

III Year B. Tech. Examination May 2023**Subject Code: 910105 (OC1):****Subject: BioMedical Instrumentation****Time: 3 Hours****Maximum Marks: 50****Minimum Pass Marks:**

Note:	1. Answer all five questions. All questions carry equal marks. 2. In each question, part a and b is compulsory and part c has internal choice. 3. All parts of each question are to be attempted at one place.. Assume suitable value of missing data, if any. 4.	Marks	COs	BL
Q. No.				
1.	(a) Write the various components of man-machine instrumentation system. (b) Write the objectives & importance of Biomedical Instrumentation in a present scenario? (c) Draw an action potential waveform and explain polarization, depolarization and repolarization process of bio-potentials..	02 02 06	CO1 CO1 CO1	L2 L2 L3
	OR			
	What is bio-potential? Name six types of bio-potential sources. Write in brief about each of them.	06	CO1	L3
2.	(a) Explain principle of operation of pacemaker. (b) Name the different types of heart sounds present in ECG. (c) Explain the mechanical & electrical activities of the heart by developing a time-phase diagram showing the correlation of the mechanical pumping of the heart, including the opening of valves, with electrical-excitation events	02 02 06	CO2 CO2 CO2	L2 L2 L3
	OR			
	Discuss the unipolar & bipolar limb leads configurations and Einthoven triangle for the measurement of ECG signal.	06	CO3	L2
3	(a) What is spirometer? Identify its diagnostic applications. (b) A person has a total lung capacity of 5.95 liters. If the volume of the air left in the lungs at the end of maximal expiration is 1.19 liters, what is his vital capacity. (c) Describe human respiratory system and indicate with the help of diagram, various volumes in relation to total lung capacity.	02 02 06	CO3 CO3 CO3	L2 L2 L2
	OR			
	Discuss the construction & working principle of following respiratory therapy equipments (i) Inhalators (ii) Ventilators and (iii) respirators	6	CO3	L2
4	(a) Write physiological effects of electric current. (b) What are the components of Hospital system. (c) Draw and explain the block diagram of intensive care unit showing all its components with brief discussion of each element.	02 02 06	CO4 CO4 CO4	L2 L3 L3
	OR			
	Explain how the electrical hazards protection can be provided in the biomedical health care systems,	06	CO4	L3
5.	(a) Mention the various types of ultrasonic scanning. (b) Write potential health hazard of ultrasound. (c) Compare the ultrasonic scanning with X-Rays.	02 02 06	CO5 CO5 CO5	L2 L3 L4
	OR			
	Explain Ultrasonic A scanning technique used for bone fracture detection.	06	CO5	L3

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Answer 1(a) The main components of the man-machine instrumentation system are as follows:-

- (i) Subject (Human Being)
- (ii) Stimulus
- (iii) Transducers
- (iv) Signal-Conditioning Equipment
- (v) Display Equipment
- (vi) Recording, Data-Processing and Transmission Equipment
- (vii) Control Devices

Answer 1(b)

- (i) Biomedical instrumentation focuses on the developments of methods and devices for treatment of diseases.
- (ii) It is an emerging field of biomedical engineering that bridges the gap between medicine and engineering.
So, biomedical instrumentation helps physicians to diagnose the problem accurately at their initial stages and provide the treatment timely.

