Basics of Imagelogy (S9)
For Radiology Technicians
Paper III Theory
Standard –XI

Dr. Ingale Jayashree

Reference Book

Basics of Imagelogy (S9)

Radiology Technicians

Paper III Theory

Standard –XI

Dr. Ingale Jayashree

Directorate of Vocational Education and Training,
Maharashtra State Mumbai 400 001.

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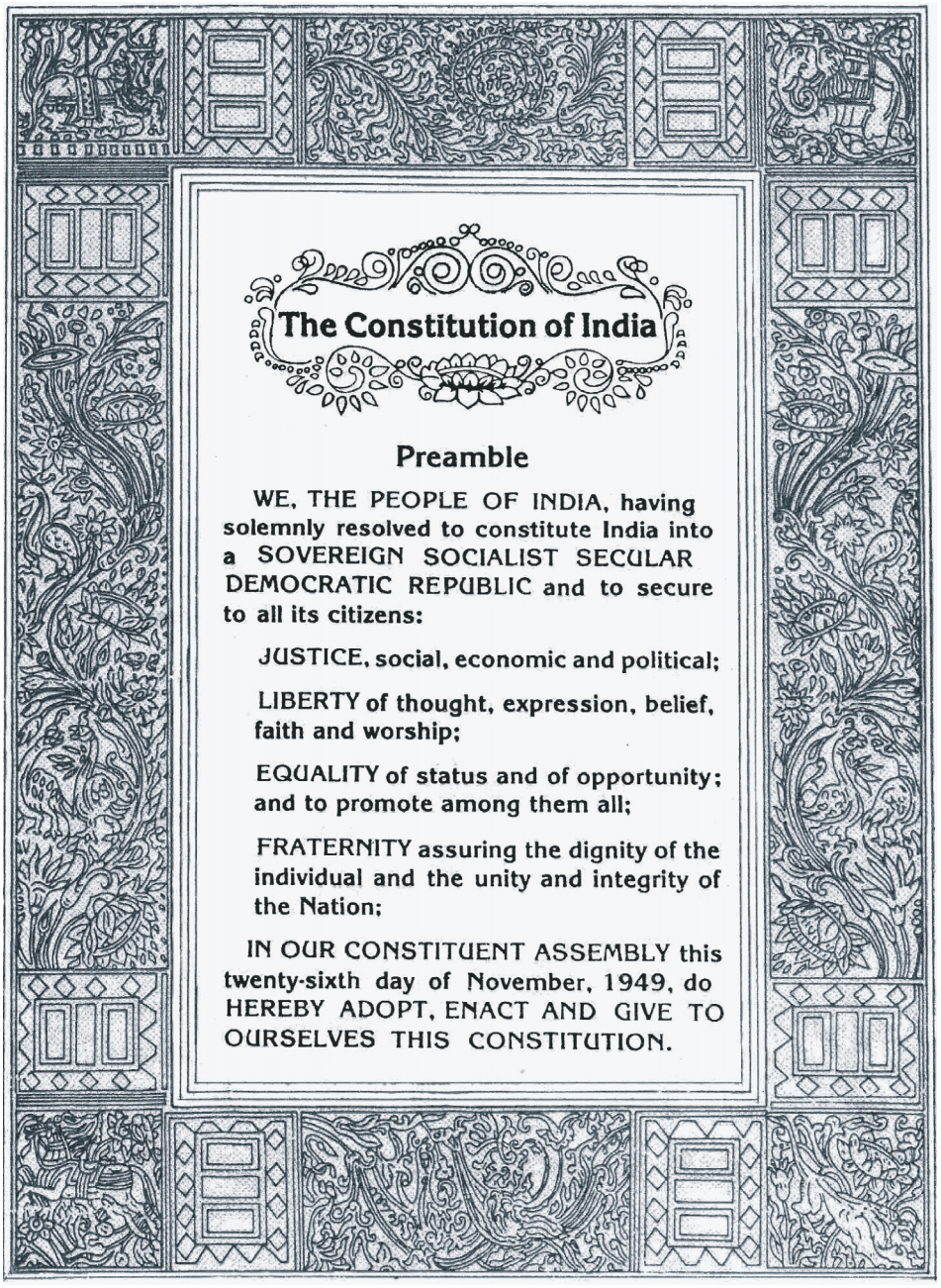

The Constitution of India

Preamble

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC and to secure to all its citizens:

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all;

FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.

****

NATIONAL ANTHEM

Jana-gana-mana-adhināyaka jaya hē

Bhārata-bhāgya-vidhātā

Punjāba-Sindhu-Gujarāta-Marāthā

Drāvida-Utkala-Banga

Vindhya-Himāchala-Yamunā-Gangā

Uchchala-jaladhi-taranga

Tava subha nāmē jāgē, tava subha āsisa māgē,

Gāhē tava jaya-gāthā,

Jana-gana-mangala-dāyaka jaya hē

Bhārata-bhāgya-vidhātā,

Jaya hē, Jaya hē, Jaya hē,

Jaya jaya jaya jaya hē.

****

PLEDGE

India is my country. All Indians are my brothers and sisters.

I love my country and I am proud of its rich and varied heritage. I shall always strive to be worthy of it.

I shall give my parents, teachers and all elders respect and treat everyone with courtesy.

To my country and my people, I pledge my devotion. In their well-being and prosperity alone lies my happiness.

PREFACE

The national policy of education (1986) envisages that the introduction of systematic, well planned and rigorously implemented programme of vocational education is crucial in the proposed educational reorganization. In accordance with the policy of Govt. of India, State govt. of Maharashtra introduces +2 Vocationlization of Education in 1988-89. During last 25 years no substantial efforts has been taken to revamp the curriculum.

Ministry of Human Resource Development, Govt. of India developed the National Skill Qualification Framework (NSQF) to introduce vocational courses according to series of levels of knowledge & skills. Qualifications are made up of vocational standards for specific areas of learning units or units of competency. Units of competency are the specification of the knowledge and skill to the standard of performance expected in the workplace. The unit of competency or National Occupation Standards comprising generic and technical competencies an employee should possess is laid down by the Sector Skill Council of the respective economic or social sector.

The challenges before us were to make smooth transition of curriculum from knowledge based to skill based and rapid technological changes in all sectors of economy. Hence, the few obsolete courses were either merge with core courses or deleted. Hence, in first phase 30 courses were converted into 20 courses. In second phase 20 more courses can be added sector wise as per National Occupational Standards.

I acknowledge the hard team work done by District Vocational Education & Training Officer, who were the coordinators for curriculum designing, theory & practical books writing, along with the vocational teachers of various vocational field & experts from the industry. Shri.S.M.Haste, Joint Director & Shri.A.G.Gavit, Dy.Director has taken the sincere efforts from Directorate to produce the best text material with limited resources & time.

