E-Content (Biomedical Instrumentation)

Syllabus

Introduction to Biomedical Instrumentation
1.1 Introduction
1.2 Development of biomedical instrumentation
1.3 Man-instrumentation system and its components
1.4 Research and clinical instrumentation
1.5 In-vivo and in-vitro measurements
1.6 Specifications of medical instrumentation system.
2. Physiology
2.1 Introduction
2.2 Physiological systems of the body
2.2.1 Cardiovascular system
2.2.2 Respiratory system
2.2.3 Nervous system
2.2.4 Bio-chemical system
3. Biomedical Signals and Electrodes
3.1 Study of bio-electric potentials
3.2 Resting and action potentials
3.3 Bio-electrodes
3.4 Electrode- tissue interface
3.5 Contact impedance
3.6 Types of electrodes
4. Diagnostic Instruments (16hrs)
Brief study of the following
4.1 Electro cardiograph(ECG)
4.2 Electro encephalograph (EEG)
4.3 Electro myograph (EMG)
4.4 Pacemakers
4.5 Defibrillators
4.6 Spirometer
4.7 Pulse oxymeter SPO2
4.8 NIBP (non invasive blood pressure)
4.9 Glucometer
4.10 Speech audiometer
5. Bio-telemetry
5.1 Introduction
5.2 Block Diagram of Bio-Telemetry Systems
5.3 Telemedicine
6. Intensive Care Unit
6.1 Introduction
6.2 Elements of Intensive Care Unit (ICU)
6.3 Introduction of Ventilators
7. Computer applications

7.1 Computer applications in biomedical devices
7.2 Computerized Axial Tomography (CAT) scanners
7.3 Applications of Embedded system

CHAPTER.-1 (BMI)

Introduction to Biomedical Instrumentation

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Bioinstrumentation

It is the application of electronics and measurement principles and techniques to develop devices used in diagnosis and treatment of disease. The recent publications in the field of bioinstrumentation talk about the following areas

- In vivo bioelectrical measurements with coated electrodes
- mHealth technology
- Noninvasive instruments for healthcare

Development biomedical Instrumentation Devices

A generalized structure for how medical devices should be developed follows from determining a clinical condition of a patient such as diabetes.Then the relevant physiological parameter to be measured would in this case be blood sugar concentrations, but for other situations could be blood pressure, heart rate, white blood cell count, or other signals and amounts in the body. Next, the method in which this physiological parameter is taken must be determined. For someone with type one diabetes, these could be a glucose monitoring system with a sensor placed just below the skin in the interstitial fluid that can measure the concentration of glucose. The next parameter that is chosen for the development of a biomedical instrumentation device would be the transducer design, which for this example would be changing glucose concentration to a measurable value such as voltage via the reaction from glucose and glucose oxidase's products with a reduction reaction causing a current to flow being transformed to a voltage change to be measured. The final step to the development of the device before signal digitization, processing, and display is filter and amplifier design which will clean up and increase the size of the physiological signal so that it is able to be detected and read out on the device.

Man-instrumentation system

Man Instrumentation System is a term used in engineering analysis and biomedical instrumentation. It involves the measurement of outputs from an unknown system as they are affected by various combination of inputs. The main object of such exercise is to learn the nature and characteristics of the system. In biomedical instrumentation, the man instrumentation system includes both the human being and the instrumentation required for measurement of the parameters related to human being. The concept of the man-instrument system is applicable to both clinical and research instrumentation.

Components of Man-instrumentation system

The main components of the Man-Instrument system are:

- Subject (Human being)
- Stimulus
- Transducers
- Signal conditioning equipment
- Display equipment
- Recording data processing unit
- Control Device
- Other components of the system include control feedback, transmission of data, and signal transducer equipment.

Research and clinical instrumentation

A research instrument is a tool used to obtain, measure, and analyze data from subjects around the research topic.

Clinical instrumentation refers to medical equipment and supplies used to measure and observe various aspects of a patient's health. It is used for diagnostic, therapeutic, and monitoring applications in areas such as cardiology, lung function, cerebral and muscular signals, surgery and anesthesiology, ultrasound, and specialized devices for infants and neonates.

In-vivo and in-vitro measurements

In vitro tests (pictured) occur outside of a living organism. In vitro is Latin for “in glass.” It describes medical procedures, tests, and experiments that researchers perform outside of a living organism. An in vitro study occurs in a controlled environment, such as a test tube or petri dish.

In vivo is Latin for “within the living.”

Specifications of medical instrumentation system

Any medical instrument consists of the following functional basic parts:

1. Measurand: The measurand is the physical quantity, and the instrumentation systems measure it.

2. Sensor / Transducer: The transducer converts one form of energy to another form usually electrical energy.

3. Signal Conditioner: Signal conditioning circuits are used to convert the output from the transducer into an electrical value.

CHAPTER.-2 (BMI)
PHYSIOLOGY

Cardiovascular system

The circulatory system is composed of the heart and blood vessels, including arteries, veins, and capillaries. Our bodies actually have two circulatory systems: The pulmonary circulation is a short loop from the heart to the lungs and back again, and the systemic circulation (the system we usually think of as our circulatory system) sends blood from the heart to all the other parts of our bodies and back again.

The heart is the key organ in the circulatory system. As a hollow, muscular pump, its main function is to propel blood throughout the body. It usually beats from 60 to 100 times per minute, but can go much faster when necessary. It beats about 100,000 times a day, more than 30 million times per year, and about 2.5 billion times in a 70-year lifetime.

The heart gets messages from the body that tell it when to pump more or less blood depending on an individual's needs. When we're sleeping, it pumps just enough to provide for the lower amounts of oxygen needed by our bodies at rest. When we're exercising or frightened, the heart pumps faster to increase the delivery of oxygen.

The heart has four chambers that are enclosed by thick, muscular walls. It lies between the lungs and just to the left of the middle of the chest cavity. The bottom part of the heart is divided into two chambers called the right and left ventricles, which pump blood out of the heart. A wall called the interventricular septum divides the ventricles.

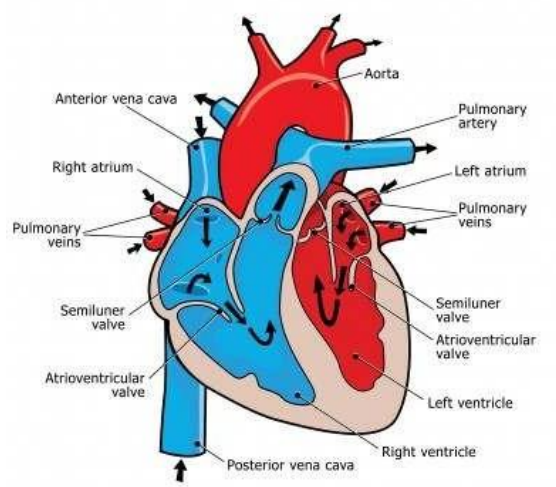
The upper part of the heart is made up of the other two chambers of the heart, the right and left atria. The right and left atria receive the blood entering the heart. A wall called the interatrial septum divides the right and left atria, which are separated from the ventricles by the atrioventricular valves. The tricuspid valve separates the right atrium from the right ventricle, and the mitral valve separates the left atrium and the left ventricle.

Two other cardiac valves separate the ventricles and the large blood vessels that carry blood leaving the heart. These are the pulmonic valve, which separates the right ventricle from the pulmonary artery leading to the lungs, and the aortic valve, which separates the left ventricle from the aorta, the body's largest blood vessel.

Arteries carry blood away from the heart. They are the thickest blood vessels, with muscular walls that contract to keep the blood moving away from the heart and through the body. In the systemic circulation, oxygen-rich blood is pumped from the heart into the aorta. This huge artery curves up and back from the left ventricle, then heads down in front of the spinal column into the abdomen. Two coronary arteries branch off at the beginning of the aorta and divide into a network of smaller arteries that provide oxygen and nourishment to the muscles of the heart.

Unlike the aorta, the body's other main artery, the pulmonary artery, carries oxygen-poor blood. From the right ventricle, the pulmonary artery divides into right and left branches, on the way to the lungs where blood picks up oxygen.

The circulatory system works closely with other systems in our bodies. It supplies oxygen and nutrients to our bodies by working with the respiratory system. At the same time, the circulatory system helps carry waste and carbon dioxide out of the body.



One complete heartbeat makes up a cardiac cycle, which consists of two phases:

In the first phase, the ventricles contract (this is called systole), sending blood into the pulmonary and systemic circulation. To prevent the flow of blood backwards into the atria during systole, the atrioventricular valves close, creating the first sound (the lub). When the ventricles finish contracting, the aortic and pulmonary valves close to prevent blood from flowing back into the ventricles. This is what creates the second sound (the dub).

1. Then the ventricles relax (this is called diastole) and fill with blood from the atria, which makes up the second phase of the cardiac cycle.

A unique electrical conduction system in the heart causes it to beat in its regular rhythm. The sinoatrial or SA node, a small area of tissue in the wall of the right atrium, sends out an electrical signal to start the contracting of the heart muscle. This node is called the pacemaker of the heart because it sets the rate of the heartbeat and causes the rest of the heart to contract in its rhythm.

These electrical impulses cause the atria to contract first, and then travel down to the atrioventricular or AV node, which acts as a kind of relay station. From here the electrical signal travels through the right and left ventricles, causing them to contract and forcing blood out into the major arteries.

In the systemic circulation, blood travels out of the left ventricle, to the aorta, to every organ and tissue in the body, and then back to the right atrium. The arteries, capillaries, and veins of the systemic circulatory system are the channels through which this long journey takes place. Once in the arteries, blood flows to smaller arterioles and then to capillaries. While in the capillaries, thebloodstream delivers oxygen and nutrients to the body's cells and picks up waste materials. Blood then goes back through the capillaries into venules, and then to larger veins until it reaches the vena cavae.

Blood from the head and arms returns to the heart through the superior vena cava, and blood from the lower parts of the body returns through the inferior vena cava. Both vena cavae deliver this oxygendepleted blood into the right atrium. From here the blood exits to fill the right ventricle, ready to be pumped into the pulmonary circulation for more oxygen.

In the pulmonary circulation, blood low in oxygen but high in carbon dioxide is pumped out the right ventricle into the pulmonary artery, which branches off in two directions. The right branch goes to the right lung, and vice versa.

In the lungs, the branches divide further into capillaries. Blood flows more slowly through these tiny vessels, allowing time for gases to be exchanged between the capillary walls and the millions of alveoli, the tiny air sacs in the lungs.

During the process called oxygenation, oxygen is taken up by the bloodstream. Oxygen locks onto a molecule called hemoglobin in the red blood cells. The newly oxygenated blood leaves the lungs through the pulmonary veins and heads back to the heart. It enters the heart in the left atrium, then fills the left ventricle so it can be pumped into the systemic circulation.