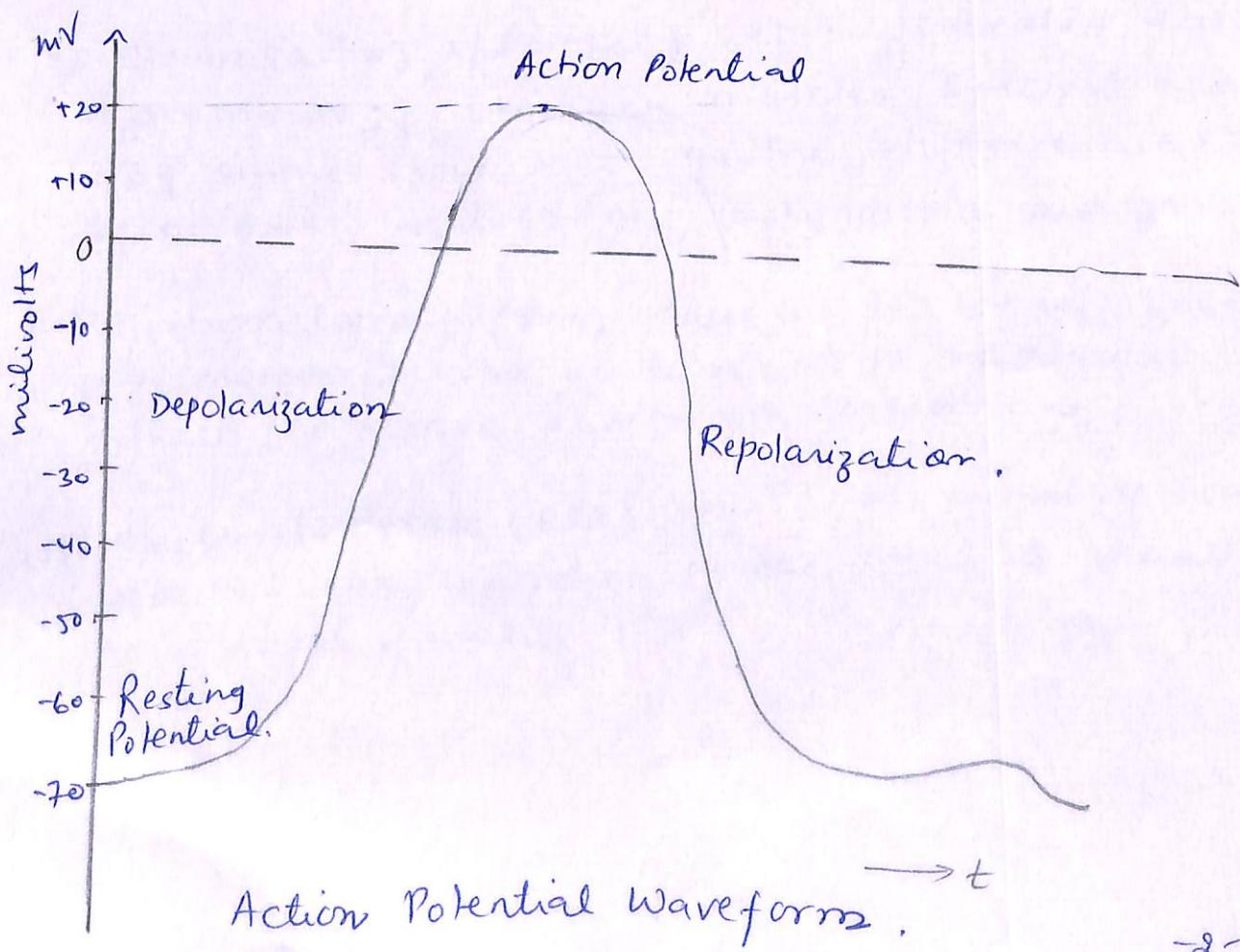
Answer 1(c) An action potential is defined as a sudden, fast, transitory and propagating change of the resting membrane potential.

When a section of the cell membrane is excited by the flow of ionic current or by some form of externally applied energy, the membrane changes its characteristics and begins to allow some of the sodium ions to enter and constitutes an ionic current flow which reduces the barrier of the membrane to sodium ions.

At the same time, potassium ions, which were in higher concentrations inside the cell during resting state, try to leave the cell but unable to leave as rapidly as the sodium ions. As a result, the cell has a slightly high positive potential on the inside. This potential is known as action potential and is approximately +20 mV.

A cell that has been excited and displays an action potential is said to be depolarized and the process of changing from the resting state to the action potential is called depolarization.

Once the rush of the sodium ions through the cell membrane is stopped, a new state of equilibrium is reached and by an active process called sodium pump, the sodium ions are quickly transported to the outside of the cell and the cell again becomes polarized and assumes its resting potential. This process is called repolarization.