J. D. Bhutange

Director (Vocational Education)

Directorate of Vocational

Education and Training,
Mumbai,

Maharashtra State

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Paper-III Basic Imageology

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Unit-1

Radiation & Radiation Measuring Units

- **Objectives :- At the end of this lesson you will be able to know radiation, types of radiation electro magnetic radiation. Sources of radiation, Roentgen, Rad, Rem, Sievert, Cathode rays & x-rays.**

• 1.1 Radiation :-

Radiation is defined as form of energy which can travel from one place to another in vacuum i.e. without any medium.

- **Types of Radiation :-**

There are 3 types of Radiation.

(1) Alpha rays

(2) Beta rays

(3) Gamma rays (X-Rays)

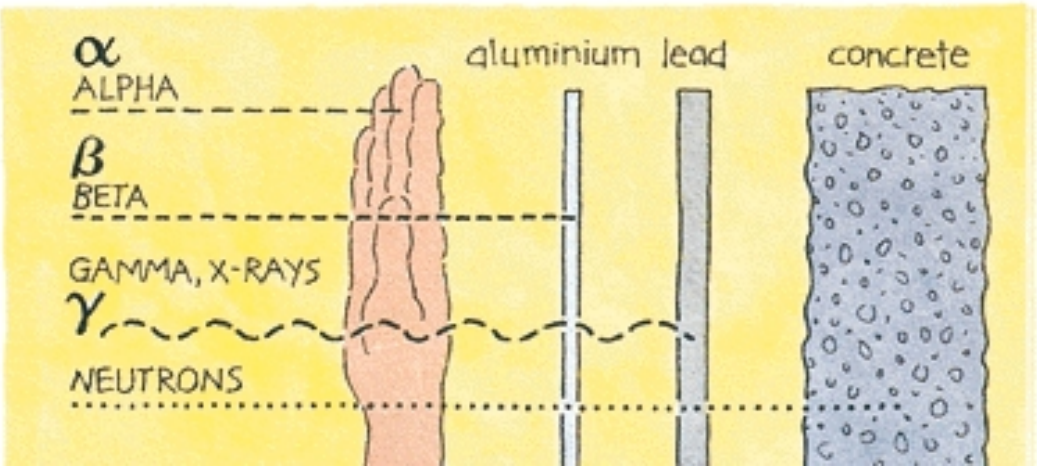


Fig.1.1

1. Alpha Radiation :-

Is made up of fast moving helium nuclie. The helium are called alpha particles. The particles have a positive charge. Alpha particles change direction if they pass through an electric or magnetic field. They are said to be deflected by the field, Alpha particles are quite easily stopped by thin materials. Even air will stop them. If you hold a Geiger – Muller tube more than a few centimeters from an alpha source, you will not able to detect the radiation. It is stopped by the air.

2. Beta Radiation:-

Is made up of electrons moring at high speed. The electrons are called beta particles. They have a negativew charge. Like alpha particles, they are deflected by electric and magnetic fields. But because they have a negative charge instead of a positive charge, they are deflected in the apposite direction. Beta Particles are not stopped as easily as alpha particles. Beta Particles can travel several meters in air.

3. Gamma Radiation:-

Is not a stream of particles. It is a form of electromagnetic radiation. Gammo radiation dose not carry a charge, so it is not deflected by electric or magnetic fields. Gamma radiation has very high energy. It can even pass through several centimeters of lead or an even thicker piece of concrete.

1.2 Electromagnetic Radiation :-

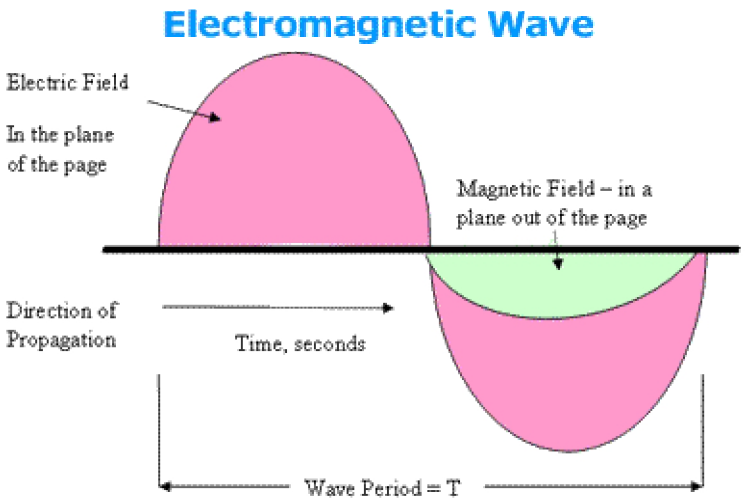


Fig.1.2

The electromagnetic waves, which constitutes different types of radiation like infrared radiation, risible light etc. are the constitute part of the much wider range of radiation called electromagnetic radiation.

The common things of all waves in Radiation are **:** -

(1) They are all rapidly fluctuating electric and magnetic field.

(2) They all travel through free space with the same velocity as of light.

(3) In free space they increase square law i.e.

a. In passing through a matter intensity of the Radiation is reduced.

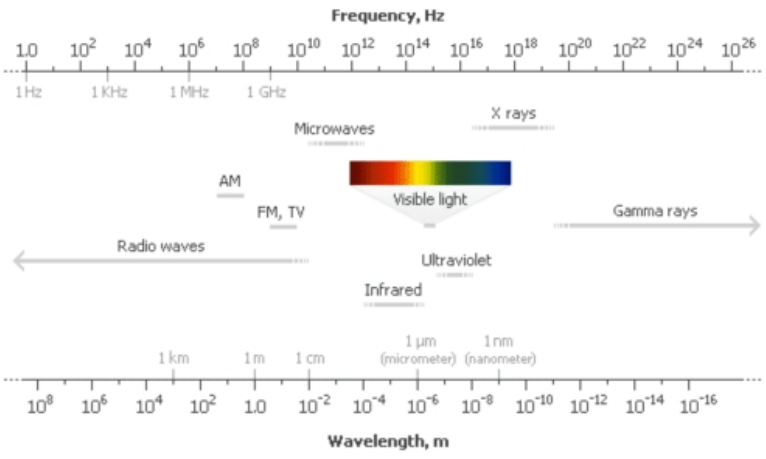
b. And some is deflected form its original path to travel in new direction.

(4) In free they all travel in a straight line and transfer energy from place to place in quantum.

(5) The water energy transfer the hardest ray but the smaller energy transfer travel the softer X-ray.