Central nervous system

The nervous system is made up of all the nerve cells in your body. It is through the nervous system that we communicate with the outside world and, at the same time, many mechanisms inside our body are controlled. The nervous system takes in information through our senses, processes the information and triggers reactions, such as making your muscles move or causing you to feel pain. For example, if you touch a hot plate, you reflexively pull back your hand and your nerves simultaneously send pain signals to your brain. Metabolic processes are also controlled by the nervous system.

There are many billions of nerve cells, also called neurons, in the nervous system. The brain alone has about 100 billion neurons in it. Each neuron has a cell body and various extensions. The shorter extensions (called dendrites) act like antennae: they receive signals from, for example, other neurons and pass them on to the cell body. The signals are then passed on via a long extension (the axon), which can be up to a meter long.

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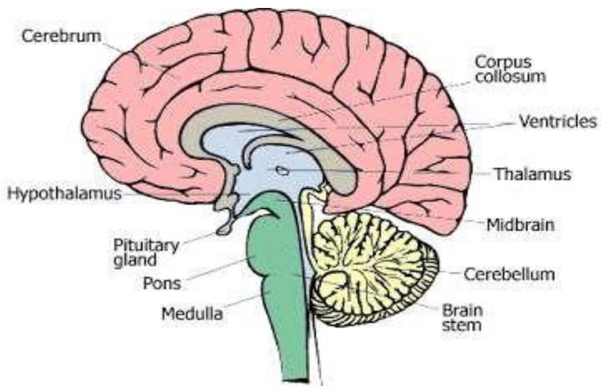
The nervous system has two parts, called the central nervous system and the peripheral nervous system due to their location in the body. The central nervous system (CNS) includes the nerves in the brain and spinal cord. It is safely contained within the skull and vertebral canal of the spine. All of the other nerves in the body are part of the peripheral nervous system (PNS).

Regardless of where they are in the body, a distinction can also be made between voluntary and involuntary nervous system. The voluntary nervous system (somatic nervous system) controls all the things that we are aware of and can consciously influence, such as moving our arms, legs and other parts of the body.

The involuntary nervous system (vegetative or autonomic nervous system) regulates the processes in the body that we cannot consciously influence. It is constantly active, regulating things such as breathing, heart beat and metabolic processes. It does this by receiving signals from the brain and passing them on to the body. It can also send signals in the other direction – from the body to the brain – providing your brain with information about how full your bladder is or how quickly your heart is beating, for example. The involuntary nervous system can react quickly to changes, altering processes in the body to adapt. For instance, if your body gets too hot, your involuntary nervous system increases the blood circulation to your skin and makes you sweat more to cool your body down again.



Human brain

The brain is one of the largest and most complex organs in the human body.

It is made up of more than 100 billion nerves that communicate in trillions of connections called synapses.

The brain is made up of many specialized areas that work together:

• The cortex is the outermost layer of brain cells. Thinking and voluntary movements begin in the cortex.

• The brain stem is between the spinal cord and the rest of the brain. Basic functions like breathing and sleep are controlled here.

• The basal ganglia are a cluster of structures in the center of the brain. The basal ganglia coordinate messages between multiple other brain areas.

• The cerebellum is at the base and the back of the brain. The cerebellum is responsible for coordination and balance.

The brain is also divided into several lobes:

• The frontal lobes are responsible for problem solving and judgment and motor function.

• The parietal lobes manage sensation, handwriting, and body position.

• The temporal lobes are involved with memory and hearing.

• The occipital lobes contain the brain's visual processing system.

The brain is surrounded by a layer of tissue called the meninges. The skull (cranium) helps protect the brain from injury.

Respiratory System

The respiratory system consists of all the organs involved in breathing. These include the nose, pharynx, larynx, trachea, bronchi and lungs. The respiratory system does two very important things: it brings oxygen into our bodies, which we need for our cells to live and function properly; and it helps us get rid of carbon dioxide, which is a waste product of cellular function. The nose, pharynx, larynx, trachea and bronchi all work like a system of pipes through which the air is funneled down into our lungs. There, in very small air sacs called alveoli, oxygen is brought into the bloodstream and carbon dioxide is pushed from the blood out into the air. When something goes wrong with part of the respiratory system, such as an infection like pneumonia, it makes it harder for us to get the oxygen we need and to get rid of the waste product carbon dioxide. Common respiratory symptoms include breathlessness, cough, and chestpain When a muscle contracts, usually just one bone moves. The other is stationary. The origin is where the muscle joins the stationary bone. The insertion is where it joins the moving bone. When a muscle contracts, the insertion moves towards the origin.

TENDONS

Tendons are the cords and straps that connect muscles to bones. At the bone, the fibers of the tendon are embedded in the periosteum of the bone. This anchors the tendon strongly and spreads the force of the contraction, so the tendon won’t tear away easily.
MUSCLE WORKING IN PAIRS

Muscles usually work in pairs or groups, e.g. the biceps flex the elbow and the triceps extends it.

This is called antagonistic muscle action. The working muscle is called the prime mover or agonist. (it’s in agony!) The relaxing muscle is the antagonist. The other main pair of muscle that work together are the quadriceps and hamstrings.

The prime mover is helped by other muscles called synergists. These contract at the same time as the prime mover. They hold the body in position so that the prime mover can work smoothly.

When muscles cause a limb to move through the joint's range of motion, they usually act in the following cooperating groups:

agonists

These muscles cause the movement to occur. They create the normal range of movement in a joint by contracting. Agonists are also referred to as prime movers since they are the muscles that are primarily responsible for generating the movement.

antagonists

These muscles act in opposition to the movement generated by the agonists and are responsible for returning a limb to its initial position.

synergists

These muscles perform, or assist in performing, the same set of joint motion as the agonists. Synergists are sometimes referred to as neutralizers because they help cancel out, or neutralize, extra motion from the agonists to make sure that the force generated works within the desired plane of motion.

fixators

These muscles provide the necessary support to assist in holding the rest of the body in place while the movement occurs. Fixators are also sometimes called stabilizers.

TYPES OF CONTRACTION

The contraction of a muscle does not necessarily imply that the muscle shortens; it only means that tension has been generated. Muscles can contract in the following ways:

isometric contraction

This is a contraction in which no movement takes place, because the load on the muscle exceeds the tension generated by the contracting muscle. This occurs when a muscle attempts to push or pull an immovable object.

isotonic contraction

This is a contraction in which movement does take place, because the tension generated by the contracting muscle exceeds the load on the muscle. This occurs when you use your muscles to successfully push or pull an object.

Isotonic contractions are further divided into two types:

concentric contraction

This is a contraction in which the muscle decreases in length (shortens) against an opposing load, such as lifting a weight up.

eccentric contraction

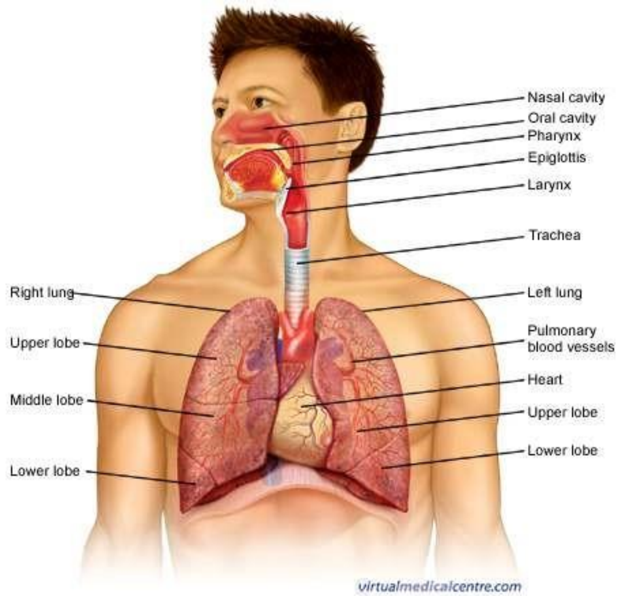
This is a contraction in which the muscle increases in length (lengthens) as it resists a load, such as lowering a weight down in a slow, controlled fashion.

During a concentric contraction, the muscles that are shortening serve as the agonists and hence do all of the work. During an eccentric contraction the muscles that are lengthening serve as the agonists (and do all of the work).

The Upper Airway and Trachea

When you breathe in, air enters your body through your nose or mouth. From there, it travels down your throat through the larynx (or voice box) and into the trachea (or windpipe) before entering your lungs. All these structures act to funnel fresh air down from the outside world into your body. The upper airway is important because it must always stay open for you to be able to breathe. It also helps to moisten and warm the air before it reaches your lungs.

The lungs are paired, cone-shaped organs which take up most of the space in our chests, along with the heart. Their role is to take oxygen into the body, which we need for our cells to live and function



properly, and to help us get rid of carbon dioxide, which is a waste product. We each have two lungs, a left lung and a right lung. These are divided up into 'lobes', or big sections of tissue separated by 'fissures' or dividers. The right lung has three lobes, but the left lung has only two, because the heart takes up some of the space in the left side of our chest. The lungs can also be divided up into even smaller portions, called 'bronchopulmonary segments'.

These are pyramidal-shaped areas which are also separated from each other by membranes. There are about 10 of them in each lung. Each segment receives its own blood supply and air supply.

How they work

Air enters your lungs through a system of pipes called the bronchi. These pipes start from the bottom of the trachea as the left and right bronchi and branch many times throughout the lungs, until they eventually form little thin-walled air sacs or bubbles, known as the alveoli. The alveoli are where the important work of gas exchange takes place between the air and your blood. Covering each alveolus is a whole network of little blood vessel called capillaries, which are very small branches of the pulmonary arteries. It is important that the air in the alveoli and the blood in the capillaries are very close together, so that oxygen and carbon dioxide can move (or diffuse) between them. So, when you breathe in, air comes down the trachea and through the bronchi into the alveoli. This fresh air has lots of oxygen in it, and some of this oxygen will travel across the walls of the alveoli into your bloodstream. Travelling in theopposite direction is carbon dioxide, which crosses from the blood in the capillaries into the air in the alveoli and is then breathed out. In this way, you bring in to your body the oxygen that you need to live, and get rid of the waste product carbon dioxide.

Blood Supply

The lungs are very vascular organs, meaning they receive a very large blood supply. This is because the pulmonary arteries, which supply the lungs, come directly from the right side of your heart. They carry blood which is low in oxygen and high in carbon dioxide into your lungs so that the carbon dioxide can be blown off, and more oxygen can be absorbed into the bloodstream. The newly oxygen-rich blood then travels back through the paired pulmonary veins into the left side of your heart. From there, it is pumped all around your body to supply oxygen to cells and organs.

