock circuit

Leakage Currents: Caused by stray capacitances, which are always present between conducting surfaces.

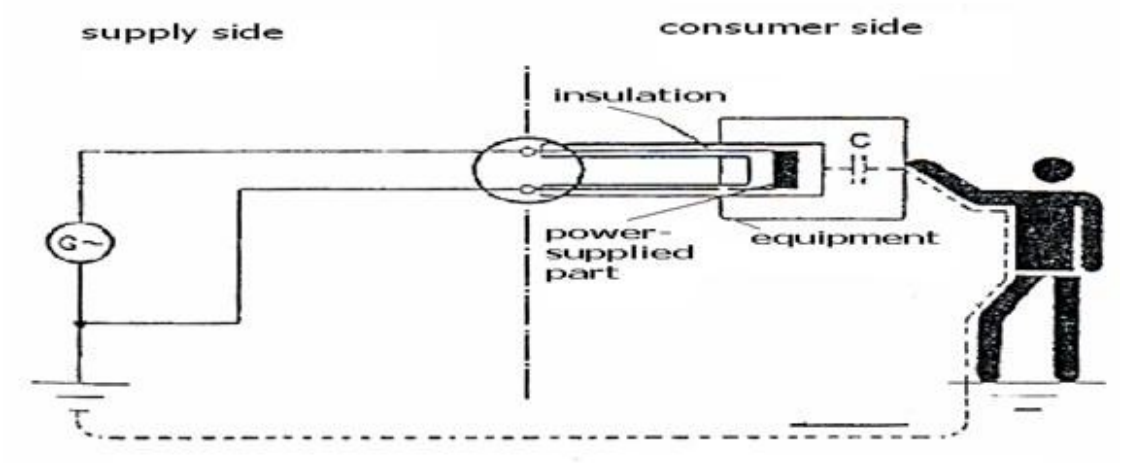

Fig Stray capacitance and leakage current

UNIT V

RECENT TRENDS IN MEDICAL INSRUMENTATION

What is thermography? Explain the block diagram of infrared imaging system. APRIL/MAY 2016

THERMOGRAPHY

Thermograph, thermal imaging, or thermal video, is a type of infrared imaging. Thermo graphic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly

900–14,000 nanometers or 0.9–14 μ m) and produce images of that radiation. Since infrared radiation is emitted by all objects based on their temperatures, according to the black body radiation law, thermograph makes it possible to see one's environment with or without visible illumination.

The amount of radiation emitted by an object increases with temperature, therefore thermograph allows one to see variations in temperature (hence the name). When viewed by thermo graphic camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night. As a result, thermograph's extensive use can historically be ascribed to the military and security services. Thermal imaging

photography finds many other uses. For example, firefighters use it to see through smoke, find persons, and localize the base of a fire.

Methods of Thermography

Infrared thermography Liquid crystal thermography Microwave thermography**.**

INFRARED THERMOGRAPHY

Infrared thermography is the science of acquisition and analysis of thermal information by using non contact thermal imaging devices.Human skin emits infrared radiation as an exponential function of its absolute temperature and the emissive properties of the skin temperature.

The maximum wavelength λ_{max} = 10 μm and range from 4 to 40μm.The thermal picture is usually displayed on a TV tube may be photographed to provide a permanent record.

Every thermo graphic equipment is provided with a special infrared camera that scales the object. The camera contains an optical system in the form of an oscillating plane mirror which scans the field of view at a very high speed horizontally and vertically and focuses the collected infrared radiations onto chopper.

The chopper disc interrupts the infrared beam so that a.c signals are produced. Then they are given to detector. The detector is infrared radiation detector. The detected output by detector is amplified and led to phase sensitive.

LIQUID CRYSTAL THERMOGRAPHY

Liquid crystals are a class of compounds which exhibit colour temperature sensitivity in the cholestric phase. Scattering effects with the material give rise to iridescent colours, the dominant wavelength being influenced by very small changes in temperature.

The high temperature sensitivity makes cholesteric liquid crystals useful for thermal mapping.In this technique, the temperature sensitive plate consists of a blackened thin flim support into which encapsulated liquid crystals cemented to a pseudo solid powder (with particle sizes between 10 to 30) have been incorporated.

Thermal contact between the skin surface and plate produces a color change in the encapsulated liquid crystals; red for relatively low temperatures through the visual spectrum to violet for high temperatures. But in infrared thermograms, the violet colour is used to identify the low temperature regions and the bright colour or red is used to identify the temperature regions.