The example of continuous Radiation is rainbow where there is an unbroken hand of colors gradually changing from dark radiation side to dark violet

1.3 Sources of Radiation :-



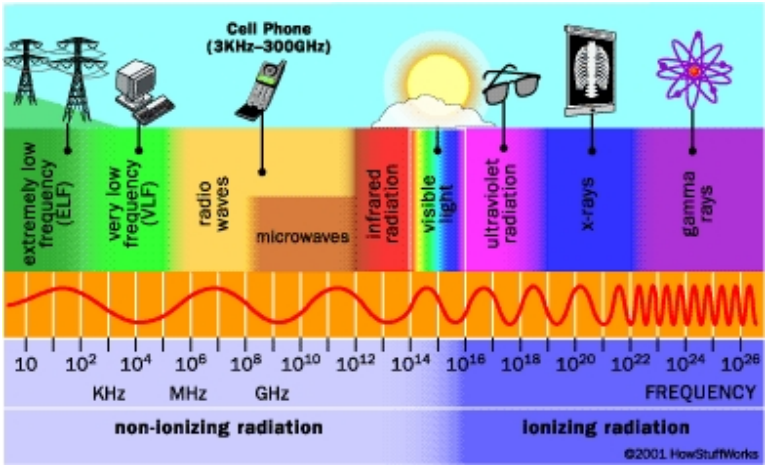


Fig. 1.3

Radiation occurs when energy is emitted by a source & then travels through a medium such as air until it is absorbed by matter.Radiation can be described as 2 basic types :- 1) **Ionising** 2) **Non-Ionising** Radiation.

a) Ionising Radiation :- Some types of Radiation have enough energy that they can knock electrons out of their orbits around atoms,upsetting the electron/proton balance & giving the atom a positive charge.Electrically charged molecules & atoms are called ions.The radiation that can produce ions is called ionising radiation.

b) Non-Ionising Radiation :-People use and are exposed to non-ionising radiation sources everyday. This form of radiation does not carry enough energy to ionise atoms or molecules.e.g.,microwave ovens,global positioning systems,cellular telephones,television stations.FM and AM radio,baby monitors,cordless phones,some electric appliances etc.

c) Natural Background Radiation :- This radiation is always present all around us.Our bodies are adopted to eat,is known as “Natural Background Radiation”.

It is Subdevided into :-

1) Cosmic Radiation

2) Terrestrial Radiation.

3) Inhalation.

4) Ingestion.

d) Artificial Radiation (Man-Made Sources) :-

E.g., Atmospheric Testing, Medical Sources, Industrial Sources,Nuclear Fuel Cycle etc.

1.4 Roentgen :-

It is unit of exposure as a measure of the radiation being delivered to a particular area, based on the joining ability of the radiation. The direct measurement of observed dose is difficult as well as impractical. Therefore the amount of ionization by a beam of radiation in air is measured and this is called that it is the amount of radiation observed in air at a given point i.e. no. of ions produced in 1ml. of air.

Presently Roentgen is being replaced by SI units called coulomb / Kg.

One Roentgen = 2.58 x 10 coulomb / kg. air.

The Roetgen is limited to X-rays and gamma rays upto 3 MV (Million Volt)

- **Rad :-**

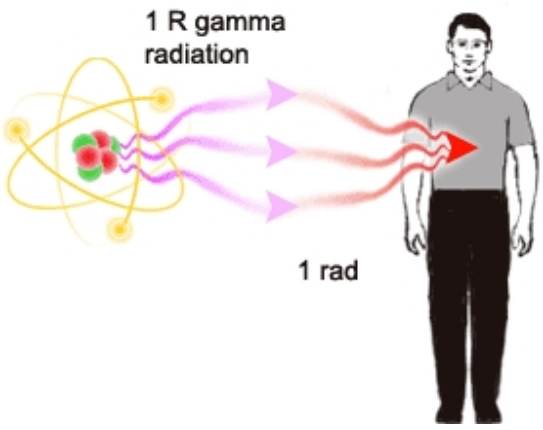


Fig.1.4

It is the most commonly used unit. It is the unit of 'absorbed dose' since only the energy actually transferred to irradiated volume is responsible for the ensuing logical changes 'rad' is the amount of radioactive energy absorbed per gram of tissue or only material.

These days 'rad' is being replaced by

Gray (GY) =

Gray (GY) = 1 Toule / Kg.

Thus 1 Gray = 100 rads

For each rad given, each gram of tissue will absorb an energy of 100 ergs. In the usual therapy range of 100kv to 2mv the absorbed dose in soft tissues exposed to 1R (Roentgen) is approximately 1 Rad with an error of only a few percent.

- **Rem :-**

It is the product of absorbed dose and the modifying factors. It indicates the degree of potential dangers to health. Present day concept is that Maximal Permissible Dose (MPD) should not be more than 5 rems over a period of 30 years to whole population for from all societies.

1.5 Cathode Rays & X-rays :-.

- **Production of Cathode rays :-**

When a potential difference of a few thousand volts is applied between the electrodes of a discharge tube and the pressure in the tube is gradually reduced, the discharge is observed to pass through various stages. When the pressure decreases to about 0.01 mm of mercury, the crooks dark space completely fills the discharge tube. At this stage the walls of the tube opposite to the cathode begin to glow with a greenish fluorescence. This fluorescence is due to the impact of some invisible rays coming out from the cathode. These rays are called cathode rays.

Properties of cathode rays :-

(1) Cathode rays travel in straight lines.

(2) Cathode rays are emitted in a perpendicular to the surface of the cathode.

(3) Cathode rays exert mechanical pressure on the surface on which they are incident

(4) Cathode rays are defle3cted by a magnetic field.

(5) Cathode rays are deflected by an electric field.

(6) Cathode rays affect produce fluorescence in many substances.

(7) Cathode rays produce ionization of a gas through which they are allowed to pass.

(8) Cathode rays affect photographic plates

(9) Cathode rays can penetrate through thin foils of aluminum or gold.

(10) Cathode rays are constituents of the atoms of all substances.

(11) When cathode rays are suddenly stopped. X-rays are produced.