The Work of Breathing

The Pleurae

The lungs are covered by smooth membranes that we call pleurae. The pleurae have two layers, a 'visceral' layer which sticks closely to the outside surface of your lungs, and a 'parietal' layer which lines the inside of your chest wall (ribcage). The pleurae are important because they help you breathe in and out smoothly, without any friction. They also make sure that when your ribcage expands on breathing in, your lungs expand as well to fill the extra space.

The Diaphragm and Intercostal Muscles

When you breathe in (inspiration), your muscles need to work to fill your lungs with air. The diaphragm, a large, sheet-like muscle which stretches across your chest under the ribcage, does much of this work. At rest, it is shaped like a dome curving up into your chest. When you breathe in, the diaphragm contracts and flattens out, expanding the space in your chest and drawing air into your lungs. Other muscles, including the muscles between your ribs (the intercostal muscles) also help by moving your ribcage in and out. Breathing out (expiration) does not normally require your muscles to work. This is because your lungs are very elastic, and when your muscles relax at the end of inspiration your lungs simply recoil back into their resting position, pushing the air out as they go.

CHAPTER.-3 (BMI)

Biomedical Signals and Electrodes

Biosignals

A bio signal is any signal in living beings that can be continually measured and monitored. The term bio signal is often used to refer to bioelectrical signals, but it may refer to both electrical and non-electrical signals. The usual understanding is to refer only to time-varying signals, although spatial parameter variations (e.g. the nucleotide sequence determining the genetic code) are sometimes subsumed as well.

Electrical biosignals, or bioelectrical time signals, usually refers to the change in electric current produced by the sum of an electrical potential difference across a specialized tissue, organ or cell system like the nervous system. Thus, among the best-known bioelectrical signals are:

- Electroencephalogram (EEG)
- Electrocardiogram (ECG)
- Electromyogram (EMG)
- Mechanomyogram (MMG)
- Electrooculography (EOG)
- Galvanic skin response (GSR)
- Magneto encephalogram (MEG)

EEG, ECG, EOG and EMG are measured with a differential amplifier which registers the difference between two electrodes attached to the skin. However, the galvanic skin response measures electrical resistance and the MEG measures the magnetic field induced by electrical currents (electroencephalogram) of the brain.
With the development of methods for remote measurement of electric fields using new sensor technology, electric biosignals such as EEG and ECG can be measured without electric contact with the skin. This can be applied for example for remote monitoring of brain waves and heartbeat of patients who must not be touched, in particular patients with serious burns.

Electrical currents and changes in electrical resistances across tissues can also be measured from plants.

Biosignals may also refer to any non-electrical signal that is capable of being monitored from biological beings, such as mechanical signals (e.g. the mechanomyogram or MMG), acoustic signals (e.g. phonetic and non-phonetic utterances, breathing), chemical signals (e.g. pH, oxygenation) and optical signals (e.g. movements).

Bio electrodes

Bio electrodes function as an interface between biological structures and electronic systems. Electrical activity within the biological structure is either sensed or stimulated. The electrical systems are either passively sensing (measuring) or actively stimulating (inducing) electrical potentials within the biological structure or unit.

Electrical currents are generated by many biological structures. Currents give rise to potential differences that can be measured using electrodes and can be interpreted to gain insight in the functioning of the source structure. Conversely, current can be applied to the biological structure through electrodes to affect the target.

The same electrode may function either passively or actively, depending on the purpose and the electronic system controls. An example seen on TV is the large defibrillation paddles used by paramedics to resuscitate people in cardiac distress. When the paddles are applied to a patient, the electrical system is programmed to first passively sense the electrical activity (or lack of) within the heart. Then the electrical system uses algorithms to determine if a stimulation (shock) is required, and finally to provide the appropriate electrical stimulation.

The size of bio electrodes ranges from microscopic intra-cellular research electrodes to large (3 x 5-inch) defibrillation paddles.

Most bio electrodes are made of metal, but the microscopic intra-cellular research electrodes are glass capillary tubes filled with a conductive saline solution.

Contact impedance

Electrical Impedance Tomography (EIT) applies current and measures the resulting voltage on the surface of a target. In biomedical applications, this current is applied, and voltage is measured, through electrodes attached to the body. Models are used to represent these electrode connections in the reconstruction of the conductivity image, tying circuit models to Finite Element Method (FEM) simulations. Changes in the contact impedance or boundary shape relative to the electrode's surface area can introduce artifacts in the reconstructed image. The quantity and quality of these artifacts is dependent upon the electrode model and the properties assigned to that model. The electrode models were originally formulated in the context of mathematical proofs of solution existence and uniqueness for EIT (Calder´on 2006, Nachman 1996). The Complete Electrode Model (CEM) allows a complex impedance for each electrode that models the metal electrode, conductive gel and chemical interaction at the skin electrode interface (Cheng et al. 1989, Somersalo et al. 1992). The FEM is used in the numerical solution of EIT images. The simplest electrode model to implement in the FEM is the Point Electrode Model (PEM) which applies current and measures voltage at single nodes on the boundary and requires no further equations to implement. The PEM does not consider the geometry or contact impedance of an electrode. To reconstruct accurate images from in vivo data, an accurate electrode model is frequently required, and thus, the CEM is generally preferred (Cheng et al. 1989). (Figure 1)

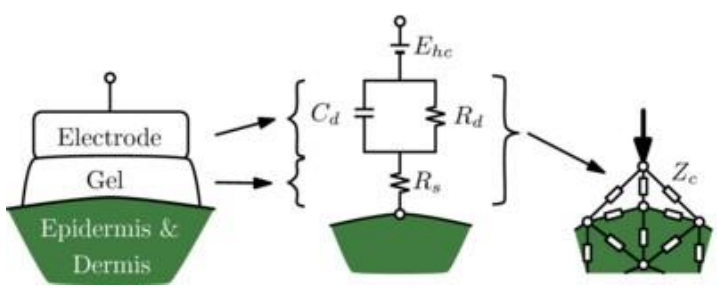


Figure 1 Generalized electrode model

Electrodes in Biomedical Instrumentation

Electrodes are devices that convert ionic potentials into electronic potentials. The type of electrode used for the measurements depends on the anatomical location of the bioelectric event to be measured. In order to process the signal in electronic circuits, it will be better to convert ionic conduction into electronic conduction. So simply bio-electrodes are a class of sensors that transduces ionic conduction into electronic conduction. The purpose of bio-electrodes is to acquire bioelectrical signals such as ECG, EMG, EEG etc.

Electrodes are mainly classified into two. They are perfectly polarized electrodes and perfectly non-polarized electrodes. There are a wide variety of electrodes which can be used to measure bioelectric events. The three main classes of electrodes are Microelectrodes, Body Surface electrodes and Needle electrodes.

A. **Microelectrodes** are electrodes with tips having tips sufficiently small enough to penetrate a single cell in order to obtain readings from within the cell. The tips must be small enough to permit penetration without damaging the minute cell. The main functions of microelectrodes are potential recording and current injection. Microelectrodes are having high impedances in mega ohm range because of their smaller size. Microelectrodes are generally of two types. With the use of a microelectrode or an array of microelectrodes, researchers can gather all sort of information regarding living organism.

- Metal type
- Micropipette type

a. **Metal microelectrode:** Metal microelectrodes are formed by electrolytic ally etching the tip of fine tungsten to the desired size and dimension. Then the wire is coated almost to the tip with any type of insulating material. The metal-ion interface takes place where the metal tip contacts the electrolyte. The main features of metal microelectrodes are

1. Very good S/N ratio
2. Strong enough to penetrate
3. High biocompatibility

b. **Micropipette**: The micropipette type of microelectrode is a glass micropipette with its tip drawn out to the desired size. The micropipette is filled with an electrolyte which should be compatible with the cellular fluids. A micropipette is a small and extremely fine pointed pipette used in making microinjections. A commercial type of micropipette is shown in figure below.

B. Body Surface Electrodes:

Surface electrodes are those which are placed in contact with the skin of the subject in order to obtain bioelectric potentials from the surface. Body surface electrodes are of many sizes and types. In spite of the type, any surface electrode can be used to sense ECG, EEG, EMG etc. The various types of body surface electrodes are discussed below. Major body surface electrodes are

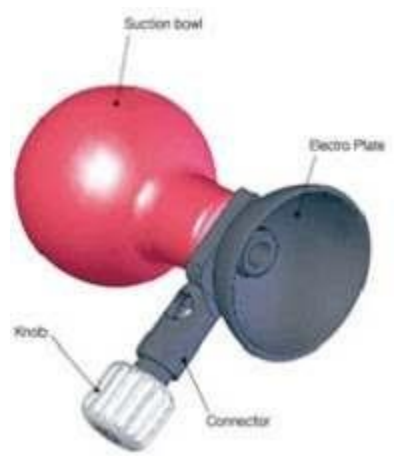
1. **Immersion electrodes:** They are one of the first type of bioelectric measuring electrodes. Immersion electrodes were simply buckets of saline solution in which the subject placed his hands and feet. So it was not a comfortable type of measurement and hence it was replaced with plate electrodes.
2. **Plate electrodes**: These electrodes were separated from subject's skin by cotton pads socked

in a strong saline solution. The plate electrodes have generally smaller contact area and they do not totally seal on the patient. The electrode slippage and displacement of plates were the major difficulties faced by these type of electrodes because they have a tendency to lose theiradhesive ability as a result of contact with fluids on or near the patient. Since these types of electrodes were very sensitive, it led to measurement errors.

3. **Floating electrodes**: These types of electrodes can eliminate the movement errors (called artifacts) which is a main problem with plate electrodes. This is done by avoiding any direct contact of the metal with the skin. So the main advantage of floating electrodes is mechanical reliability. Here the conductive path between the metal and the skin is the electrolyte paste or jelly.

4. **Disposable electrodes**: Normally plate electrodes, floating electrodes etc. can be used more than one time. This requires the cleaning and cares after each use. We can use disposable electrodes which can be used only once and be disposed after the use. These types of electrodes are now widely used.

5. **Suction electrodes**: These type of electrodes are well suited for the attachment to flat surfaces of body and to regions where the underlying tissue is soft, due to the presence of contact surface. An advantage of these type of electrodes is that it has a small surface area. These types of electrodes are mainly used for the measurement of ECG. Suction electrodes used a plastic syringe barrel to house suction tubing and input cables to an AC amplifier.



6. **Ear clip & Scalp electrodes**: These type of electrodes is widely used in the measurement of EEG exclusively. Scalp electrodes can provide EEG easily by placing it over bare head. A typical ear clip electrode is shown in figure below. The most common method for EEG measurementis 10 – 20 electrode placement system and here we use scalp electrode usually. They can avoid measurement errors and movement errors. During labour internal

monitoring may be needed and is usually in the form of an electrode placed under the baby's scalp. It is called fetal scalp electrode which is used to monitor baby's heartbeat while still in uterus.