If we want to study a breast's temperature distribution, several different plates are necessary to cover a breast temperature range from 28^0C to36^0C. Each plate covers a range of temperature 3^0C. A record of the liquid crystal image may be obtained by colour photography. The response time varies according to the thickness of plate (ranges from 0.06mm to 0.3 mm) and is 20 to 40 seconds.

MICROWAVE THERMOGRAPHY

Eventhough we get microwave emissions from the skin surface, that intensity is very small when we compare with Infra red radiation intensity . (10 wavelenght emission intensity is

10^8 times greater than 10 cm wavelength emission intensity). But using modern microwave radiometers one can detect temperature change of 0.1K. since body tissues are partially transparent to microwave radiations which orginates from a tissue volume extending from the skin surface to a depth of several centimeters. Microwave radiometers consisting of matched antennae placed in contact with the skin surface for use at 1.3 G Hz and 3.3 G Hz have been used

to sense subcutaneous temperature.

The present day thermographic systems, using Infrared radiation, only give a temperature map of the skin due to low penetration depth of the short wavelength of the infrared component of the emitted radiation. Using a microwave receiver with a frequency response from 1.7 GHz to 2.5

GHz a penetration depth of 1 cm in tissue and 8 cm in fat and bone can be obtained.

A severe problem is the unknown emissivity of the body surface for microwaves, as part of the radiation is reflected back into the body.In a conventional radiometer this gives rise toa measurement error proportional to the temperature difference between the body surface and the applied antenna. This error lies in the order of 1-2 K which is too high for medical applications.

The problem has been solved iv an elegant way by adding artificial microwave noise from the antenna,thus providing a radiation balace between the receiver and body surface. With this a temperature sensitivity of 0.1 K could be obtained. Based on the transducer attachment on the skin surface, we can classify the thermography into contact thermography and tele-thermography.

Advantages of Thermography

Get a visual picture so that you can compare temperatures over a large area

It is real time capable of catching moving targets

Able to find deteriorating components prior to failure Measurement in areas inaccessible or hazardous for other methods It is a non-destructive test method

Limitations & disadvantages of thermography

Quality cameras are expensive and are easily damaged

Images can be hard to interpret accurately even with experience

Accurate temperature measurements are very hard to make because of emissivities

Most cameras have ±2% or worse accuracy (not as accurate as contact)
Training and staying proficient in IR scanning is time consuming Ability to only measure surface areas

Applications

Healthy Cases Tumors Inflammation

Diseases of peripheral Vessels

Burns and Perniones

Skin Grafts and Organ Transplantation

Describe the different operations performed using Endoscopy. APRIL/MAY2016

ENDOSCOPY UNIT

HISTORY

The first endoscope, of a kind, was developed in 1806 by Philip Bozzini with his introduction of a Lichtleiter (light conductor) for the examinations of the canals and cavities of the human body. However, the Vienna Medical Society disapproved of such curiosity. An endoscope was first introduced into a human in 1822 by William Beaumont, an army surgeon at Mackinac Island, MichiganThe use of electric light was a major step in the improvement of endoscopy. The first such lights were external. Later, smaller bulbs became available making internal light possible, for instance in a hysteroscope by Charles David in 1908Hans Christian Jacobaeus has been given credit for early endoscopic explorations of the abdomen and the thorax with laparoscopy (1912) and thoracoscopy (1910).Laparoscopy was used in the diagnosis of liver and gallbladder disease by Heinz Kalk in the 1930. Hope reported in 1937 on the use of laparoscopy to diagnose ectopic pregnancyIn 1944, Raoul Palmer placed his patients in the Trendelenburg position after gaseous distention of the abdomen and thus was able to reliably perform gynecologic laparoscopy

Endoscopy

An endoscopy is a test that looks inside the body. The endoscope is a long flexible tube that can be swallowed. It has a camera and light inside it. Some doctors call it a telescope.Most likely to have an endoscopy to look at the inside of

Gullet (oesophagus)
Stomach

Duodenum - the first part of the small bowel that attaches to the stomach

Large bowel (colon)

There is more detailed information about having a colonoscopy in the bowel cancer section of CancerHelp UK. Below is information about having other types of endoscopy.

It is used to take photograph of the hollow internal organs

Depending on the body part, each type of endoscopy has its own special term, such as

laparoscopy (abdomen, uterus, fallopian tube),
laryngoscopy (vocal cords),

bronchoscopy (lungs),
colonoscopy (colon),
arthroscopy (joint) and
Gastroscopy (Stomach).

