Bio-medical Instruments.

A clinical thermometer - its used to measure the temperature of the human or animal body by inserting the tip of the thermo-meter in the mouth, armpit or rectum of human body.

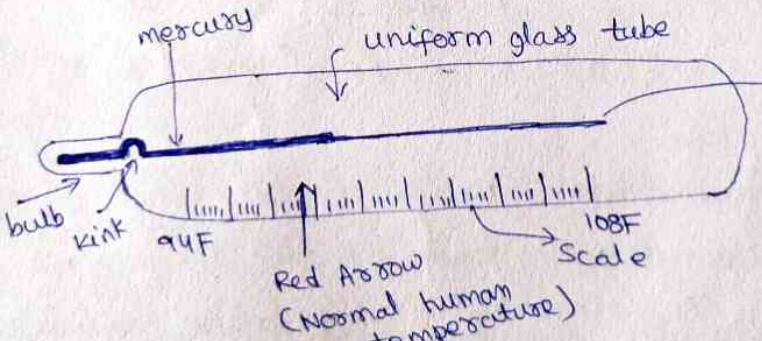
- Its used to indicate the body temperature is higher or lower than the normal temperature.

Various types of clinical thermometers available are -

1) mercury thermometer
2) Digital thermometer
3) strip-type thermometer
4) Infra red thermometer.

⇒ principle of operation of mercury type clinical thermometer-

- It consists of a long glass tube having a glass bulb at its one end and other end is sealed.
- The glass bulb has mercury inside it.
- Glass tube is calibrated with Fahrenheit scale (94°F to 108°F) or celsius scale (35°C to 42°C) on it.



- mercury thermometers works based on the practical phenomenon that mercury expands with rise in temperature.
- A small amount of mercury in a reservoir is subjected to heat.
- It expands and pushes the mercury in a capillary tube (thin)

Thus we can measure the readings where the mercury is attained in the capillary tube corresponding on its temperature scale.

- The qualities of good thermometers are
  - High sensitivity
  - easy readability
  - accuracy over desired range of temperatures.

⇒ The temperature in °F can be converted into °C by the following expression.

$$°C = (F - 32)/1.8$$

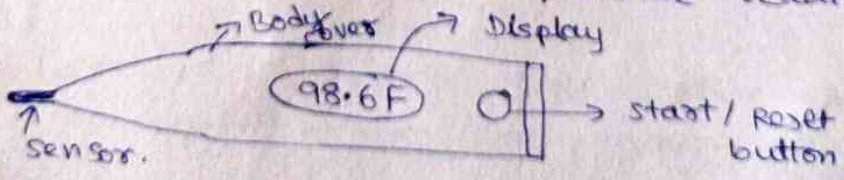
⇒ After reading the value, the thermometer has to be reset.
- It's done by repeatedly swinging it sharply to shake the mercury back.

Advantages of mercury thermometer -
1) mercury is a good conductor of heat.
2) mercury is opague and shining
3) mercury does not stick to the walls of the glass
4) mercury has uniform expansion.
5) Hence they are cheap, durable and accurate.

Dis advantages of mercury thermometers
1) mercury is toxic, if any mishappening occurs, even a small traces of mercury in the blood is harmful.
2) The display is some what difficult to read.
3) they donot work below $-39°C$ (freezing point of mercury)

Digital Thermometer -

A electronic thermometer uses a sensor based on thermistors whose electrical characteristics change with temperature and also a digital display to show the temperature readings.



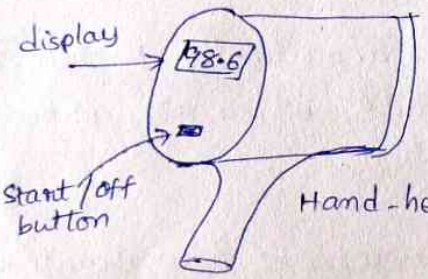
- The readings are recorded very fastly with in seconds.
- LCD screen will display the readings.
- It's provided with auto shut-off feature which helps in improving battery life.
- It has also designed with last reading recall feature.

3) strip type Thermometer

- It consists of heat-sensitive (thermo-chromic) liquid crystals in a plastic strip.
- Temperature change effects the colour of a liquid crystal.
- This property is used to measure temperature.
- when the strip is kept on forehead of the person then it changes its colour. which indicates the temperature of that person.
- These thermometers does not provide precise temperature measurements.
- It simply warns to identify a person has fever or not.

Infra red thermometer -

- It's also known as non-contact thermometer or temperature guns or laser thermometers. which are able to measure temperature from some distance.
- They measure temperature by the radiation emitted by the body.