C. **Needle Electrodes**:

To reduce the interface and noise (artifact) caused due to electrode movement, during the measurement of EEG, EMG etc. we can use small sub-dermal needle electrodes which penetrate the scalp. Actually the needle electrodes are not inserted into the brain. They nearly penetrate the skin. Generally they are simply inserted through a small section of the skin just beneath the skin parallel to it.

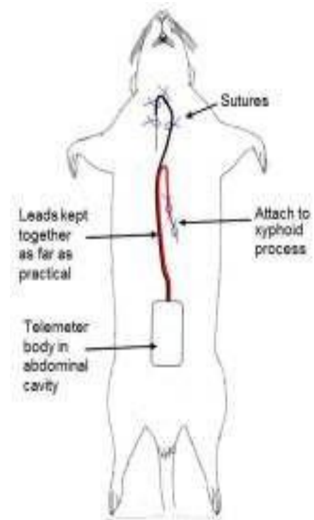
The needle electrodes for EMG measurement consist of fine insulated wires placed in such a way that their tips are in contact with the muscle, nerve or other tissues from which the measurement is made. The needle creates the hole necessary for insertion and the wires forming the electrodes are carried inside it. A typical EEG needle electrode is shown in figure.

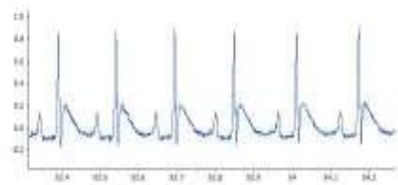
One of the main advantage of needle electrodes is that they are less susceptible to movement errors than surface electrodes. Also the needle electrodes have lower impedances when compared to surface electrodes as it makes direct contact with the sub-dermal tissues or

Electrocardiography – ECG or EKG

ECG records the net change in electrical activity across the heart with each heartbeat over time. Under normal conditions, the mechanical activity is temporally linked with the electrical activity. Changes in the electrical potential from the depolarization of the myocardium result in muscular contraction in the region of depolarization while repolarization results in the relaxation. The wave of depolarization in each heart beat originates from the sinoatrial node, travels through the atria to the atrial-ventricular node, then travels down the ventricular septum and up walls of the ventricles.

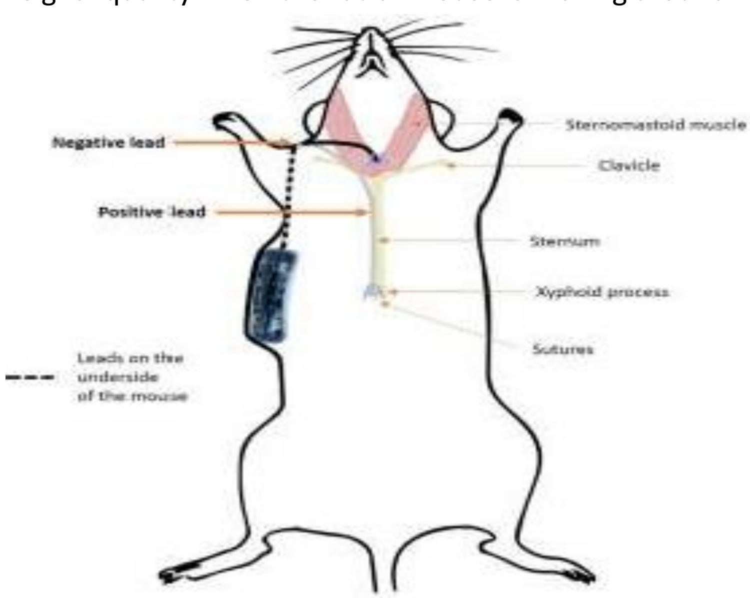
The P, QRS and T waves recorded in an ECG represent the change in electrical potential during the depolarization of the atria, the depolarization of the ventricles (and the simultaneous repolarization of the atria), and the repolarization of the ventricles respectively.

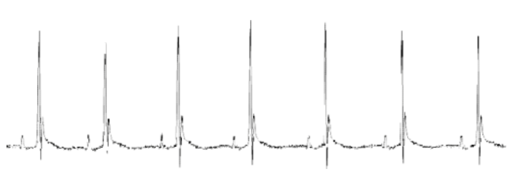




Example placement of electrode leads for recording of high quality ECG in the modified lead II configuration (left) and signal recorded (above).

Clinically, ECG is recorded using 12 lead positions to generate information about how the electrical activity propagates in 3 dimensions. In rats and mice, telemetry ECG is often recorded using two electrodes recording a single lead configuration. Depending on the position of the electrodes and lead configuration, different ECG profiles are seen. The modified lead II position of an ECG in a rat is shown in the figure below. The lead wire positions have been adjusted slightly from the standard lead II position, which is most in line with the ventricles, to improve signal quality when the rat or mouse is moving around.





100ms

Adjusting the position of the electrodes to record from different ECG lead configurations changes the relative size of the P, QRS and T waves, which allows detailed focus on one event. Good muscle contact will be required for large clean telemetry ECG signals as electrical conductance through connective tissue is poor. It is also

important to keep the lead wires together as far as practical and avoid curling the leads into a loop to minimize interference from ambient electrical noise.

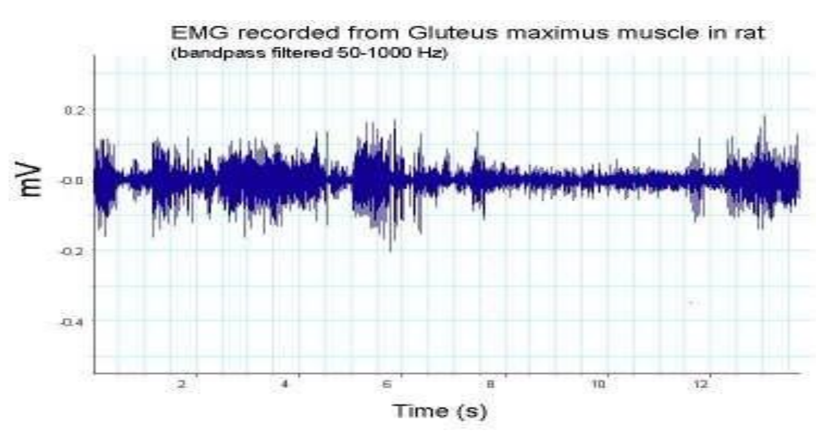
The most common use for ECG is the measurement of heart rate, which can be calculated by the number of R waves in a given period of time. In addition to the detection of the heart rate, the ECG can be used to record:

- heart rate variability (R-R intervals)
- duration of depolarization of the atria (P wave duration) or ventricles (QRS duration)
- arrhythmias and counts of P, QRS, T waves
- electrical conductance across the heart and waveform abnormalities
- relative amplitudes of the waveforms can also be calculated
- These measurements can be useful in basic cardiovascular physiology, behavioural or pharmacological/toxicology studies.

Electromyography - EMG

EMG records the electrical potential and the change in potential (electrical activity) across the skeletal muscle. The electrical potential changes during contraction and relaxation of the skeletal muscle as the muscle depolarizes and then repolarizes. EMG can be used to assess the muscle contraction, mechanics or inferring movement rates across the muscle. For example, attaching the lead wires to the diaphragm allows for the measurement of respiration rate, while attachment of the lead wires to the gluteus Maximus muscle can be used to assess walking or movement. Other potential applications include measurement of gastrointestinal peristaltic movements and movement of specific muscles such as nuchal EMG.

Below is an example of the EMG signal recorded from the gluteus Maximus muscle in a walking rat.



EMG can be recorded from a muscle or muscle groups, provided that the size of the muscle is large enough for the attachment of the two electrodes with a gap to prevent contact between the electrodes. It is important that the electrodes do not contact as this results in electrical shortening, and a signal will not be detected. It is also important that the electrodes are tied securely to the muscle that is being recorded from to minimize movement artifacts.

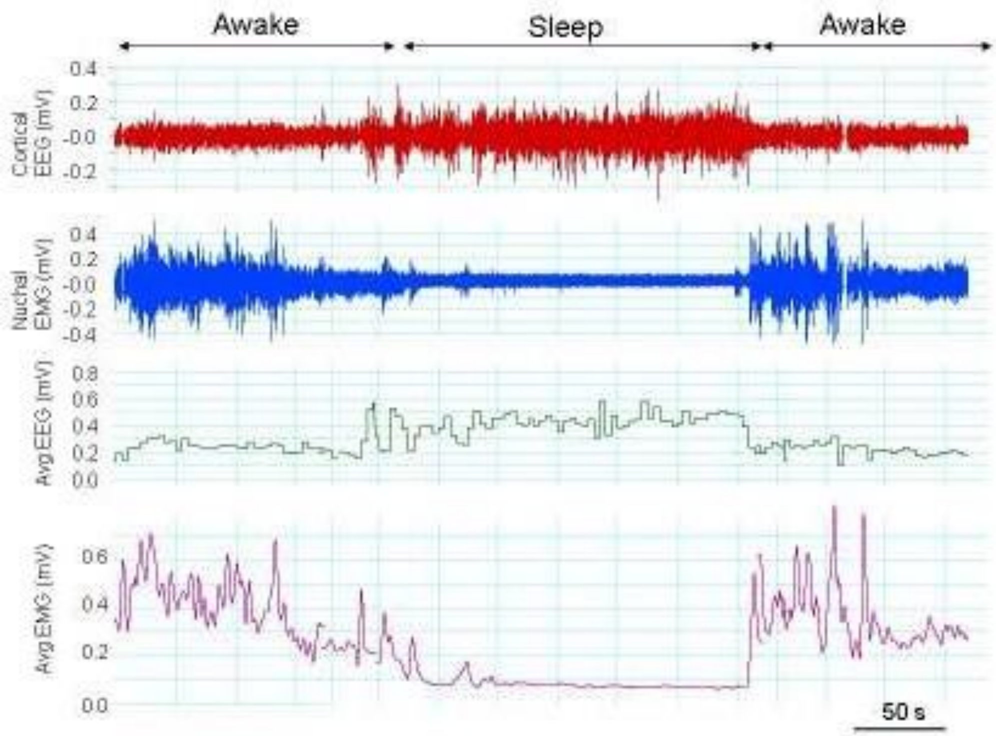
Telemetry is advantageous over tethered systems for measuring EMG as the rats and mice are allowed to move freely in their home cage eliminating behavioural adaptations to tethering. The battery of the rat telemeters also allows recording of EMG away from the home cage and tethers, opening up opportunities such as EMG recordings during behavioural tests. Rat bio potential telemeters provide up to 4 hours of continuous data transmission powered by a rechargeable battery when the rat telemeter is not actively being powered by the Smart Pad.