OR
Answer 1(c)

Biopotentials are electrical signals that are generated by physiological processes occurring within the body. The various types of biopotentials generated in human body are:

- (i) ECG (Electrocardiography) :- This is generated due to electrical activity of heart muscle and as the time changes. The cardiac muscle contracts in response to the electrical depolarization of the heart muscle cell. So, the condition of the heart can be evaluated from ECG and, further diagnosis can be performed.
- (ii) Electroencephalogram (EEG) :- It is the activity along the scalp produced by firing of brain neurons within the brains. In neurology, the main diagnostic applications of EEG is in case of epilepsy.
- (iii) Electromyogram (EMG) :- EMG signals are the electrical currents generated in muscle during its contraction, representing neuromuscular activities. The EMG potentials range between $\pm 50 \text{ mV}$ and up to 30 mV , depending upon the muscle under observations.
- (iv) Electrogastrography (EGG) : It is generated due to the movement of stomach muscles. Spectral analysis of the EGG signal shows that gastric rhythms can be classified as normal, bradystomia, tachystomia and arrhythmia.
- (v) Electrooculography (EOG) : These are the signals generated due to eye movement and position. It is the potential that exists between the cornea and Bruch membrane.
- (vi) Electrotretinogram (ERG) : It is the record of complex signals obtained from the retina of eye. This is usually a response to a visual stimulus.

Answer 2(a) A device capable of generating artificial pacing impulses and delivering them to heart is known as pacemaker. A pacemaker senses the activity of heart. If it senses that the heart has slowed down or missed a beat, then it will send an electrical impulse to stimulate the heart to restore it to its normal state.

Answer 2(b) The heart sounds heard by the physician through its stethoscope occur at the time of closure of major valves in the heart. The first sound "lub" occurs at the time of the QRS complex of ECG. The second sound "dub" occurs about the time of the end of T wave of ECG. The third sound is sometimes heard, which occurs from 0.1 to 0.2 sec after the second heart sound. In abnormal hearts additional sounds called "murmurs" are heard between normal heart sounds.

Answer 2(c) The heart may be considered as a two-stage pump, physically arranged in parallel but with the circulating blood passing through the pumps in a series sequence. The right half of the heart, known as right heart, is the pump that supplies blood to rest of the system. The circulatory path for blood flow through lungs is called pulmonary circulation and the circulatory system that supplies oxygen and nutrients to the cells of body is called the systemic circulation. ^{It is} The left part heart may be considered as a pressure pump. The muscle contractions of the left heart is larger and stronger than that of the right part heart because of greater pressure required for systemic circulation.

The heart's pumping cycle is divided into two major parts (i) systole and (ii) diastole. Systole is defined as the period of contraction of heart muscles, specifically the ventricular muscle, at which time blood is pumped into pulmonary artery and the aorta. Diastole is the period of dilation of the heart cavities as they fill with blood.

Answer 2(c) continued -

The cardiovascular system consists of the heart, blood vessels, and blood. Its primary function is to transport nutrients and oxygen-rich blood to all parts of the body and to carry de-oxygenated blood back to the lungs. The four main functions of the cardiovascular system are

1. To transport nutrients, gases and waste products around the body
2. To protect the body from infection and blood loss
3. To help the body maintain a constant body temperature
4. To help maintain the fluid balance within the body.

The cardiovascular system works in conjunction with the respiratory system to deliver oxygen to the tissues of the body and remove CO_2 .

The vital role of cardiovascular system in maintaining of homeostasis depends upon continuous and controlled movement of blood through the thousands of miles of capillaries that permeate every tissue and reach every cell in the body.

Answer 3(a) The electrical signals from the heart are measured with the surface electrode. The three type of electrode systems are:

- (i) Bipolar limb leads.
- (ii) Unipolar limb leads, and
- (iii) chest leads.