Components

An endoscope can consist of

- A rigid or flexible tube
- A light delivery system to illuminate the organ or object under inspection. The light source is normally outside the body and the light is typically directed via an optical fiber system A lens system transmitting the image to the viewer from the fiberscope
- An additional channel to allow entry of medical instruments or manipulators

Uses

Endoscopy can involve

The gastrointestinal tract (GI tract):

esophagus, stomach and duodenum (esophagogastroduodenoscopy)

small intestine

colon (colonoscopy,proctosigmoidoscopy) Bile duct

Non-medical uses for endoscopy

The planning and architectural community have found the endoscope useful for pre-visualization of scale models of proposed buildings and cities (architectural endoscopy) Internal inspection of complex technical systems (borescope) Endoscopes are also a tool helpful in the examination of improvised explosive devices by bomb disposal personnel. The FBI uses endoscopes for conducting surveillance via tight spaces.

Recent developments

With the application of robotic systems, telesurgery was introduced as the surgeon could operate from a site physically removed from the patient. The first transatlantic surgery has been called the Lindbergh Operation.

Upper Endoscopy

Upper endoscopy enables the physician to look inside the esophagus, stomach, and duodenum (first part of the small intestine). The procedure might be used to discover the reason for swallowing difficulties, nausea, vomiting, reflux, bleeding, indigestion, abdominal pain, or chest pain. Upper endoscopy is also called EGD, which stands for esophagogastroduodenoscopy (eh- SAH-fuh-goh-GAS-troh-doo-AH-duh-NAH-skuh-pee).

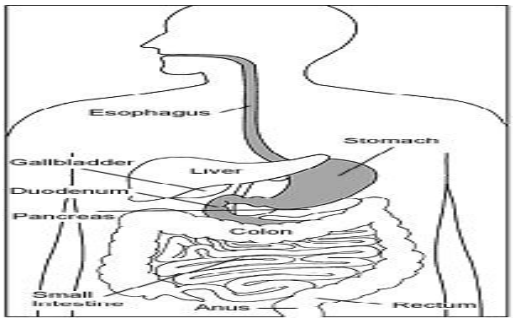

Figure Upper Endoscopy

Types of Endoscopy

Fiber optic endoscopes now have widespread use in medicine and guide a myriad of diagnostic and therapeutic procedures including:

Arthroscopy: Examination of joints for diagnosis and treatment (arthroscopic surgery)

Bronchoscopy: Examination of the trachea and lung's bronchial trees to reveal abscesses, bronchitis, carcinoma, tumors, tuberculosis, alveolitis, infection, inflammation

Colonoscopy: Examination of the inside of the colon and large intestine to detect polyps, tumors, ulceration, inflammation, colitis diverticula, Chrohn's disease, and discovery and removal of foreign bodies.

Colposcopy: Direct visualization of the vagina and cervix to detect cancer, inflammation, and other conditions.

Cystoscopy: Examination of the bladder, urethra, urinary tract, uteral orifices, and prostate (men)

with insertion of the endoscope through the urethra.

ERCP (endoscopic retrograde cholangio-pancreatography) uses endoscopic guidance to place a catheter for x-ray fluorosocopy with contrast enhancement. This technique is used to examine the liver's biliary tree, the gallbladder, the pancreatic duct and other anatomy to check for stones, other obstructions and disease. X-ray contrast is introduced into these ducts via catheter and fluoroscopic x-ray images are taken to show any abnormality or blockage. If disease is detected, it can sometimes be treated at the same time or biopsy can be performed to test for cancer or other pathology. ERCP can detect biliary cirrhosis,.cancer of the bile ducts, pancreatic cysts, pseudocysts, pancreatic tumors, chronic pancreatitis and other conditions such as gallbladder stones.

EGD (Esophogealgastroduodensoscopy): visual examination of the upper gastro-intestinal (GI) tract. (also referred to as gastroscopy) to reveal hemorrhage, hiatal hernia, inflammation of the esophagus, gastric ulcers.

Endoscopic biopsy is the removal of tissue specimens for pathologic examination and analysis.

Gastroscopy: examination of the lining of the esophagus, stomach, and duodenum. Gastroscopy is often used to diagnose ulcers and other sources of bleeding and to guide biopsy of suspect GI cancers.

Laparoscopy: visualization of the stomach, liver and other abdominal organs including the female reproductive organs, for example, the fallopian tubes.

Laryngoscopy: examination of the larynx (voice box).