Electroencephalography - EEG

EEG records the electrical activity over an area of brain tissue. Electrical activity in the brain is generated by depolarization of neurons. As the electrical activity provided by a single neuron is too small to be detected, recorded telemetry EEG represents the summation of electrical activity from a large number of neurons in an area.

Electrodes can be placed on the surface of the brain for cortical surface EEG, or deeper into the tissue to measure from a particular area of interest. EEG can be applied to the study of neurological disorders, such as seizure detection or epilepsy studies and pharmacological studies into neurostimulating drugs. EEG can also be used in behavioural research to study brain activity patterns in response to stimuli or in studies of sleep-wake cycles. Both the Rat and mouse use Telemetry Systems allow recording of EEG from animals living in their home cages freefrom the stress and restriction of using tethers.

Below is an example of EEG recorded in a rat using the TR50BB telemeter with simultaneous nuchal EMG recordings in a study of the sleep-wake cycle.



In addition to EMG, it is possible to record EEG in conjunction with brain oxygen (TR50B + TR57Y) or intracranial pressure (TRM54PB) using the Rat Telemetry System.

CHAPTER.-4 (BMI)
Diagnostic Instruments

Muscle Action

HOW MUSCLES WORK

A voluntary muscle usually works across a joint. It is attached to both the bones by strong cords called tendons.

When the muscles contracts, usually just one bone moves.

For example, when the biceps in the arm contracts, the radius moves but the scapula does not.

ORIGIN AND INSERTION

When a muscle contracts, usually just one bone moves. The other is stationary. The origin is where the muscle joins the stationary bone. The insertion is where it joins the moving bone. When a muscle contracts, the insertion moves towards the origin.

TENDONS

Tendons are the cords and straps that connect muscles to bones. At the bone, the fibers of the tendon are embedded in the periosteum of the bone. This anchors the tendon strongly and spreads the force of the contraction, so the tendon won't tear away easily.

MUSCLE WORKING IN PAIRS

Muscles usually work in pairs or groups, e.g. the biceps flex the elbow and the triceps extends it.

This is called antagonistic muscle action. The working muscle is called the prime mover or agonist. (it's in agony!) The relaxing muscle is the antagonist. The other main pair of muscle that work together are the quadriceps and hamstrings.

The prime mover is helped by other muscles called synergists. These contract at the same time as the prime mover. They hold the body in position so that the prime mover can work smoothly.

When muscles cause a limb to move through the joint's range of motion, they usually act in the following cooperating groups:

agonists

These muscles cause the movement to occur. They create the normal range of movement in a joint by contracting. Agonists are also referred to as prime movers since they are the muscles that are primarily responsible for generating the movement.

antagonists

These muscles act in opposition to the movement generated by the agonists and are responsible for returning a limb to its initial position.

synergists

These muscles perform, or assist in performing, the same set of joint motion as the agonists. Synergists are sometimes referred to as neutralizers because they help cancel out, or neutralize, extra motion from the agonists to make sure that the force generated works within the desired plane of motion.

fixators

These muscles provide the necessary support to assist in holding the rest of the body in place while the movement occurs. Fixators are also sometimes called stabilizers.

TYPES OF CONTRACTION

The contraction of a muscle does not necessarily imply that the muscle shortens; it only means that tension has been generated. Muscles can contract in the following ways:

isometric contraction

This is a contraction in which no movement takes place, because the load on the muscle exceeds the tension generated by the contracting muscle. This occurs when a muscle attempts to push or pull an immovable object.

isotonic contraction

This is a contraction in which movement does take place, because the tension generated by the contracting muscle exceeds the load on the muscle. This occurs when you use your muscles to successfully push or pull an object.

Isotonic contractions are further divided into two types:

concentric contraction

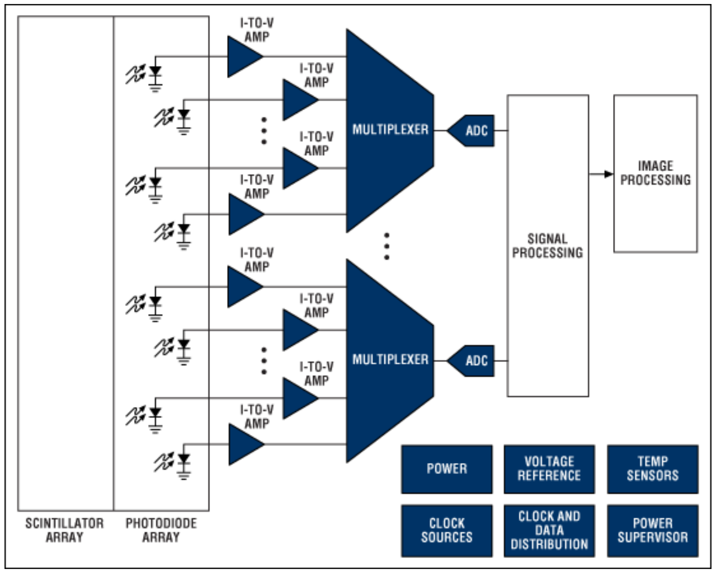
This is a contraction in which the muscle decreases in length (shortens) against an opposing load, such as lifting a weight up.

eccentric contraction

This is a contraction in which the muscle increases in length (lengthens) as it resists a load, such as lowering a weight down in a slow, controlled fashion.

During a concentric contraction, the muscles that are shortening serve as the agonists and hence do all of the work. During an eccentric contraction the muscles that are lengthening serve as the agonists (and do all of the work). Computed tomography (CT)

medical-imaging systems generate three-dimensional (3-D) images of internal body structures



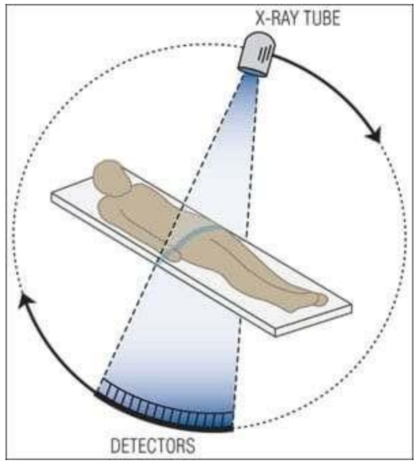
using complex x-ray and computer-aided tomographic imaging techniques.

The x-ray images used to generate the tomographic images are generated first by exposing the patient to a fan-shaped x-ray beam and then detecting the projected image on a thin semi-circular, digital x-ray detector. The patient is placed between the source and detector, and the detector is configured with its geometric centre located at the x-ray source. Each image is an x-ray projection of a very thin transverse slice of the body. To collect the multitude of x-ray projections necessary to generate a tomographic CT image, both the x-ray source and detector are rotated about a patient within a supporting gantry. While the source and detector rotate, images are collected and stored. As in a traditional x-ray, the signal levels in the image slice represent the relative radio density of the patient along a line from the x-ray source to the corresponding pixel location.

To improve image-capture times and resolution, manufacturers utilize multislice CT imaging techniques. Instead of a single 2D detector array which provides only a single image slice, multislice imaging uses a 3-D array. The added imaging dimension allows the system to generate multiple slices in parallel. Photodetector arrays used in CT imaging have as many as 1000 detectors in the long dimension along the semi-circular detector arch; 16 or more detectors are positioned in the shorter dimension tangential to the arch. The number of detectors in the short dimension determines the number of available image slices.

The patient is exposed to a fan-shaped x-ray beam and the projected image is detected on a thin, semi-circular digital x-ray detector.

Modern CT imaging systems can also generate images in any plane within the body by using a technique called spiral CT. In a spiral-CT system the patient is slowly moved into the centre of the gantry while the x-ray source and detector rotate about the patient. Very-high-speed computers are necessary to process the images collected in this manner. Sophisticated tomographic imaging techniques are used to produce the required image.



X-Ray Detection

Early CT imaging systems accomplished x-ray detection using both scintillation crystals and photo-multiplier tubes. The scintillation crystals converted x-rays to light and the photomultiplier tubes converted these light signals to a usable electrical signal. Modern CT systems now employ more sophisticated scintillation crystal materials and solid-state photodetector diodes for this purpose.

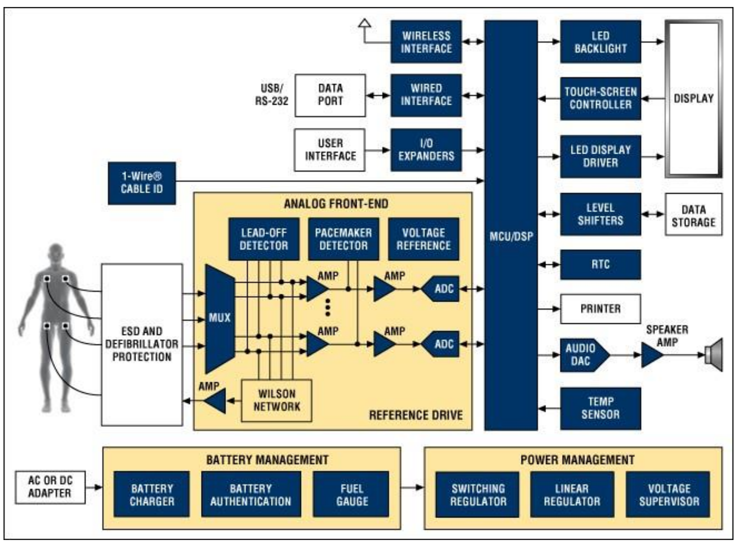
The output from each photodiode is a current proportional to the light striking the diode. These currents can be directly converted to a voltage by a low-noise trans impedance amplifier (TIA), or integrated over time using a capacitor or active integrator op-amp circuit to produce a voltage output. Integration of the current from each diode can be accomplished in multiple ways. Capacitance in the photodiode detector array itself can be used for this purpose. The signals from these capacitors are multiplexed using FET switches in the diode-array detector. The signals are then routed to the digital acquisition system (DAS) which amplifies and converts the signals to a digital format using high-resolution analog-to-digital converters (ADCs). An alternative method routes the signals from every photodiode to an integrator in the DAS. In these implementations, the integrated current signals are converted to a voltage, sampled at the same time, and multiplexed into the input of an ADC.

Tomographic Imaging

The resulting x-ray image data set is converted to an image by the image processor. The image processor is typically a very-high-speed computer which performs the massive calculations required for the tomographic image reconstruction. The resulting image will commonly have a very large dynamic range (i.e., 16-bit grayscale images). Further image processing is necessary to map this large dynamic range most effectively into the limited visible display range.