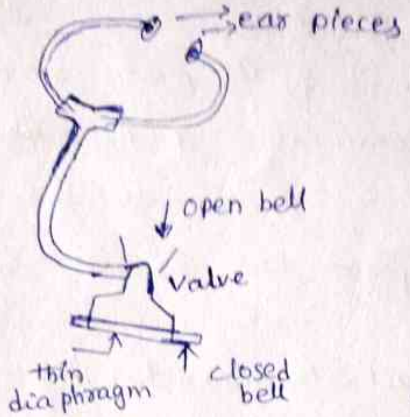
Hand-held Infrared thermometer.

- It consists of a lens to focus the infrared thermal radiation on to a detector.
- The detector converts the radiation into electrical form.
- This electrical signal is used to display the digital temperature on the LCD display.
- During covid these infrared thermometers were mostly used.

⇒ Stethoscope -

- The stethoscope is an instrument used for listening to the sounds produced by the body.
- It's primarily used to listen to sounds of lungs, heart and intestinal tract.
- It's also used to listen to blood flow in peripheral vessels and the heart sounds of developing fetuses in pregnant women.
- The acoustic stethoscope is mostly used by medical professionals.

- It has a diaphragm on one side for high-pitched sounds and -a bell on the other for low-pitched sounds.
- The tubing is thick and heavy which helps to conduct sound.



⇒ stethoscope contains the following main parts
① Bell (open or closed by diaphragm)
② Tubing
③ Earpieces (2)

⇒ Both the ear-pieces are commonly connected to a common bell (open/closed)

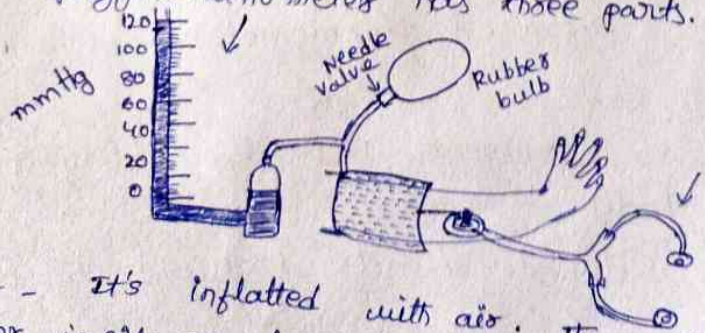
⇒ the open bell acts like impedance matcher b/n skin and air.

⇒ The skin under open bell acts like diaphragm. (low freqency sounds)
⇒ the closed bell is simply a bell with diaphragm of known resonant frequency which is usally high and tunes out low freqency sounds.

⇒ Heart beats are amplified acoustically through resonance and transmitted through hollow tube which are picked up by the ear of the physician for interpretation.

⇒ sphygmomanometer -
The word sphygmomanometer is a combination of greek word "sphygmo" means beating of heart or pulse and "manometer" means device for measuring pressure.

- The arterial blood pressure in humans is routinely measured by the auscultatory method using a sphygmomanometer and a stethoscope
- The sphygmomanometer has three parts. as shown below.



1) cuff
2) manometer
3) stethoscope

① cuff - It's inflatted with air. The cuff consists of a rubber bladder inside an elastic fabric covering which will be wrapped around the upper arm.
② manometer - It measures the air pressure in the cuff.
③ stethoscope - used to listen to the sound which the blood makes

as it flows through Brachial Artery (major artery in upper arm).

⇒ the average blood pressure norms for a young adult is

① Brachial artery - Systolic 110-120 mmHg
Diastolic 65-80 mmHg

② capillaries - 20-30 mmHg

③ veins - 0-20 mmHg

The blood pressure is normally recorded as systolic over diastolic

⇒ 120/80 mm Hg.

⇒ ECG machine: means Electro cardio graph used for recording of electrical activity of heart on a graph paper.

- The graph on which the electrical activity is recorded as Electro-cardiogram.

principle - As in the human body, trans-membrane ionic currents are generated by ion fluxes across cell membranes and adjacent on-es

- These currents are produced electric field in and around the heart
- This field varies with time during cardiac cycle.
- Depolarization is the electrical changes that takes place due to contra-ction of any muscle.
- These changes are detected by electrodes attached on specific locations on the surface of the body.
- At every heart beat, the heart is depolarized to triggers its contra-ction
- This electrical activity is transmitted throughout the body and can be picked up the skin. then by the electrodes of ECG machin-e and finally displays it graphically.