- **Use of cathode rays :-**
  (1) Cathode rays are for the production of X-rays.
  (2) Cathode rays produce florescence in many substance.
- **X- Rays :-**
  - **Production of X-rays :-**

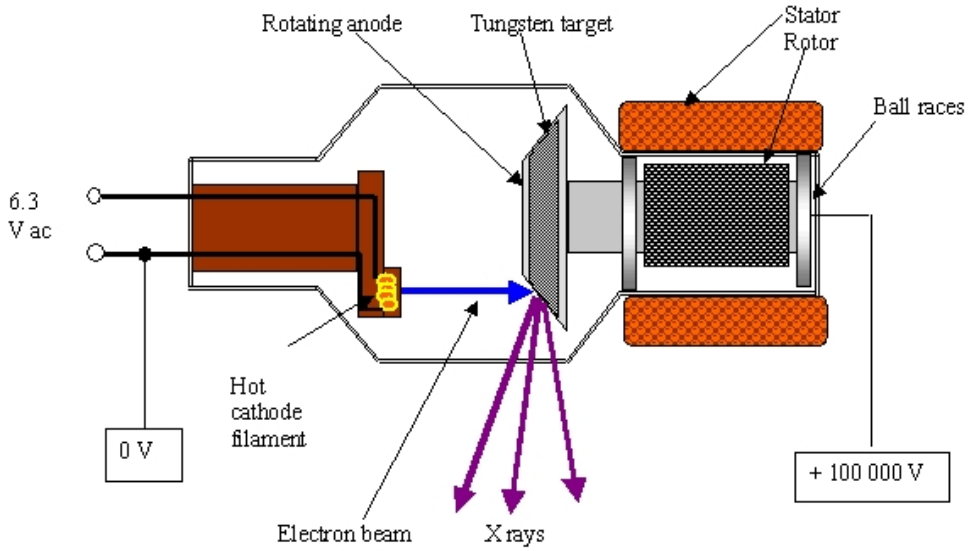


Fig. 1.5

In 1895, Prof. Roentgen – A German Physicist discovered. While was performing experiments to investigate the properties of cathode rays.

X- rays are produced when cathode rays, i.e. fast moving electrons are suddenly stopped by collision with an obstacle.

The early form of the X-ray tube used for the production of X-rays is shown in if is a discharge tube containing a gas at very low pressure. The anode is a thick rod of tungsten. Which also acts as a target. Cathode rays emitted by a concave cathode are focused at the centre of the target. They are stopped by the target from which X-rays emitted.

It was not possible to control the wavelength and intensity of X-rays produced by such X-ray tubes. There these X-ray tubes were replaced by the X-rays tubes of a type designed by an American Physicist named Coolidge.

A Coolidge X-ray tube is an evacuated glass bulb in which electrons (i.e. cathode rays) are obtained from a heated tungsten filament kept at the centre of a concave cathode. The filament is heated electrically by a battery or a low voltage transformer. The anode is a thick copper rod. A piece of metal such as tungsten or molybdenum, having a high melting point is kept embedded in the face of the copper rod and this piece acts as the target. A high P. D. of about 10,000 volts is maintained between the

anode and the cathode. The heated filament emits electrons which are focused on the target by the concave cathode.

When the electrons emitted by the filament with very high velocity are suddenly stopped due to their impact on the target X-rays are produced only a small part of the energy of the electrons is converted into X-rays. The remaining large part of energy is converted into heat. Even though the target has a high melting point, the large quantity of heat is capable of melting the target. The prevent this the heat produced is conducted oway by the thick copper rod forming the anode. In some tubes, the anode is kept cooled by circulating water around it.

The target is kept inclined to the axis of the tube at an angle of 45^0, so that X-rays are emitted from the target in a direction perpendicular to the axis. The X-ray tube is enclosed in a thick lead box provided with a small window X-rays pass through the tube and emerge through the window in the lead box.

The intensity of X-rays depends upon the number electrons emitted by the filament per second. This depends upon the temperature of the filament which in turn depends upon the filament current. By adjusting the filament current, the intensity of X-rays can be controlled.

The entreating power of the X-rays depends upon their energy which in turns depends upon the velocity with which the electrons strike the target. The velocity of electrons depends upon the P.D. applied between the anode and the cathode. By adjusting the P.D. applied between the anode and the cathode. By adjusting the P.D. the penetrating power of the X-ray is greater if a target of greater atomic number is used.

- **Properties of X-rays :-**
  (1) X-ray are electromagnetic waves of very short wavelengths. Their wavelengths range from 10^{-10} m to 10^{-8} m.
  (2) Being electromagnetic waves, the velocity of X-rays in air or vacuum is the same as the velocity of light i.e. $3x10^8$ m/s.
  (3) X-rays are not deflected by eclectic or magnetic fields. Intense X-rays are not charged particles.
  (4) X-rays are diffracted by crystals. Their diffraction proves that X-rays are electromagnetic waves.
  (5) X-ray are affect photographic plates.
  (6) X-rays produce ionization in the gases through which they are.
  (7) X-rays produce fluorescence in many substances.
  (8) When X-rays are incident on metal surfaces, electrons are emitted from the surface.
  (9) X-rays kill living plant and animal tissues. Hence long exposure to X-rays is harmful.
  (10) X-rays have a high penetrating power. They can penetrate through paper, wood sheets of lighter metal, flesh etc. They cannot penetrate through heavy materials such as thick sheets of lead or iron, bones of animals etc.

Unit-2

Radioactivity

- **Objective :- At the end of this lesson you will be able to State the structure of Atom, Nucleus, Atomic Mass No. & learn Isotopes & Radioisotopes, Radioactive Decay,**

Radioactive substances, their properties, uses in medical field, artificial & natural radioactivity & its units.

2.1 Atomic & Nuclear Structure :-

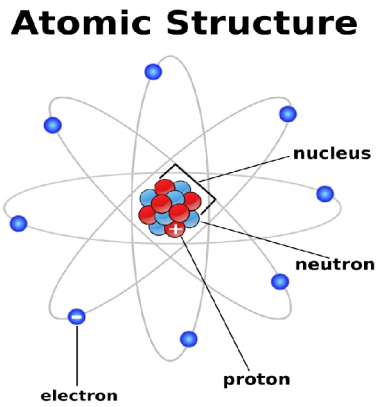


Fig. 2.1

The Atom is smallest part of element. Atom consist of tvely charge protons and uncharged neutrons.

The electrons which are negatively charged revolve around the nuclease in certain orbits.

2.2 Atomic Number, Mass Number :-

- **Atomic Number :-**

  The number of protons or tve charge in the neucleas of atom presents its atomic number.

- **Mass Number :-**

  Total number of protons neatrons in tve neucles or an atom denots its mass number.

2.3 Isotopes & Radioisotopes :-

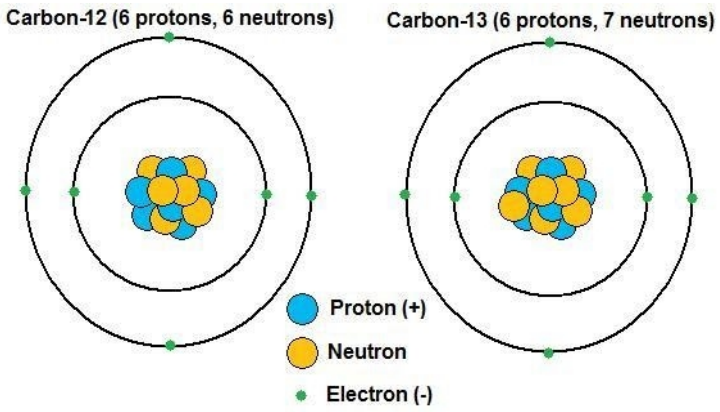


Fig. 2.3

- **Isotopes :-**

Atoms which have same atomic number Z but have different mass number are called Isotapes. Eg. Deutrium nucleas has one proton and one neutron.