Proctoscopy, sigmoidoscopy, proctosigmoidoscopy: examination of the rectum and sigmoid colon.

Thoracoscopy: examination of the pleura (sac that covers the lungs), pleural spaces, mediastinum, and pericardium.

Endoscopy Equipment

Endoscopes have many practical needs. And H.M.B. Endoscopy Products (Hollywood, Florida) has been providing endoscopic equipment and educating people on the use of endoscopes for more than 17 years..

Video Systems *Fiber Endoscopes* *Video Endoscopes*

Figure Endoscopic Equipment

In the simplest terms, Endoscopy equipment consists of instruments that can look at the inside of many different organs — these are small, flexible or rigid tubes with a light or lenses on the end that can look into the esophagus, stomach and colon — and in more general terms endoscopy equipment can help doctors look deep inside body structures and hollow organs. An endoscope and related endoscope products and equipment are usually composed of three components:

An optic system that allows the doctor to look through the scope into the organ or cavity, or to attach a video camera to the scope

A fiberoptic cable to light up the bodily area

A lumen (e.g. the bore of a tube, like a needle or catheter) to take tissue samples of the area being viewed.

Write short notes on applications of LASER in medicine. APRIL/MAY 2016

LASERS IN MEDICINE

LASERS (Light Amplification by Stimulated Emission of Radiation)

Characteristics of laser sources

•Tissue optical properties

•Laser/tissue interactions

•Some diagnostic applications

Components of a Laser

a) Lasing Medium: provides appropriate transition and determines wavelength.Solid: Ruby, v

Nd:YAG, Ti:Sapphire, etc. Liquid: Organic dyes, e.g. rhodamine Gas: Ar, CO_2, HeNe, ArF, etc.

b) Pump: provides energy necessary for population inversion. E.g.
electric discharge, flashlamp, another laser.

c) Cavity: provides opportunity for amplification and produces a directional beam.

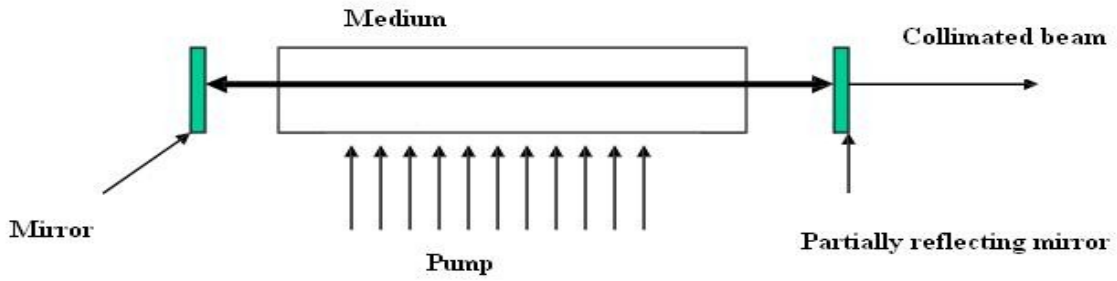

Figure Components of Laser

Optical Properties of Tissues

Scattering

- Elastic (i.e. no energy loss), although Doppler shift and Raman shift have been exploited for diagnostic information.
- Mean free path for scattering is typically 100 microns.
- Scattering is forward peaked, typically the average cosine of the scattering angle is > 0.9 (for isotropic scatt
- Scattering coefficient decreases slowly as a function of wavelength.

Absorption

Depends on concentration and absorption spectra of specific molecules in the tissue. Highly dependent on wavelength. UV - high absorption by proteins.Visible - can identify specific features of absorption by hemoglobin, melanin, and other pigments.700 - 900 nm - the “optical window” where tissue absorption is low, maximum light penetration in tissue.IR - absorption is mainly due to water, highest at 2.95 microns.