⇒ Types of ECG machines

① single channel ECG (uses one lead trace at a time)
② Three channel ECG (four leads at a time)
③ Twelve channel ECG (twelve leads simultaneously).

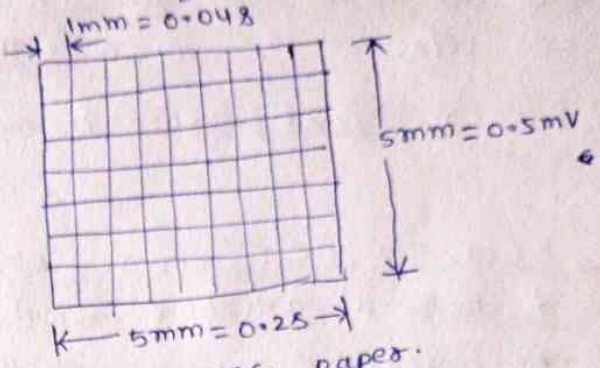
ECG lead measures the potential difference b/n two points. Two types of leads are used in ECG machine.

① Bipolar leads - They are placed on two different points on the body.
② unipolar leads - They are placed on one point on the body and a virtual reference point with electrical potential located in the center of heart.

The standard ECG machine has 12 leads.

① 3 standard limb leads
② 3 augmented limb leads
③ 6 precordial leads.

Each lead represents a different direction of cardiac activation in 3D-space.

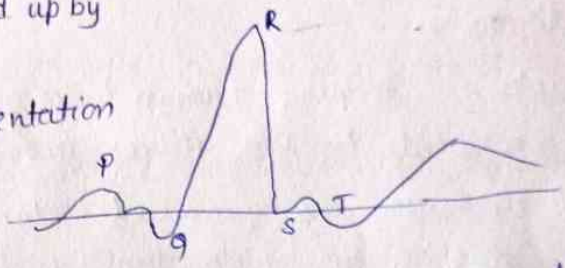


⇒ Horizontally -
- one small box - 0.04 sec
- one large box - 0.2 sec

⇒ vertically
- one large box = 0.5 mV

→ ECG processes the signals picked up by electrodes placed on the skin.

→ It produces a graphical representation of electrical activity of the patients heart.



→ Electrical activity near the electrode in lead causes upward deflection

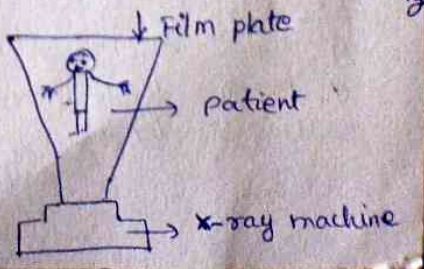
→ Electrical activity away from the lead produces downward deflection.

→ Depolarization and repolarizations deflections occurs in opposite directions.

- Radiography -

Radiology is a branch of medicine, where as Radiography is an imaging technique for generating and recording an x-ray pattern after termination of the exposure.

- Radiography is used to diagnoise or treat patients by recording images of the internal structure of the body.
- we can know the presence or absence of abnormalities / diseases, foreign objects or structural damage by studying the images.
- Radiography may be used during the planning of radiation therapy treatment.



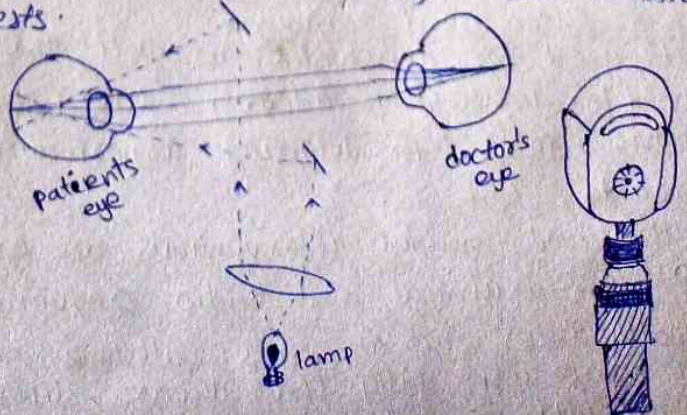
Principle of operation- During radiographic procedure, an X-ray beam is passed through the body of patient as shown in the fig.
- A portion of the X-rays are absorbed through or scattered by the internal structure of patient's body.
- The remaining X-ray pattern is transmitted to a detector so that an image may be recorded by evaluation.
- The recording of the pattern is done on the film or through electronic means.