- **Production of Radioisotapes :-**

The way in which isotopes arise in the radioactive elements can be understood in storms of the effect of radioactive decay on the atomic number and atomic weight. Each time an ∂ particles is emitted the charge of the nuclease of the radioactive atom decreases by two units, since the ∂ particle carries a positive charge of two units. At the same time, the atomic mass decreases by four units.

Each time a B – Particle is emitted, the nuclear charge increases by one unit because one negative charge is removed, but the mass is practically uncharged.

Thus the emission of ∂ particle causes a decrease of two in the atomic number i.e. a shift of two places to the left in the periodic table. The emission of a B–Particle causes an increase of one in the atomic number. i.e. a shift of one place to the right in the periodic table.

This law, first deduced by soddy and fajans in 1913, is known as the displacement law of radioactivity. Consider what happens as a result of the radioactive decay of the element called uranium I (UI) with an atomic number of 92 and an atomic weight (or mass number) of 238 units. This element emits and ∂ particle and according to the uranium X1 (UX1) has an atomic number of go and a mass number of 234. Uranium X1 emits a B – Particle giving the product uranium X2 (UX2) with an atomic number of 91 and a mass number of 234; UX2 in turn emits a B-Particle giving the element uranium II (UII), with an atomic number of 92 and a mass number 234. Hence, UI and UII have the same atomic number 92.

It follows that these two elements must be entirely iilentical in all element from each other by chemical means; they are isotopes.

2.4 Radioactive decay :-

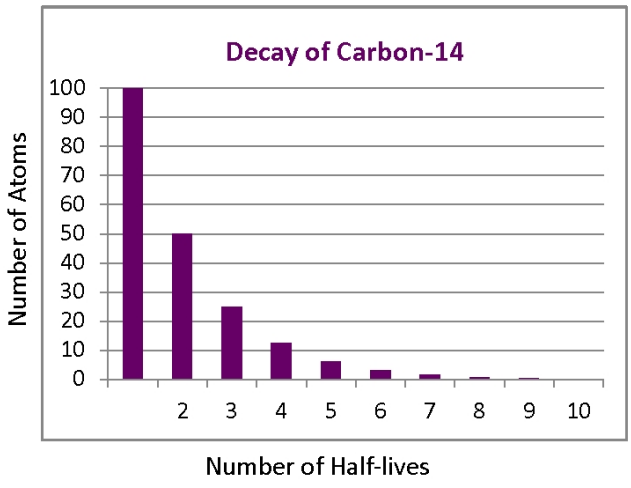


Fig. 2.4

Along of heavy element like uranium, thorium, polonism & radium etc. constantly breaking up into fresh radioactive atoms with the emission of ∂ B and Y rays from their nuclei.

In the process the original (or Parent) atom disappore and gives to new (daughter) atom.

This series is continuous until and inactive element (Usually lead) is reached.

This spontinuous breaking up of the nucleas is known as radioactive disentrigation.

E.g. :

When Radium (Ra.) disentigrates by injucting an ∂ particlesing nucleas loses anet positive charge of 2 units and mass of 4 unit. Hence it changes into a new atom called radon (Rn). It means that there occurs transmutation of radium in to radon.

- **Laws of Radioactive Disentigration : -**

Radioactive desentigration is found to obey the following two laws:

1 Atoms of all radioactive elements undergo spontenuous desentigration to form fresh radioactive products with the emission of ∂ B. and & ray's.

2 The rate of radioactive desentigration i.e. the number of desentigration per second is not affected by enviormental factors (like temp, pressure and chemical etc.) but depends on the number of the atoms of original kind present at any time.

2.5 Radioactive Substances & their properties :-

- **Radioactive Substance :-**

The Phenomenon of spontaneous emission of radiations by disintegration of nuclease is called radioactivity and such substance which emit these rays are called Radioactive Substance.

2 Characters of Radioactive Substance (Properties) :-

(1) These radiations are high penetrating power.

(2) They affect photographic plate

(3) They ionize the gases.

(4) They couses scintillation on fluroscent screen.

(5) They develop heat and produce chemical changes.

(6) They produce fluroscence in certain materials.

(7) They emission of radioactive substance is spontinuous and is not affected by external agent.

(8) They are absorbed by matter and stopped by an aluminium foil of thickness 0.01 cm.

2.6 Uses of Radioactive substance in Medical Field :-

(1) Gamma rays are often used to kill bacteria and viruses on dressings, syringes, and other medical equipments. This is called sterilization. Sterilisation means killing all living things. These items used to be sterilized using very high temperatures, or steam. Gamma radiation is a more convenient and more effective method.

(2) Cancer cells can be killed by radiation:-

Cabalt 60, Phosphors 32 or strontium 90 may be used.

(3) They kill living plant and animal tissues. Hence long exposure to X-rays is harmful.

(4) They can pass through skin and flesh but they cannot pass through the bones. Therefore they can be used to photograph the bone structure. Fracture of bones, presence of foreign bodies such as bullets or gold hidden in the human body can be detected by means of X-ray & photographs.

(5) They are used to cure skin disease and to destroy tumours in a body.

(6) They used for treatment of tumours.

(7) They used for sterilization of foodstuffs.

(8) They used for nuclear pacemakers for the heart.

(9) They used for checking blood circulation and blood volume.

(10) They used for radiographs of casting and teeth.

2.7 Artificial & Natural Radioactivity :-

- **Artificial Radioactivity :-**

It was discovered by Mr. & Mrs. Juliet that products of some artificial nuclear reaction were radioactive.

This process of artificial radioactivity founds when Juliot exprements for studying effect of ∂ particles bombardment on the light element like boron, aluminium & magneshium etc.

As shown in fig Juliot bombarded aluminium with ∂ Particle for polonium and measured the energies of ejected neutron by recooling of protons from paraffin.

They also found even after polonism source was taken away, the detector continued to respond to some kind of penetrating radiations. There were later found to be positions.

By repeated experiments it was continued that under the bombardment of ∂ particle, aluminium become by it own Right.

- **Natural Radioactivity :-**

Natural radioactivity is that which is exhibited by elements as found in nature.

It is always found in heavier elements in periodic table.