ECG

All ECGs pick up heart signals through electrodes connected externally to specific locations on the body. The heart signals are generated by the body and have amplitudes of a few millivolts. The specific locations of the electrodes allow the heart's electrical activity to be viewed from different angles, each of which is displayed as a channel on the ECG printout. Each channel represents the differential voltage between two of the electrodes, or the differential voltage between one electrode and the average voltage from several electrodes. The different combinations of electrodes allow more channels to be displayed than there are electrodes. The channels are commonly referred to as "leads," so a 12-lead ECG device has 12 separate channels displayed graphically. The number of leads varies from 1 to 12 depending on the application. Unfortunately, the wires running to the electrodes are occasionally referred to as leads as well. This can create confusion, as a 12-lead (12-channel) ECG device only requires 10 electrodes (10 wires), so be careful of the context in which "lead" is used. In addition to the biological signals, most ECGs also



signals comes from implanted pacemakers and is referred to simply as "pace." The pace signal is relatively short, tens of microseconds to a couple of milliseconds, with an amplitude ranging from a few millivolts to nearly a volt. Often, the ECG must detect the presence of a pace signal while simultaneously preventing it from distorting the signals from the heart.

The second manmade signal is for detecting "lead-off," which is when an electrode is making poor electrical contact. Many ECG devices must provide an alert when this poor contact occurs. Therefore, the ECG device generates a signal to measure the impedance between the electrode and the body for detecting a lead-off occurrence. The measurement may be AC, DC, or both. In some ECG devices, respiration rate is also detected by analysing the impedance from the lead-off measurement. Lead-off detection is continuous and should not interfere with accurate measurement of the heart signals.

Modern heart rate monitors usually comprise two elements: a chest strap transmitter [needs update] and a wrist receiver (which usually is a smartwatch). In early plastic straps, water or liquid was required to get good performance. Early units have used conductive smart fabric with built-in microprocessors that analyse the electrical activity to determine the heart rate similar to an EKG. More recent devices use optics to measure heart rate by which measures changes in blood flow by shining a light from an LED through the skin and measuring how it scatters off blood vessels.

Pulse rate monitor

Strapless heart rate monitors (often referred to as "wearables") now allow the user to just touch two sensors on a smartwatch display for a few seconds to view heart rate data. These are popular for comfort and ease of use, though they don't give as much detail as monitors that use a chest strap. Some models of these variations of heart rate monitors use either infrared light or red visible light to measure the heart rate, as opposed to two or more electrodes. In addition

to measuring the heart rate, devices using this technology are able to measure blood oxygen saturation (SpO2)

More advanced models offer measurements of heart rate variability, activity, and breathing rate to assess parameters relating to a subject's fitness. Sensor fusion algorithms allow these monitors to detect core temperature and dehydration.

Another style of heart rate monitor replaces the plastic around-the-chest strap with fabric sensors - the most common of these is a sports bra that includes sensors in the fabric.

In old versions, when a heartbeat is detected a radio signal is transmitted, which the receiver uses to determine the current heart rate. This signal can be a simple radio pulse or a unique coded signal from the chest strap (such as Bluetooth, ANT, or other low-power radio link); the latter prevents one user's receiver from using signals from other nearby transmitters (known as cross-talk interference).

Newer versions include a microprocessor, which simultaneously monitors heart rate, SpO2, and other parameters. These may include sensors such as accelerometers, gyroscopes, and GPS to detect speed, location and distance eliminating the need for ankle worn devices.

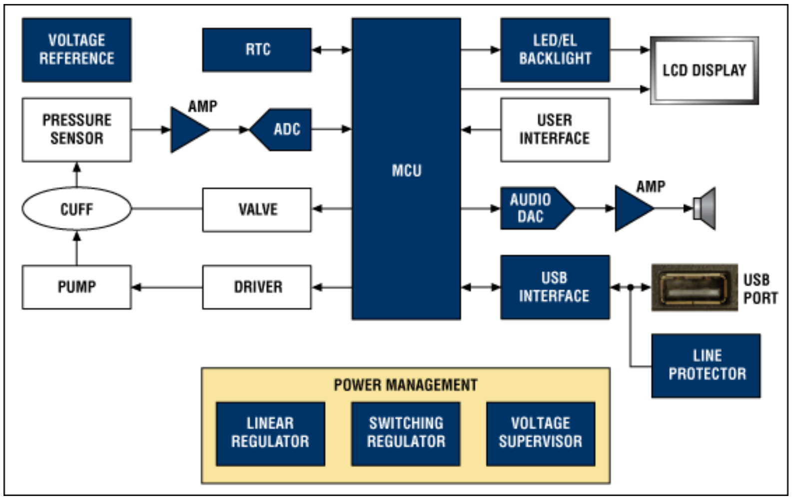
There are a wide number of receiver designs, with various features. These include average heart rate over exercise period, time in a specific heart rate zone, calories burned, breathing rate, built-in speed and distance, and detailed logging that can be downloaded to a computer. The receiver can be built into a smartwatch or smartphone. Bracelets with integrated sensors work optically, and have poor accuracy.

Blood pressure monitor

A blood pressure monitor, or sphygmomanometer, uses an inflatable air-bladder cuff and a listening device or pressure sensor to measure blood pressure in an artery. This monitoring can be performed by using either of two methods: a manually inflated cuff with a stethoscope for listening to arterial wall sounds (the auscultatory method), or a blood pressure monitor that contains a pressure sensor for sensing arterial wall vibrations (the oscillometric method).

Automatic Monitor Types

The two main types of automatic blood pressure monitors are upper-arm and wrist models. The upper-arm model has a cuff that is placed on the upper arm; the cuff is connected by a tube to the monitor that rests on a surface near the arm. The wrist model is smaller and the entire unit wraps around the wrist—this is a much more space-critical design. Some upper-arm models



require manual inflation of the cuff, but most upper-arm and all wrist models are fully automatic.

Measurement Techniques

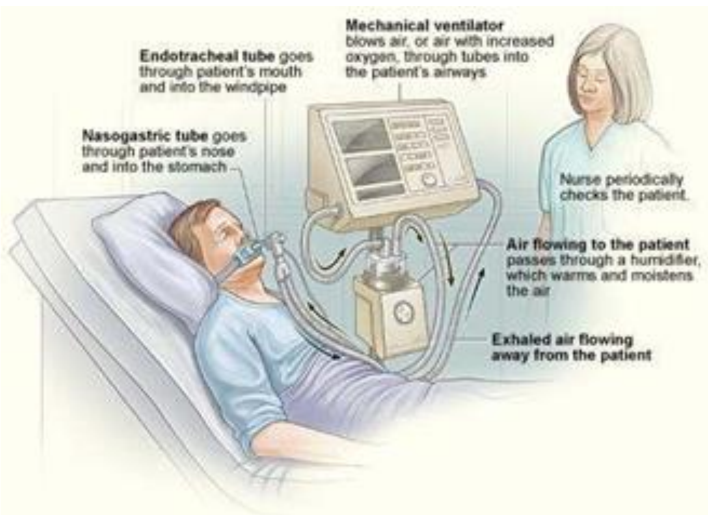
An automatic blood pressure monitor inflates a cuff surrounding an arm with sufficient pressure to prevent blood flow in the local main artery. This pressure is gradually released until the moment that the blood begins to flow through the artery, the measurement of which determines the systolic pressure. Pulse rate is also sensed at this time. The measurement taken when the blood flow is no longer restricted determines the diastolic pressure. This complete measurement cycle is performed automatically with a pump, cuff, valve, and pressure sensor.

The signal from the pressure sensor is conditioned with an op-amp circuit or by an instrumentation amplifier before data conversion by an analog-to-digital converter (ADC). The systolic pressure, diastolic pressure, and pulse rate are then calculated in the digital domain using a method appropriate for the type of monitor and sensor utilized. The resulting systolic, diastolic, and pulse-rate measurements are displayed on a liquid-crystal display (LCD), time/date-stamped, and stored in non-volatile memory.

Ventilator

A medical ventilator (or simply ventilator in context) is a mechanical ventilator, a machine designed to move breathable air into and out of the lungs, to provide breathing for a patient who is physically unable to breathe, or breathing insufficiently. While modern ventilators are computerized machines, patients can be ventilated with a simple, hand-operated bag valve mask. Ventilators are chiefly used in intensive care medicine, home care, and emergency medicine (as standalone units) and in anaesthesia (as a component of an anaesthesia machine).

Function: - In its simplest form, a modern positive pressure ventilator consists of a compressible air reservoir or turbine, air and oxygen supplies, a set of valves and tubes, and a disposable or reusable "patient circuit". The air reservoir is pneumatically compressed several times a minute to deliver room-air, or in most cases, an air/oxygen mixture to the patient. If a turbine is used, the turbine pushes air through the ventilator, with a flow valve adjusting pressure to meet patient-specific parameters. When over pressure is released, the patient will exhale passively due to the lungs' elasticity, the exhaled air being released usually through a one-way valve within the patient circuit called the patient manifold. Ventilators may also be equipped with monitoring and alarm systems for patient-related parameters (e.g. pressure, volume, and flow) and ventilator function (e.g. air leakage, power failure, mechanical failure), backup batteries, oxygen tanks, and remote control. The pneumatic system is nowadays often replaced by a computer-controlled turbo pump. Modern ventilators are electronically controlled by a small embedded system to allow exact adaptation of pressure and flow characteristics to an individual patient's needs. Fine-tuned ventilator settings also serve to make ventilation more tolerable and comfortable for the patient. In Canada and the United States, respiratory therapists are responsible for tuning these settings, while biomedical technologists are responsible for the maintenance. The patient circuit usually consists of a set of three durables, yet lightweight plastic tubes, separated by function (e.g. inhaled air, patient pressure, exhaled air). Determined by the type of ventilation needed, the patient-end of the circuit may be either non-invasive or invasive. Non-invasive methods, which are adequate for patients who require a ventilator only while sleeping and resting, mainly employ a nasal mask. Invasive methods require intubation, which for long-term ventilator dependence will normally be a tracheotomy



cannula, as this is much more comfortable and practical for long-term care than is larynx or nasal intubation.

Life-critical system: -Because failure may result in death, mechanical ventilation systems are classified as a life-critical system, and precautions must be taken to ensure that they are highly reliable, including their power-supply. Mechanical ventilators are therefore carefully designed so that no single point of failure can endanger the patient. They may have manual backup mechanisms to enable hand-driven respiration in the absence of power (such as the mechanical ventilator integrated into an anaesthetic machine). They may also have safety valves, which open to atmosphere in the absence of power to act as an anti-suffocation valve for spontaneous breathing of the patient. Some systems are also equipped with compressed-gas tanks, air compressors, and/or backup batteries to provide ventilation in case of power failure or defective gas supplies, and methods to operate or call for help if their mechanisms or software fail.

CHAPTER.-5 (BMI)

Bio-telemetry

Introduction

DEFINITION:

Biotelemetry is the measurement of biological parameters over distance.