Uses of Radiography -
① Dental examination
② Verification of correct placement of surgical markers prior to invasive procedures.
③ mammography
④ chiropratic examinations
⑤ orthopedic evaluations
⑥ spot film (or) static recording during fluoroscopy.

⇒ Opthalmoscope -
→ It's the instrument which is used to detect and evaluate symptoms of retinal detachment or eye diseases like glucoma.
→ Opthalmology is the branch of medical science that deals with the structure, functions and diseases of the eye.
→ operation principle -
- The opthalmoscope directs a small beam of light through the patient pupil.
- This helps the doctor to detect abnormalities on the lens of the eye, optic disc, vitreous humor and the retina.

There are two types of opthalmoscopes - ① Direct opthalmoscope.
② In-direct opthalmoscope.

① Direct opthalmoscope -
- It's an hand held instrument, contains concave mirror, a light source, an eye piece for the doctor and an handle.
- It provides almost 15 times magnification, most commonly used in routine eye tests.
- It provides an upright (un reversed) images.



Indirect opthalmoscope

- It's typically head mounted instrument with a light attached to headband and a small hand-held lens.
- They project three elements into the eye rather than one.
- Therefore, the doctor gets a three-dimentional rendition of the interior of eye.
- Hence it allows thorough examination.
* It provides an inverted (reverse) image of 2 to 5 times magnification.

⇒ Ultra sound Scanning -

→ The normal audible range of human ears is 20Hz to 20kHz.
→ ultra sound signals have frequencies 20kHz to 30kHz.
→ An ultrasound scanning uses high freqiency sound waves to create images of inside the body.
→ This type of scanning is used to detect problems in the liver, heart, kidney or abdomen etc.
→ They also used to evaluate fetus (embryo) development.

principle of operation -

- ultra sound scanning is based on the fact that ultrasound travels through tissue and fluids but bounces back or echoes off denser surface.
- The denser the object the ultrasound hits, the more of the ultrasound bounces back.
- This bouncing back (or echo) gives various shades of gray on the image implying different densities.
- The transducer is placed against the patient's skin with a thin layer of coupling gel.
- This gel displaces the air which could reflect the ultrasound beam.
- The transducer is moved over the part of the body that is to be examined.

uses of ultra sound scanning -

- It's used for diagnostic as well therapeutic uses.
- used for imaging of adomen, liver, gall bladder, pancreas, kidneys, pelvis, fetus (for detecting abnormalities in baby), vasular system, breasts, chest etc.
- ultra sound - guided interventions are used to facilitate lesion biopsy; abscess drainage and radio frequency ablation.
- Health issues such as cysts, gallstones, abnormal growths in the liver or pancreas, fatty liver disease, liver cancer, etc. can be diagnosed using ultra sound scanning.

- Its inferior to CT scans for detecting certain cancer tumors and other abnormalities in the body.
- Advantages of ultrasound scanning -

① Non-Invasive - They are generally painless and donot require needles injections or incisions.

② Safety - patients are not exposed to ionizing radiation. This makes the procedure safer than other diagnostic techniques such as X-ray or CT scans.

③ ultra sound captures images of soft tissues that donot show up very well on X-rays.

④ No special preparation is normally required before an ultrasound scan.

- pulse Oximeter -

- A pulse oximeter is a device which uses light beams to estimate the oxygen saturation of the blood and pulse rate.
- oxygen saturation gives the information about the amount of oxygen being carried in the blood.
- Its non-invasive i.e no blood is drawn out.

There are three types of pulse oximeters available in the market -

1) Finger tip pulse oxymeter - mostly used type.
2) Hand held " "
3) fetal " "

- The most important number is oxygen saturation level abbriviated as SpO_2.
- oxygen saturation are between 95% to 100% for healthy individual
- Those who lives in higher altitudes have lower oxygen saturation levels (around 85%)

principle of pulse oxymeter

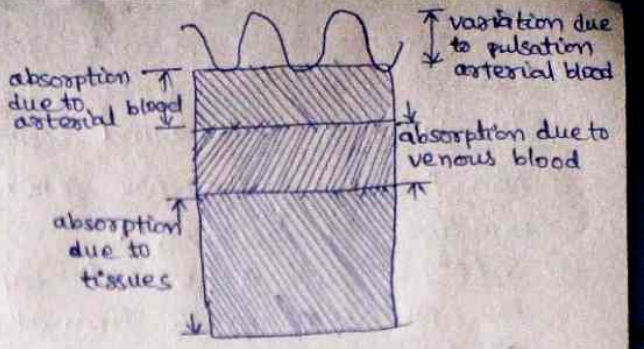
Pulse oximeter (oxymetry) is based on following two principles.