It is discovered by Bacquerel in 1896 almost one year after discovery of X-ray by Roentgen.

Bacquerel discovered that heaviest element like uranium gave out some kinds of radiations which are highly penetrating, could affect photogtraphic plate, ionize gases couse scintillation in fluroscent screen.

It was also discovered that radioactive herior of uranium was unaffected by temp, pressure electric & magnetic field etc.

The radioactive radiations emitted by these elements are.

(1) Alpha (∂) rays or ∂ particle.

(2) B- rays or B Particles.

(3) Y- rays or Photons.

- **Assignment**

Q. 1. Choose the correct word & rewrite the sentence.

1) Protons are _____ charged. (Positive, Negative, No).
2) Electrons have _____ charge. (Positive, Negative, No).
3) The neutrons & protons are held together by _____ energy. (Atom, mass, binding).
4) The Electrons revolve arround the nucleus in certain _____ (atom, proton, orbit).
5) Neutrons have _____ charge. (Positive,No,Negative).

Q.2. Match the following.

'A' Group	'B' Group
1) Atom	1) Total no.of protons & neutrons.
2) Mass Number	2) No. of Protons.
3) Atomic Number	3) Same atomic no. & different mass no.
4) Isotope	4) The central & innermost part of atom.
5) Nucleus	5) Smallest particle of substance.

Unit-3

Interaction of X-Rays with matter

3.1 Interaction of X-rays with matter :

- **Objective:-** At the end of this lesson you shall be able to

3 State Interaction of X-Rays with matter.

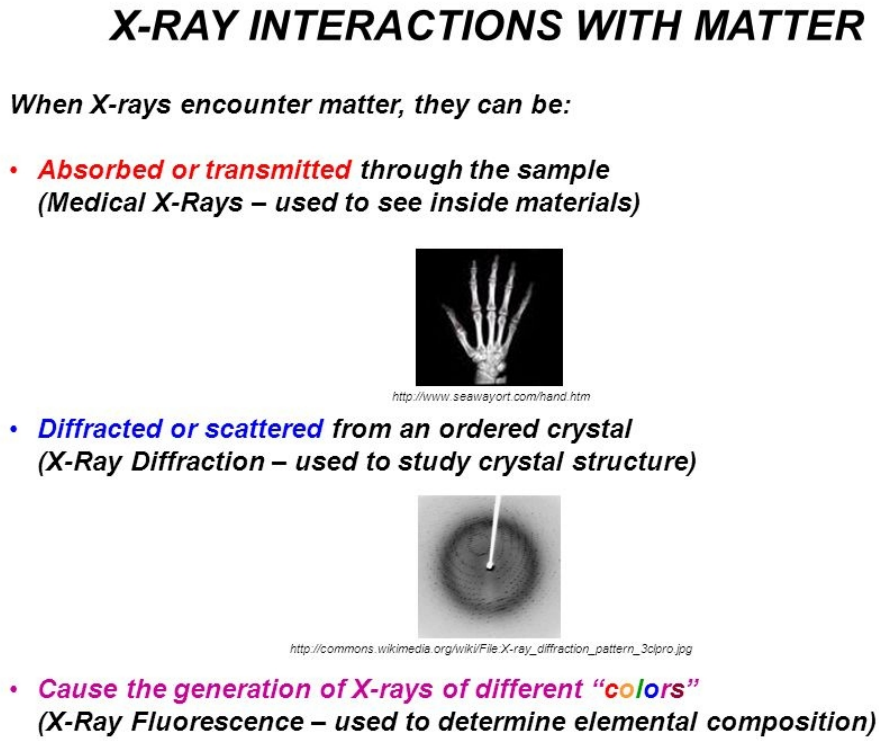


Fig. 3.1

On of the important properties of X-rays of course, their strong penetrating power. The extent to which a beam of X-rays will penetrate in to a substance depends on the nature of the X-rays as well as on that of the substance, and to some extent X-rays can be characterized by their penetrating power in a given material. A rough differentiation may be easily absorbed, and hard rays, which have relatively high penetrating power. A distinction may also be made, on the basis of their absorption between homogenous X-rays. The absorption of a homogenous radiation can be described by the formula.

$I = Joe^{-ud}$

Where Io represents the observed intensity of the beam incident normally on the absorbing material. I is the intensity after passing through a thick nessd, and u is a constant, called the absorption coefficient.

The process of absorption of X-rays is complicated and involves several phenomena closely connected with the properties of atoms. When a beam of primary X-rays coming from the anticathode of an X-ray tube falls on a plate some chosen element, part of the radiation goes on through the plate, while the rest is transformed into heat, or into radiation of another sort. The rays going out from the pate consist in part of primary X-rays, the transmitted beam, and in part of rays excited by the primary beam and called collectively the secondary radiation. Is a schematic representation of what happens. The secondary radiation contains four distinct, important types of radiation a) scatterd X-rays (b) characteristic X-rays (c) scattered B-rays d) characteristic B-rays. The B-rays are not of interest for the present and will be discussed in a later chapter. The X-rays of the secondary radiation have turned out to be a fruitful source of information about atoms.

The scattered X-rays have very nearly the same absorption coefficient in a given material as the primary rays: they seem to be primary rays which have merely and their direction changed by the material through which they pass, and their character is independent of the nature of the from an X-ray tube are heterogenous, the scattered radiation is also heterogenous provided the absorbing plate is not too thick.