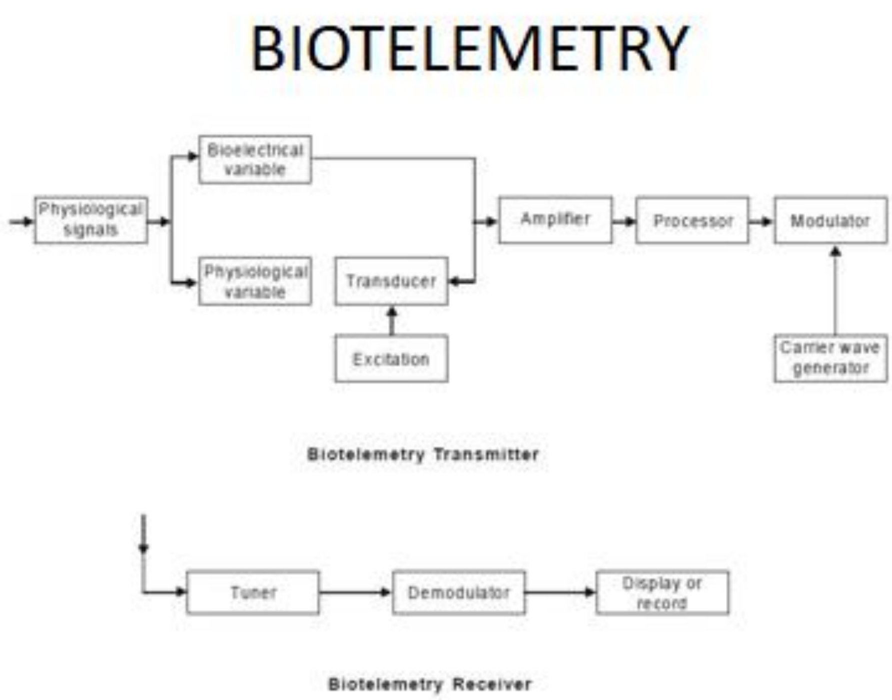
e.g. Heart Beats, Blood pressure, Blood Flow etc.

COMPONENTS:

A typical biotelemetry system comprises:

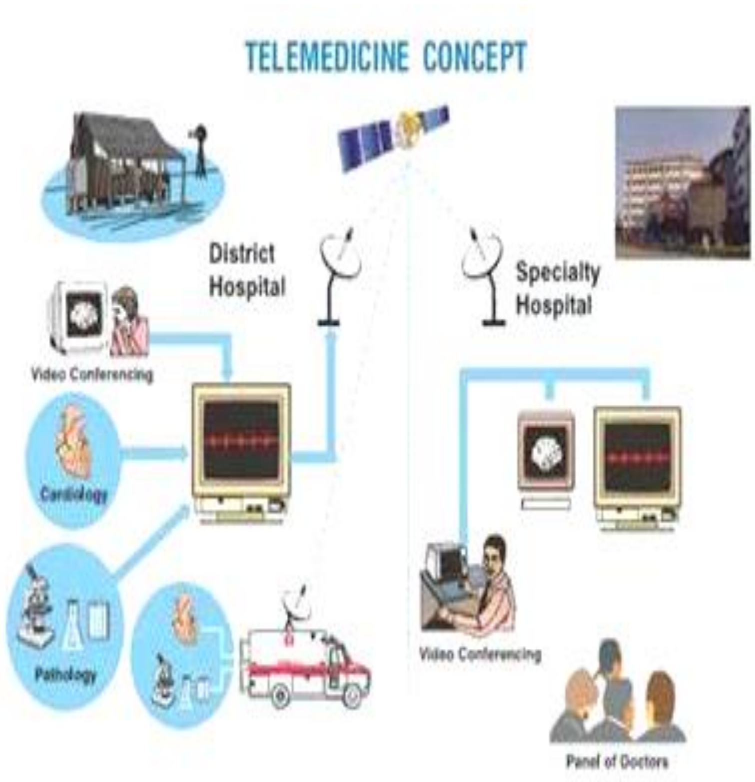
- Sensors appropriate for the particular signals to be monitored
- Battery-powered, Patient worn transmitters
- A Radio Antenna and Receiver
- A display unit capable of concurrently presenting information from multiple patient

Block Diagram of Bio-Telemetry Systems



Telemedicine

The term "telemedicine" describes providing remote health care when the patient and the clinician are not physically present.



Hearing Aids

A hearing aid is a device designed to improve hearing by making sound audible to a person with hearing loss. Hearing aids are classified as medical devices in most countries, and regulated by the respective regulations. Small audio amplifiers such as PSAPs or other plain sound reinforcing systems cannot be sold as "hearing aids".

Early devices, such as ear trumpets or ear horns, were passive amplification cones designed to gather sound energy and direct it into the ear canal. Modern devices are computerised electroacoustic systems that transform environmental sound to make it audible, according to audio metrical and cognitive rules. Modern devices also utilize sophisticated digital signal processing to try and improve speech intelligibility and comfort for the user. Such signal processing includes feedback management, wide dynamic range compression, directionality, frequency lowering, and noise reduction.

Modern hearing aids require configuration to match the hearing loss, physical features, and lifestyle of the wearer. This process is called "fitting" and is performed by audiologists. The amount of benefit a hearing aid delivers depends in large part on the quality of its fitting. Almost all hearing aids in use in the US are digital hearing aids. Devices similar to hearing aids include the Osseo integrated auditory prosthesis (formerly called the bone anchored hearing aid) and cochlear implant.

Hearing aids are used for a variety of pathologies including sensorineural hearing loss, conductive hearing loss, and single-sided deafness. Hearing aid candidacy is typically determined by an audiologist, who will also fit the device based on the nature and degree of the hearing loss being treated.

The amount of benefit experienced by the user of the hearing aid is multi-factorial, depending on the type, severity, and aetiology of the hearing loss, the technology and fitting of the device, and on the motivation, personality, lifestyle, and overall health of the user.

INTENSIVE CARE UNIT (ICU) – CHAP.-6 (BMI)

INTENSIVE CARE UNIT (ICU):

An intensive care unit (ICU), also known as an **intensive therapy unit** or **intensive treatment unit (ITU)** or **critical care unit (CCU),** is a special department of a hospital or health care facility that provides intensive treatment medicine.

Intensive care units cater to patients with severe or life-threatening illnesses and injuries, which require constant care, close supervision from life support equipment and medication in order to ensure normal bodily functions.They are staffed by highly trained physicians, nurses and respiratory therapists who specialize in caring for critically ill patients. ICUs are also distinguished from general hospital wards by a higher staff-to-patient ratio and access to advanced medical resources and equipment that is not routinely available elsewhere. Common conditions that are treated within ICUs include acute (or adult) respiratory distress syndrome, hypertension, metastases and other life-threatening conditions.

INTENSIVE CARE UNIT (ICU):

WHEN INTENSIVE CARE IS NEEDED:

Intensive care is needed if someone is seriously ill and requires intensive treatment and close monitoring, or if they're having surgery and intensive care can help them recover.

Most people in an ICU have problems with 1 or more organs. For example, they may be unable to breathe on their own.

There are many different conditions and situations that can mean someone needs intensive care.

Some common reasons include:

- a serious accident – such as a road accident, a severe head injury, a serious fall or severe burns
- a serious short-term condition – such as a heart attack or stroke
- a serious infection – such as sepsis or severe pneumonia
- major surgery – this can either be a planned part of your recovery, or an emergency measure if there are complications

ELEMENTS OF INTENSIVE CARE UNIT:

Patients on an ICU will be looked after closely by a team of ICU staff and will be connected to equipment by a number of tubes, wires and cables.

There will normally be 1 nurse for every 1 or 2 patients.

This equipment is used to monitor their health and support their bodily functions until they recover.

P.T.O.

ELEMENTS OF INTENSIVE CARE UNIT:

Equipment that may be used on an ICU includes:

- Ventilator – a machine that helps with breathing; a tube is placed in the mouth, nose or through a small cut in the throat (tracheostomy)
- Monitoring equipment – used to measure important bodily functions, such as heart rate, blood pressure and the level of oxygen in the blood
- IV lines and pumps – tubes inserted into a vein (intravenously) to provide fluids, nutrition and medication
- Feeding tubes – tubes placed in the nose, through a small cut made in the tummy or into a vein if a person is unable to eat normally
- Drains and catheters – drains are tubes used to remove any build-up of blood or fluid from the body; catheters are thin tubes inserted into the bladder to drain pee

ELEMENTS OF INTENSIVE CARE UNIT:

The use of diagnostic equipment is also required in the ICU. Mobile x-ray units are used for bedside radiography, particularly of the chest. Mobile x-ray units use a battery-operated generator that powers an x-ray tube. Handheld, portable clinical laboratory devices, or point-of-care

Analyzers, are used for blood analysis at the bedside. A small amount of whole blood is required, and blood chemistry parameters can be provided much faster than if samples were sent to the central laboratory.

COMPUTER APPLICATION IN BIOMEDICAL DEVICES – CHAP.-7 (BMI)

COMPUTER APPLICATION IN BIOMEDICAL DEVICES:

Computer techniques have tremendous applications in medical field, where it has the largest amount of social impact. Computers are playing an important role in the running of large hospitals.

Computer facilities are now regarded as integral to much diagnostic equipment. Major uses of computers in medicine include hospital information system, data analysis in medicine, medical imaging laboratory computing, computer assisted medical decision making, care of critically ill patients, computer assisted therapy and so on.

COMPUTER APPLICATION IN BIOMEDICAL DEVICES:

Hospital information system:

Medical informatics is a rapidly growing discipline. It seeks to organize and manage information in support of patient care, biomedical research and education through the aid of computer and information networks. A computerized hospital information system can establish consistent standards in the transmission and storage of data and continuously monitor all transactions. It provides easy access to valuable patient care information.The physicians can have direct access to all the information of his/her patient through the use of computer. A hospital information system generally covers areas like registration, admission/transfer/discharge, billing, medical record, index, wards, operation theater scheduling, stores/inventory, pharmacy, diet, CSSD, bio-medical maintenance, payroll, accounts, etc.