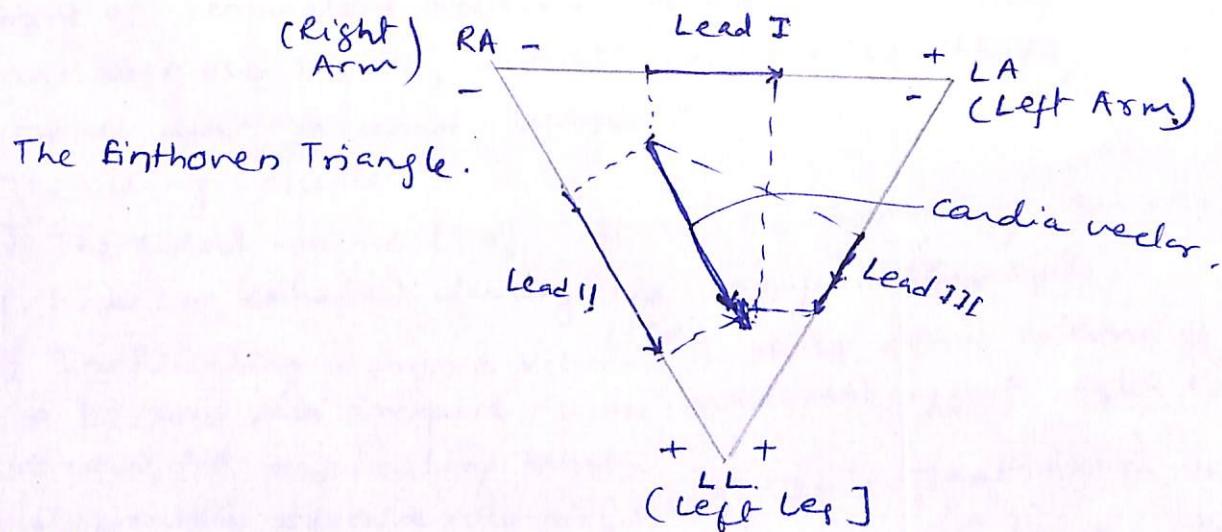
The bipolar limb lead system is also known as Einthoven lead system. Einthoven triangle is the closed path formed between right arm, left arm, left leg and right arm. The sides of the triangle represents the line along which the three projections of the ECG vector are measured. Based on this, the three bipolar limb lead selections first introduced by Einthoven, are as follows:-

Lead I : Left Arm (LA) and Right Arm (RA)

Lead II : Left Leg (LL) and Right Arm (RA)

Lead III : Left Leg (LL) and Left Arm (LA)

These three leads are called bipolar because for each lead the electrocardiogram is recorded between two electrodes and the third electrode is not connected.



Of the three limb leads, lead II produces the greatest R wave potential.

The other lead system is known as unipolar lead system. In this, the ECG is recorded between a single exploratory electrode and the central terminal, which has potential corresponding to the center of the body.

Answer 3(a)

Spirometer is an instrument used for measurements of respiratory volume in the laboratory. All lung volumes and capacities are determined by measuring the amount of gas inspired or expired under a given set of conditions or during specified time intervals by means of spirometer.

Answer 3(b)

$$\text{vital capacity} = \text{total lung capacity} - \text{residual volume}$$

$$= 5.95 - 1.19$$

$$= 4.66$$

Ans

Answer 3(c) The human respiratory system is the network of organs and tissues that helps to breathe. It includes airways, lungs and blood vessels. The muscles that power lungs are also part of respiratory system. The various parts of respiratory system are (i) nose, mouth, throat, voice box, windpipe, large airways, small airways and lungs.

The lung volumes:-

(i) The tidal volume (TV) : it is the amount of air that can be inhaled or exhaled during one respiratory cycle.

(ii) Inspiratory Reserve Volume ^(IRV) :- it is extra volume of gas that a person can inspire with maximal effort after reaching the normal end inspiratory level.

(iii) Expiratory Reserve Volume (ERV) : it is that extra volume of gas that can be expired with maximum effort beyond the end expiratory level.

(iv) Residual volume (RV) : it is volume of the gas remaining ~~in the~~ lungs at the end of the maximum expiration.

(v) Vital capacity ^(VC) :- it is maximum volume of gas that can be expelled from the lungs by forceful effort after a maximal inspiration.

(vi) Total lung capacity ^(TLC) is the amount of gas contained in the lungs at the end of a maximal inspiration.

(vii) The inspiratory capacity (IC) is the maximum amount of gas that can be inspired after ~~reaching~~ remaining reaching the end of expiratory level.

(viii) Fundamental residual capacity (FRC) is the volume of gas remaining in the lungs at the end of expiratory level.

Qn

Answer 3(c) Inhalers - it is device used to supply oxygen or some other therapeutic gas to a patient who is able to breathe spontaneously without assistance.

Ventilators and Respirators

The terms ventilators and respirators are used interchangeably to describe equipment that may be employed continuously or intermittently to improve ventilation of the lungs and to supply humidity or aerosol medications to pulmonary tree.

Respirators are commonly classified as assist-controllers and can be operated in any of the mode: assist-control or assist-control. In addition to the tree modes, many respirators can be triggered manually by means of a control on the panel.