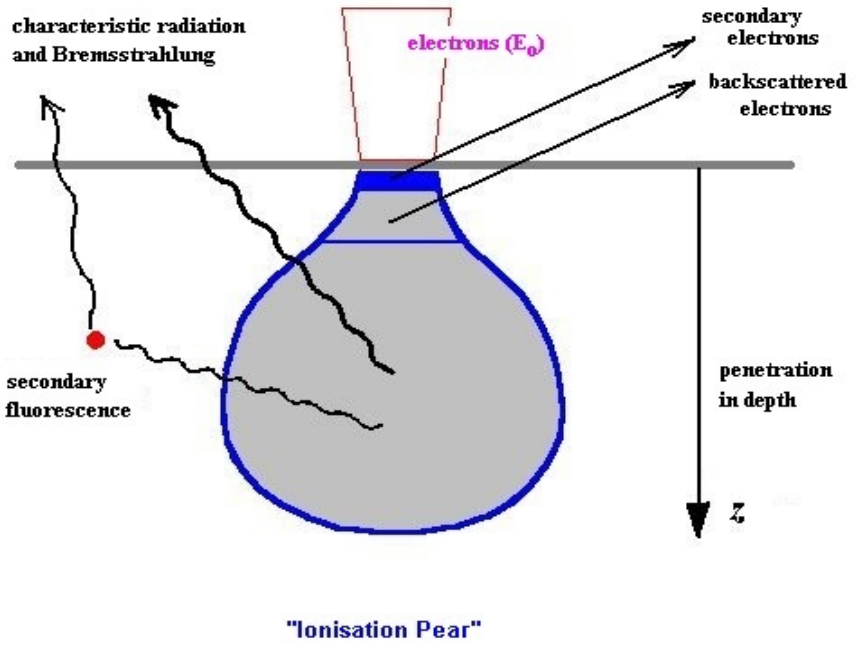


Fig. 3.2

3.2 Ionization & Atenuation :-

- **Ion :-** Atom or molecule in which the total number of electrons is not equal to the total number of protons, giving it a positive or negative electrical charge.
- **Ionizing Radiation :-**
- Radiation (such as high energy electromagnetic photons behaving like particles) that is capable of ejecting orbital electrons from atoms.
- Can also be particles (e.g. electrons)
- Ionizing energy required is the binding energy for that electrons shell.
- Energy units are electron volts (eV or keV),the energy of an electron accelerated by 1 volt.
- For Hydrogen K orbital electrons, E=69.5 keV
- In medical imaging we need photons with enough energy to transmit through tissue.so are in range of 25 keV to 511 keV and is thus ionizing.

3.3 Absorbtion co-efficient: -

- **Objective:-** At the end of this lesson you will be able to State Absoption co-efficient.

The absorption coefficient determines how far into a material light of a particular wavelength can penetrate before it is absorbed. In a mate with a low absorption coefficient depends on the material and also on the wavelength of light which is being absorbed. Semiconductor materials have a sharp edge in thir absorption coefficient, since light which has energy below the bond gup does not have sufficient energy to excite an electron into the conduction band from the valence band. Consequently this light is not absorbed. The absorption coefficient for several semiconductor materials is shown below.

The above graph shows that even for those photons which have an energy above the band gap, the absorption coefficient is not constant, but still depends strongly on wavelength. The probality of absorbing a photons depends on the likelihood of having a photon and an electron interact in such a way as to move from on energy band gup, the absorption is relatively low since only those electrons directly at the valence band edge can interact with the photon to cause absoption. As the photon energy increases, not just the electrons already having energy close to that of the band gap interact with the photon. Therefore a larger number of electrons can interact with the photon and result in the photon being absorbed.

The absorption coefficient, is related to the exitinction coefficient, k, by the following formula.

$$\propto = \frac{4\pi K}{\varphi}$$

Where Ч is the wavelength. If Ч is in nm, multiply by 10^7 to to get the absorption coefficient in the units of cm^{-1}.

3.4 Modes Of Interaction :-

The interaction of x-ray with matter is more complex than simply passing through on reaching a material. Some of the x-ray will be absorbed and some scattered. If Neither process occurs the x-rays will be transmitted through the material when absorbtion occurs. the x-rays interact with the material at the atomic level.& can cause 'fluroscence'. X-rays can also be scattered from the material. This scattering can occure both with and without loss of energy called 'Compton' and 'Rayleigh' scattering respectively.

3.5 Energy Absorption from X-ray :-

When passing matter x-rays are absorbed if an x-ray beam of the intensity passes an absorber of the thickness X with a photon energy dependent linear absorption co-efficient. μ(E) the intensity loss will be in good approximation proportional to the intensity and the absorber thickness.

dl= -μ(E)I dx

Photoelectric absorption occures,when an x-ray photon transferes energy to an electron in an absorber as electrons bound in an atom show discrete

Energy levels there are only certain possible portions of energy to undergo transitions between the different levels.

3.6 Half Value Layer: (HVL) :-

The thickness of absorber needed to reduce the dose by one half is called HVL. It is expressed in mm. or cm.

It is a method of measuring radiation quality (type of radiation). Quality is changed by filtration. An increase in either atomic number of the thickness of the filter increase the penetrating ability of the beam. In other words half value layer increases. Above 1mm cu. An increase of HVL decreases the back scatter factor because an increasingly greater penltrage of radiation is scattered in forward direction and less in lateral or backward direction.

The material in HVL is usually copper, lead or aluminium.

3.7 Fluorescent & Photographic Effect:-

Luminescence:

The emission of light from a substance bombarded by radiation is termed luminescence and includes two effects; fluorescence and phosphorescence.

Fluorescence, which is the light emission we described earlier, lasts only as long as the radiation exposure. Phosphorescence, on the other hand, is afterglow i.e. light continues to be emitted for some time even after radiation exposure has ended.

4 Choice of Fluorescent Material:-

Materials which convert invisible radiation into luminous radiation are known as phosphors, and whilst a number of such substances exist. Only a few of them have applications in radiography.

Two qualities comman to the selected phosphor are:-

(1) They are very efficient at X-ray absorption.

(2) They fluoresce strongly, with little afterglow.

5 Examples of some of the phosphors available are:-

(1) Calcium tungstate
(2) Barium fluorochloride
(3) Barium lead sulphate
(4) Barium strontium sulphate
(5) Gadolinium oxysulphide
(6) Lanthanum Oxysulphide
(7) Lanthanum Oxybromide
(8) Yttrium Oxysulphide
(9) Yttrium Tantalate.

} Rare earth series.

The last five named are commonly known as earth phosphors.

6 Calcium Tungstate:-

It was the first substance to be used in commercial prapration of intensifying screen.

Unlies the other X-ray phosphor calcium tungstate luminescent in the fiver states and no requires any activator.

7 Rare Earth:-

In recent years new phosphor have been developed for no the rare earth series of element (i.e. those element with atomic number between 57 to 71) falled rare earth phosphor.

These phosphor have two important properties.

(1) Absorbing efficiency:-

Rare earth phosphore more efficient at absorbing X-ray photons at absorbing radiation than are of convential screen calcium tungstate.

(2) Conversion efficiency:-

The rare earth are more efficient of converting X-ray photons in to the light. Eg. 15.20% light conversion efficiency as compared to calcium tungstate is 3.5%.

These means that for a given radiographic exposure much more light is produced with rare earth screen an so exposure factor can be reduced.

So with rare earth screen are more fasten and hence more useful for radiographic imagine.

3.7 Photographic Effect:-

Objective:- At the end of this lesson you shall be able to

8 State Light sensitive photographic material.

9 List the Halogens State Lattent Image.

The effect on the chemical nature of the material is known as the photographic effect of radiation.

Some chemical compounds undergo subtle structural changes when they are exposed to electromagnetic radiations such as visible light, ultraviolet radiation or X-rays.