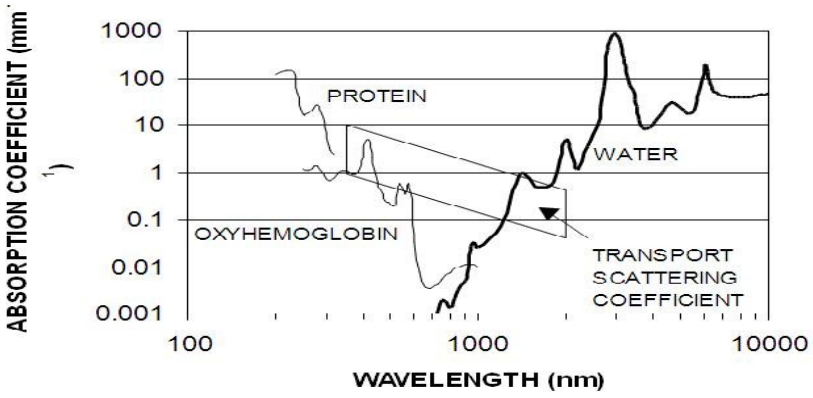

Figure Aborption vs wavelength

Distribution of Light in Tissue

The quantity we are usually interested in is the fluence rate. This is defined as the ratio of total power incident on an infinitesimal sphere to the cross sectional area of that sphere. The SI unit is W m^{-2}. It is a measure of how many photons are available per unit volume in the tissue.The fluence rate distribution in tissue is highly dependent on the absorption and scattering coefficents of the tissue.

Mechanisms of interaction

In order for light to affect tissue, absorption must take place. The rate at which energy is deposited in the tissue is given by the product of the fluence rate (W cm^{-2}) and the linear absorption coefficient (cm^{-1}). The rate of energy absorption largely determines whether photochemical, thermal, or photomechanical effects are dominant.

Photochemical

Initial absorption by specific molecules.If photon energy is high enough (UV, excimer laser), direct bond- breaking is possible.Alternatively, the molecule can be raised to an excited state from which a variety of chemical reactions are possible such as the generation of free radicals and reactive oxygen species.

Photomechanical

For very high rates of energy deposition, shock waves can be generated in the tissue by mechanisms such as bubble expansion/collapse or plasma formation.The mechanical properties of the tissue govern the propagation of these waves and their biological effect.

Tissue can be ablated (i.e. physically removed from the surface, torn or, in the case of “brittle” tissue, shattered. Interestingly, these two quantities span many orders of magnitude but their product (the light fluence), varies over a much smaller range. This emphasizes the point that is is the rate of energy absorption that determines the nature of the light-tissue interaction.

Selected Applications of Lasers in Medicine

Diagnostic: Goal is to learn something about the tissue

Therapeutic: Goal is to modify the tissue, e.g. kill malignant cells.

Write short notes on cryogenic applications.APRIL/MAY 2017

CRYOGENIC APPLICATION

Cryogenics is the study and use of materials at extremely low temperatures. Such low temperatures cause changes in the physical properties of materials that allow them to be used in unusual engineering, industrial, and medical applications. For example, in the cryogenic temperature range, air becomes a liquid—or even a solid—and living tissue freezes instantly. Matter behaves strangely at the lowest temperatures of the cryogenic range. Electric currents never stop flowing, liquids run uphill, and rubber becomes as brittle as glass. In medicine, cryogenic cooling is used in some diagnostic techniques, such as magnetic resonance imaging (MRI). Cryosurgery uses liquid nitrogen to kill unhealthy tissue by freezing it. Cryogenics is expected to play an important role in the development of better procedures for preserving human organs for transplant.

Early Research

British chemists Michael Faraday (1791-1867) and Sir Humphry Davy (1778-1829) did pioneering work in low-temperature physics that led to the development of cryogenics. In the early to middle 1800s they were able to produce gases by heating mixtures at one end of a sealed tube in the shape of an inverted "V." A salt and ice mixture was used to cool the other end of the tube. This combination of reduced temperature and increased pressure caused the gas that was produced to liquefy (turn to a liguid). When they opened the tube, the liquid quickly evaporated and cooled to its normal boiling point.

In 1877, French mining engineer Louis Paul Cailletet announced that he had liquefied oxygen and nitrogen. Cailletet was able to produce only a few droplets of these liquefied gases, however. In his research with oxygen, Cailletet collected the oxygen in a sturdy container and cooled it by evaporating (drying up) sulphur dioxide in contact with the container. He then compressed the oxygen as much as possible with his equipment. Next he reduced the pressure suddenly, causing the oxygen to expand. The sudden cooling that resulted caused a few drops of liquid oxygen to form.

The Cooling Process

A substance is normally cooled by placing it next to something colder. To make the substance super cold, however, heat must also be removed and the substance must be insulated (encased). An important method of cryogenic supercooling involves liquefying gases and using these gases to cool other substances. One technique is to convert to liquid form a gas that can be liquefied by pressure alone. Then a gas requiring a lower temperature to become a liquid is placed in a container and immersed (dipped) in the first. The gas that is already liquefied cools the second and converts it to a liquid. After several repetitions of this process, the targeted gas is liquefied. A Dewar flask is normally used to store such very low temperature liquefied gases.