COMPUTER APPLICATION IN BIOMEDICAL DEVICES:

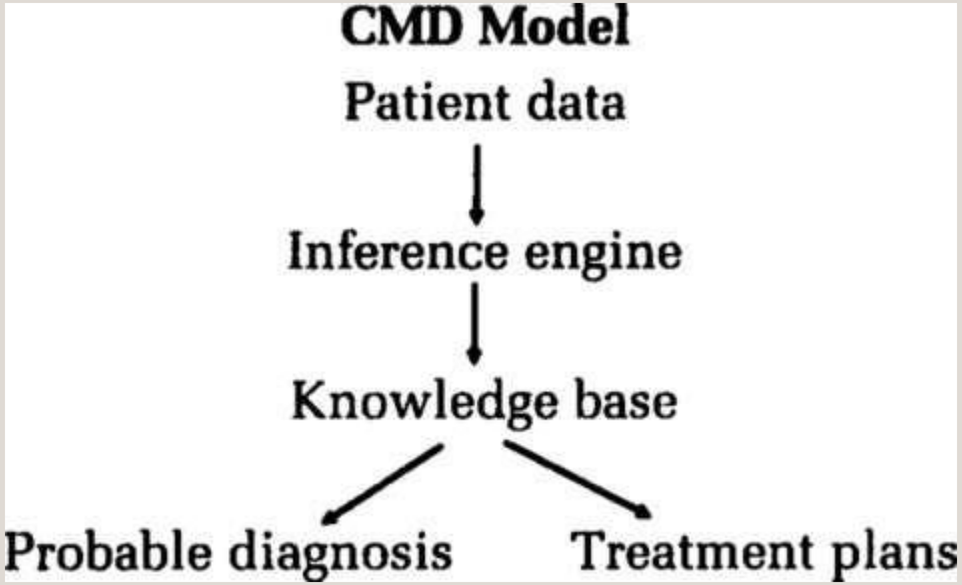
Laboratory Computing:

The primary objective of a clinical laboratory is to provide accurate results in short time. Laboratory analysis includes blood chemistry, photometry, microbiology, etc. Results must match with patient identification details and should be valid. Quick access to laboratory system can contribute to efficient patient care system.

COMPUTER APPLICATION IN BIOMEDICAL DEVICES:

Computer Assisted Decision making (CMD):

It is an interactive computer system that directly assists doctors with clinical decision making task.The system is intended to support doctors, complementing their natural abilities to make judgment with computer's vast memory, reliability and processing capabilities. A general model of computer assisted medical decision making has been developed.



COMPUTER APPLICATION IN BIOMEDICAL DEVICES:

Care of critically ill patients:

Critically ill patients require large number of therapeutic interventions to optimize their chances of survival. For this, the variables must be collected frequently and the data derived therefrom made available to the clinicians and nursing staff.This results in a large quantity of information, which may loose its significance unless the data recorded is presented in a clear manner. In the intensive care unit it is now possible to computerize the total management of data recorded on the patients. Data management includes the entry, integration and reporting of all vital signs, medications, intake and output volumes and laboratory values.

Closed loop system for the direct computer control of the infusions of vasodilator has been developed.An intraarterial canula connected to a suitable cardiovascular monitor provides the input signal to the computer.A pump which infuses the vasodilator drug to the patient is controlled by computer to maintain the arterial pressure within predetermined units.

COMPUTER APPLICATION IN BIOMEDICAL DEVICES:

Computer assisted therapy:

Methods for planning, monitoring and adjusting dosages regimens of powerful and potentially toxic drugs, e.g. digitalis and antibiotics like gentamicin have been developed. The physician can plan dosage regimens by selecting a target peak total body concentration of a drug.

COMPUTER APPLICATION IN BIOMEDICAL DEVICES:

Medical imaging:

During last decade computers were commonly used for high resolution image generation. Dedicated hardware and software is required to generate such images in CT scan, MRI, ultrasound, and gamma cameras. It is possible to integrate these workstations to the main hospital information system.Three dimensional images of living human anatomy, regional physiology and biochemistry in health and diseases are in use.

Other applications of computer:

In addition computers are being used in primary health care, psychiatry, physiological measurements, medical education.

COMPUTERIZED TOMOGRAPHY (CT):

A CAT scan is an x-ray procedure that combines many x-ray images with the aid of a computer to generate cross-sectional views and, if needed, three-dimensional images of the internal organs and structures of the body. A CAT scan is used to define normal and abnormal structures in the body and/or assist in procedures by helping to accurately guide the placement of instruments or treatments.

COMPUTERIZED TOMOGRAPHY (CT):

A computerized tomography scan (CT or CAT scan) uses computers and rotating X-ray machines to create cross-sectional images of the body.These images provide more detailed information than normal X-ray images.They can show the soft tissues, blood vessels, and bones in various parts of the body.

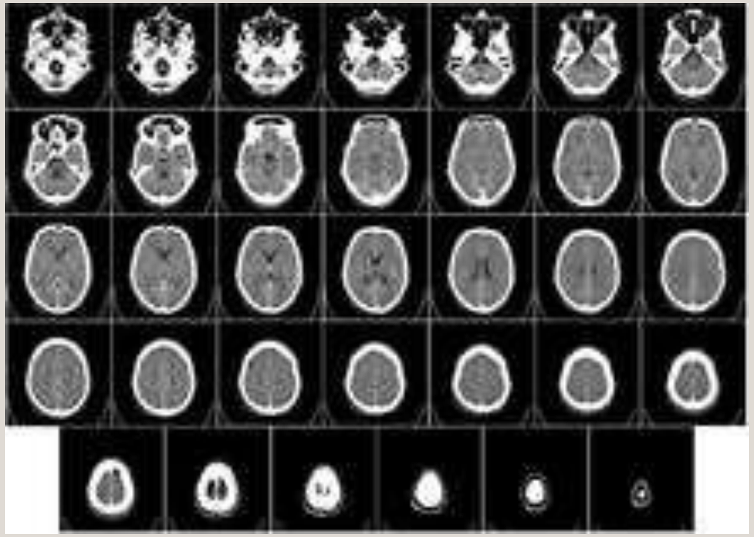
A CT scan may be used to visualize the head, shoulders, spine, heart (Cardiac), abdomen, knee and chest.

During a CT scan, you lie in a tunnel-like machine while the inside of the machine rotates and takes a series of X-rays from different angles.These pictures are then sent to a computer, where they're combined to create images of slices, or cross-sections, of the body.They may also be combined to produce a 3-D image of a particular area of the body.

COMPUTERIZED TOMOGRAPHY (CT):

Head:

CT scanning of the head is typically used to detect infarction, tumors, calcifications, haemorrhage, and bone trauma. Of the above, hypodense (dark) structures can indicate edema and infarction, hyperdense (bright) structures indicate calcifications and haemorrhage and bone trauma can be seen as disjunction in bone windows.Tumors can be detected by the swelling and anatomical distortion they cause, or by surrounding edema. Ambulances equipped with small bore multi-slice CT scanners respond to cases involving stroke or head trauma. CT scanning of the head is also used in CT-guided stereotactic surgery and radiosurgery for treatment of intracranial tumors, arteriovenous malformations, and other surgically treatable conditions using a device known as the N-localizer.



COMPUTERIZED TOMOGRAPHY (CT):

Neck:

Contrast CT is generally the initial study of choice for neck masses in adults. CT of the thyroid plays an important role in the evaluation of thyroid cancer. Also, CT scans often incidentally find thyroid abnormalities, and thereby practically becomes the first investigation modality.

COMPUTERIZED TOMOGRAPHY (CT):

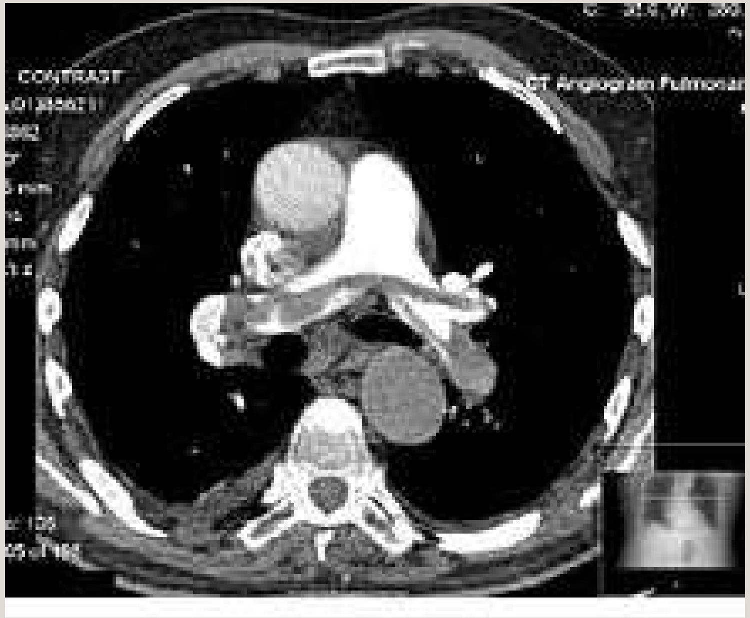
Lungs:

A CT scan can be used for detecting both acute and chronic changes in the lung parenchyma, the tissue of the lungs. It is particularly relevant here because normal two-dimensional X-rays do not show such defects. A variety of techniques are used, depending on the suspected abnormality. For evaluation of chronic interstitial processes such as emphysema, and fibrosis, thin sections with high spatial frequency reconstructions are used; often scans are performed both on inspiration and expiration.This special technique is called high resolution CT that produces a sampling of the lung, and not continuous images.

COMPUTERIZED TOMOGRAPHY (CT):

Heart (Cardiac):

A CT scan of the heart is performed to gain knowledge about cardiac or coronary anatomy.Traditionally, cardiac CT scans are used to detect, diagnose, or follow up coronary artery disease. More recently CT has played a key role in the fast evolving field of transcatheter structural heart interventions, more specifically in the transcatheter repair and replacement of heart valves.



COMPUTERIZED TOMOGRAPHY (CT):

How you prepare?

Depending on which part of your body is being scanned, you may be asked to:

- Take off some or all of your clothing and wear a hospital gown
- Remove metal objects, such as a belt, jewelry, dentures and eyeglasses, which might interfere with image results
- Refrain from eating or drinking for a few hours before your scan

COMPUTERIZED TOMOGRAPHY (CT):

How Do CT Scans Work?

They use a narrow X-ray beam that circles around one part of your body. This provides a series of images from many different angles. A computer uses this information to create a cross-sectional picture. Like one piece in a loaf of bread, this two-dimensional (2D) scan shows a "slice" of the inside of your body.

This process is repeated to produce a number of slices. The computer stacks these scans one on top of the other to create a detailed image of your organs, bones, or blood vessels. For example, a surgeon may use this type of scan to look at all sides of a tumor to prepare for an operation.

COMPUTERIZED TOMOGRAPHY (CT):

<u>Why Is a CT Scan Performed?</u>

A CT scan has many uses, but it's particularly well-suited for diagnosing diseases and evaluating injuries. The imaging technique can help your doctor:

- diagnose infections, muscle disorders, and bone fractures
- pinpoint the location of masses and tumors (including cancer)
- study the blood vessels and other internal structures
- assess the extent of internal injuries and internal bleeding
- guide procedures, such as surgeries and biopsies
- monitor the effectiveness of treatments for certain medical conditions, including cancer and heart disease

The test is minimally invasive and can be conducted quickly.