① Heamoglobin (Hb) and oxygenated heamoglobin (HbO_2) differ in their absorption of red and infrared light)

② the volume of arterial blood in tissue and as such the light absorption by the heamoglobin changes during pulse.

- pulse oxymeter has red and infrared low voltage LED's and a photo detector.
- LEDs serves has light source.
- we know that constituents of human body - blood in arteries and veins and tissue absorb light differently as shown below.
- oxygen enters the lungs and passed into blood. The blood carries oxygen to various organs in our body by heamoglobin.

- The pulsating of arterial blood results in changes in absorption of added haemoglobin (Hb) and oxygenated haemoglobin (HbO_2) in the path of light.
- HbO_2 absorbs more infrared light
  Hb absorbs more red light



$$\% \text{ oxygen saturation} = \frac{\text{Concentration } (HbO_2)}{\text{Concentration } (HbO_2) + \text{Concentration } (Hb)} \times 100$$

Applications (uses) of pulse oxymeter -
- it's used to know if human blood is well oxygenated or not.
- the health is monitored with the blood oxygen levels.
- pulse oxymeters are used while treating patients with diseases like asthma, pneumonia, lung cancer, anemia, heart diseases etc.
- for sleep studies etc.

Advantages of pulse oxymeter
- simple and convenient to use.
- Non-invasive
- Require no warm up time and have fast response time.
- cost effective
- separate respiratory and circulatory variables.
- give continuous measurements
- have light weight and compactness. Hence user friendly.

Glucometer -
Blood sugar which is also called blood glucose needs to be controlled in the human body to minimize the risk of developing complications.
- The normal blood sugar levels is nearly 140 mg/dL.
- If it's more than 200 mg/dL indicates diabetes.
- patients use glucometer to test their own blood glucose and adjust insulin (medicine) dosage to control their glucose levels.
- The three principle enzymatic reactions used by glucometers are -
  ① glucose oxidase ② glucose dehydrogenase ③ hexokinase.
- current glucometers use test strips containing glucose oxidase an enzyme that reacts to glucose in the blood droplet and an interface to an electrode inside the meter.
- The finger tip of the person is pricked with the needle provided in the test kit.
- the person than touches and hold the edge of the test strip to the drop of blood.
- The meter will display blood sugar level on a screen after few seconds.

Advantages and limitations of Glucometer -

- Glucometer allows us to take care of body sugar levels with out going to labs regularly.
- In this way money is saved.
- They also helps us to determine dosage of insulin.
- Glucometer can detect hypoglycaemia which is a more dangerous condition of blood sugar.

Limitations

- These readings are less accurate than the laboratory results.
- factors such as temperature, humidity, altitude etc. affect gluco-meter readings.
- This is because the rate of the enzyme reaction depends on these factors.

CT scan = computed Tomography scan or computerized Axial tomography scan (CAT) combines X-rays with computers to produce highly detailed cross-sectial images of the body.

- These have ability to image a combination of soft tissue, bone and blood vessels.

⇒ The word "tomography" derived from greek where "tomos" means "to cut or to slice" and "graphia" means "to describe".

= Traditional X-ray uses only 2D images at a single spot.

⇒ CT scan uses a doughnut shaped tube that rotates the X-ray 360°s around the body to capture 3D-images of the inside of body.

- CTA → CT angiography is used to study the blood vessels with the help of contrast media or dye.
- Contrast dye highlights the blood vessels and allows blockages in arteries to be seen with out using invasive method of angiography.

⇒ In CT scan Hounsfield developed CT numbers of standardized linear densitiometic scale.

In this scale water is '0'
air is '-1000'
bone is '+1000'
represents the density of tissue.

Advantages of CT Scan -

① CT scan is painless and non-invasive way to diagnose patients
② It overcomes super imposition of structures
③ Improves contrast of the image
④ It can measure small differences in tissue contrast

⑤ It takes just 15-20 minutes to study the images.

Limitations -

① There is a need of radiation exposure and use of contrast material / medium or dye in most cases.

② Risks associated with CT scans include cancer risk, allergic reactions due to contrast agent (rashes / itching)

③ There are chances of harm to unborn babies in pregnant women.

Uses of CT scan (Applications) -

① Examine internal and bone injuries

② Diagnose spinal problems and skeletal injuries

③ Detect osteoporosis (a case in which bone loose calcium and become hollow)

④ detection of cancer & spread of tumors.

⑤ locate infection and blood clots.

⑥ diagnose heart diseases.

⑦ guide procedures such as surgery, biopsy and radiation therapy.