The ventilators can be categorized by two basic levels types

- (i) pressure-cycled, positive-pressure assist-controllers
- (ii) volume-cycled ventilators, negative-pressure

volume-cycled ventilators are used in critical patient care

Answer 4(a) Electric current is able to create severe burns in the body. Shock can cause cardiac arrest, burns to tissues and organs, serious effects to the nervous system and other unexpected consequences.

Answer 4(b) The patient care unit in hospitals generally includes the following: skin electrodes, amplification equipment, CRT that displays ECG waveform, rate meter which indicates no. of heart beat/min, an alarm system activated by rate meter and recording/printing device.

Answer 4(c) In order to reduce the likelihood of electrical accidents, a number of protective devices have been evolved. some of these are:-
(i) Grounding :- In protection this method, the metal-case of equipments are connected to the ground by suitable wire. In cord connected electrical equipments, this connection is established by the third wire or U-shaped contact plug.
(ii) Double insulation :- In double insulated equipments, the case is made of non-conductive material, usually a suitable plastic, to assure the fault resistance is always very large. The double insulated equipments need not to be grounded.

(iii) Protection by low voltage:- If instead of line voltage, another voltage source such as batteries are used, then the source current can be made very small enough so case of fault and the body current can be limited to safe value. (iv) Ground fault current interruption - statistical evidence indicates that most electrical accidents are of the type in which the body of the victim provides a conductive path to ground. In the ground fault circuit interrupter, the difference between the current in hot and neutral wires of the power line is monitored by a differential transformer and an electronic amplifier. If this difference exceeds certain value, usually 5 mA, the power is interrupted by the circuit breaker. This interruption occurs so rapidly that even in the case of large current flows through the body of the victim, no harmful effects are encountered.

Answer 5(a) There are 3-type of ultrasonic scanning -

(i) A-scanning (ii) B-scanning and (iii) Time scanning.

The ultrasonic scanning is used to find any appreciable discontinuities or non-homogeneity of the elasticity in the bones.

Answer 5(b) Ultrasound exposure causes heating. The of ultrasonic waves is absorbed by our body. The depth and form of absorption of this energy is largely unknown depending on the frequency of the waves whether they are 1KHz or MHz.

Answer 5(c) Both ultrasound and x-Rays are used for medical diagnosis. Ultrasound x-ray focuses on the bones, lungs and gas-filled organs whereas an ultrasound focuses on the internal details of the organs. Ultrasound is very accurate and very useful for diagnosing heart, soft tissues etc. The physical property differences between ultrasound and x-ray are as follow. -

Property	Ultrasound	x-Rays
(i) Wave type	Longitudinal	Electromagnetic
(ii) Transmission medium	Elastic	No medium required
(iii) Velocity	depends on the medium through which it propagates	constant
(iv) Generation	Acoustic, seismic	Accelerating electric charge
(v) similar waves	Radio, light	

Application differences between ultrasound and x-rays in medical diagnosis.

Ultrasound

It is used non-invasive and it has no long-term side effects

Imaging is obtained from the echoes which are reflected beams from the targets.

It images only muscles, soft tissues and bone surfaces.

Penetration depth is limited.

X-Ray

Though non-invasive, body is invaded by ionizing radiation which has harmful effects.

Imaging is obtained from radiation that leaves the body.

X-rays show up well the high density parts such as bones and air cavities.

There is no penetration problem.

Qs

Answer 5(c) By ultrasonic scanning, see it is possible to identify the following.

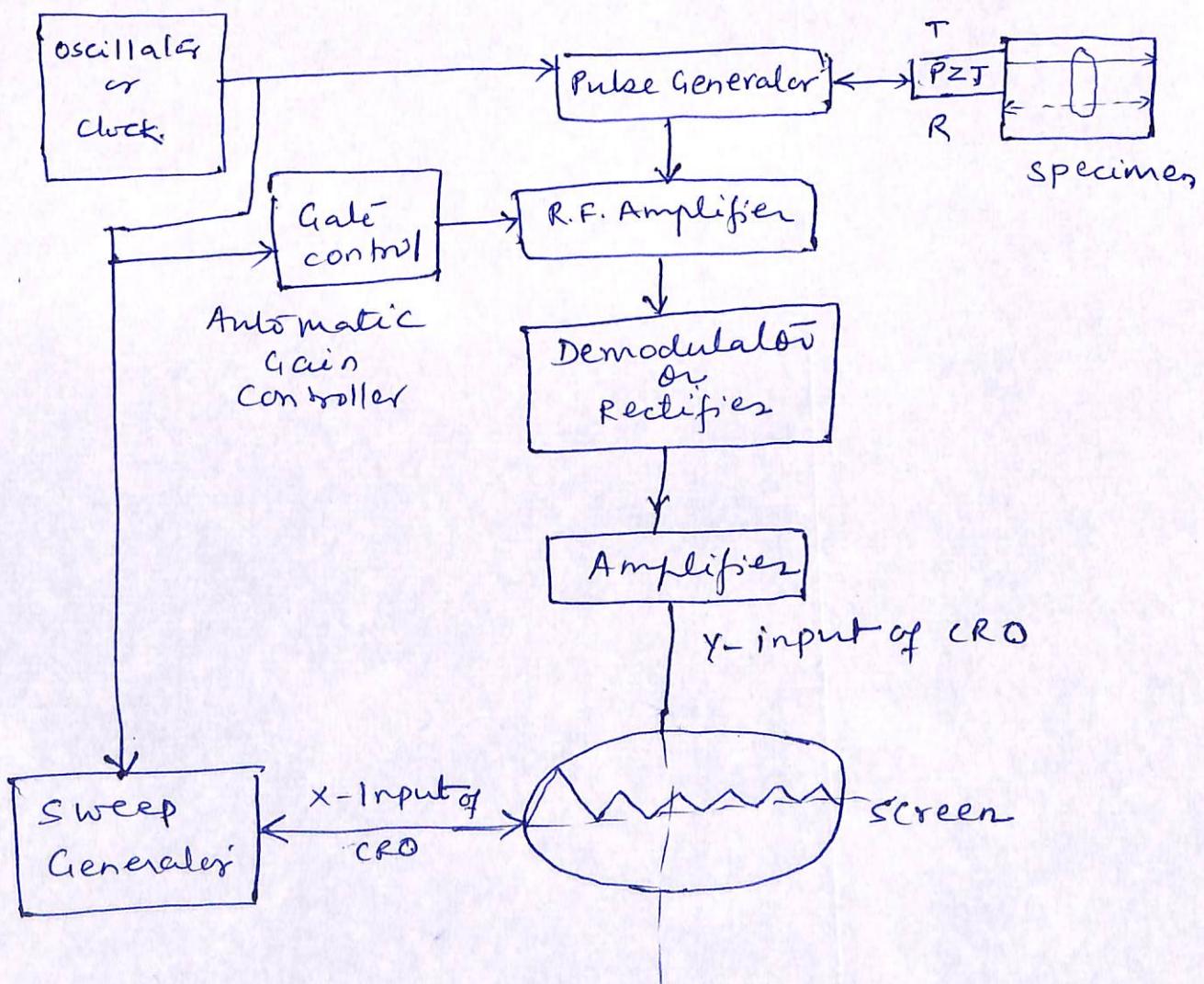
- (i) any appreciable discontinuities or inhomogeneities of elasticity in the bones
- (ii) any holes or crack/fractures within a bone and locate them exactly within certain limits
- (iii) Reflections from the small and large flaw/crack/fracture by variation in frequency or by differences in the amplitude of the reflected signal.

In A-scanning techniques, the transmitted and reflected/received pulse energy is recorded in the form of amplitude, which is used to determine the nature of discontinuity and distance of such discontinuity from the transducer.

Method of application:-

1. In this technique, a single transducer is used as a transmitter as well as receiver.

1. A short pulse of electrical wave about 1 or 2 ~~ms~~ us long is produced by the pulse generator and applied many times per second to a piezo-electric transducer, which is attached to the bone being tested, (between 20-1000 pulses/second)
2. Two echos received back, one is from the far end and other is from the flaws.
3. When these echos reach the PRT crystal, it generates the electrical signal which goes to the automatic gain control amplifiers.
4. The pulse are sent which is synchronised with the sweep of oscilloscope.



Flowchart: A-scaning method for Bone-fracture Detection.

5. If no flaws are present, the only echo received is the one from back face of the bone.