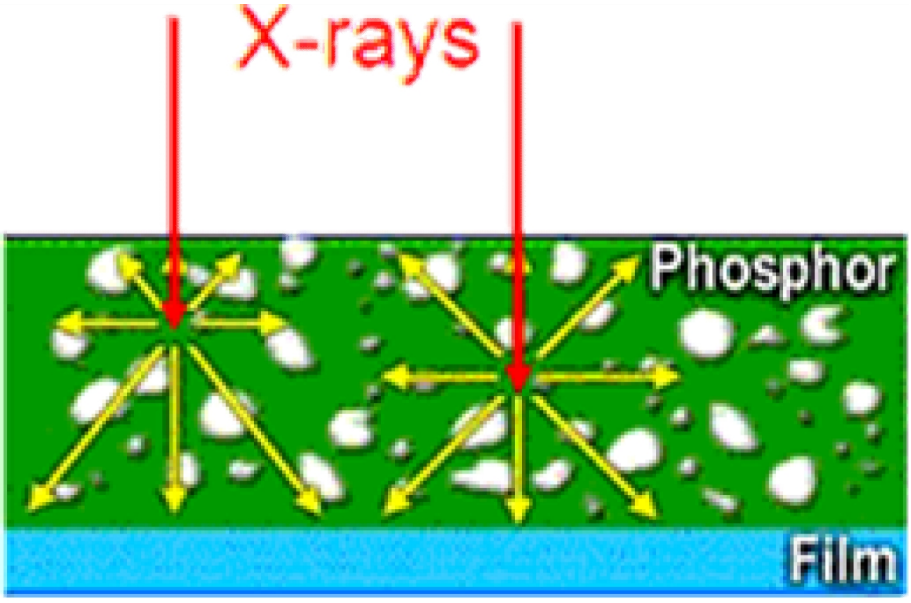


Fig. 3.7

10 Light Sensitive Photographic Material:-

The group light Sensitive Photographic Material is known as Halogens.

11 Halogens :-

Bromine
Chlorine
Iodine

These halogens combines c silver salts, which are silver halide crystal.

Silver Bromide
Silver Chloride
Silver Iodide

The salts undergo changes when exposed to light or X-ray which from the photographic image.

12 Latent image:-

It is defined as that invisible image produced in the film emulsion by light or X-ray, which is converted into the visible image after development.

The silver bromide cryste of photographic emulsion consist of + ve silver ion and - ve electons (bromine ions) which are arranged in geometric pattern called lattice.

When silver bromide grains exposed light or X-ray, the first occurance is that some of the bromine ions in the Lattice emits electrons. These electrons are able to travel through the craystal c great mobility and got them in a position called electron trap.

The silver ions in the crystals have + ve charge.

So in the formation of the latent image.

(1) Electrons (realized by light from bromine ions) are trapped by sensitivity centre.

(Electron trap regon is called sensivity centre)

(2) + ve silver ions are trapped at the sensivity centre by the negative charge on electrons.

(3) + ve charge on silver ions are neautralized by the negative charges on the electrons and silver atom is formed.

This process is repreat itself still latent image is formed.

In Short = Formation of Latent Image
= Coversition of Silver Bromide
→ In to metallic Silver.

(a) Similated by light or X-ray

1) Silver Bramide = Bromine ions (- ve)
Silver ions (+ve)

2) Bromine ions = Electrons are emitted

3) Electrons + Silver ions = Silver atom

This silver atom begins to form the latent image.

- **Assignment**

Q. Write short note on followings :

a) Latent Image

b) Rare earth phosphor

c) Ion

d) Absorption co-efficient

e) Names of phosphors

Unit - 4

Radiation Protection

4.1 RADIATION HAZARDS :-

- **Objective:-** At the end of this lesson you shall be able to

13 State Radiation Hazards – Reaction on skin, Alopecia,

14 Explain Reaction of mucous membrane. Know the treatment of local reach

15 Know Genetic effects.

Hazards means harmful effects to different organs of the body.

The effective hazard thus depends upon the nature and type of radiation and the ways the radiation is received whether externally or internally. Also depends upon total dose rate the extent and part of the body exposed, age and sex of individual and radiation sensitivity of the organs exposed.

External hazards are caused due to radiation received from the sources which are located outside of the body. The example are (X-ray, gammatherpy sources of Brachy therapy sources). The body can be exposed by keeping any source on the body on the away from the body.

Internal hazards are due to these is atopes which get located in to the body by inhalation or through mouth or nose or by injestion through the wounds.

The hazards are divided in to 3 main parts.

(1) Local Hazards On Skin → Skin rash, Itcheing
On Eye → Redness of eyes, Aloplecia.
On Hair → Alopecia.

(2) Systemic Hazards → (All systemic)
1) On blood forming organs – Liver and bone marrow
2) GIT – Acute Radiation Syndrome.

(3) Genetic effect:-
1) Genetic mutation
2) Chromosonal abnormality
3) Inferlity
4) Testies in male
5) Ovaries in female.

16 Local Hazards

Reaction of Skin:-

In skin there is period of 10 days or more depending upon the rate of input of dose before visible reaction is seen. After this a gradually increasing erythema occurs. This follows the phase of most desqumation which develops approximately 5 to 6 weeks after start of therapy.

After desquamation the exudation occurs which is last for several weeks. During this period skin becomes raw tender and it toached bleeds easily.

The reaction subside through a phase of re-epithalization.

When tolerance limit, skin and mucous membrane are beyond the tolerance this may lead to necrosis were would fells to heal. Precaution for care of skin to patient should be taken as follos.

(1) Patient should be told about the reaction.

(2) Do not apply heat not hot bath or hot water bottle or do not use ice bags.

(3) Do not scratch or the treated area:

17 Aloplecia:-

When haire bearing area is included in the treated zone aloplecia can be occur aloplecia usually beings about 3 weeks after the start of therapy and process rapidly regrowth of haire is usually noticed 3 months later and hearlly full growth weight be expected. In some patiects change in texture and colour may be seen.

18 Reaction of mucous membrane:-

After the short period of treatment reaction in mucous membrane may be develop in which completely white and yellowish mucous membrane appears.

During the appears course of radiation both the silk and mucous membrane reaction are painful deeping upon the sit patient may have Dysphagia horness of voice and sysrria in the reaction in bladder.

19 Treatment of Local Reaction:-

The golden is that the less this reaction are interfeared the better they heat. The ideal treatement is to keep damaged skin dry as long as possible and for the physiological stratification 0.75% junction violet in water is advoiced to be applied locally.

Systematic Hazards – All systemic

(1) On blood forming organs – liver and bone marrow.

(2) GIT – GIT disturbance like dysentery, vometting.

(3) Respiratory track infection – Like CO Lung.

(4) Infection

(5) Sepsis

(6) Debydration it not treated early.

(7) Death.

20 Genetic Effect:-

(1) Genetic mutation

(2) Chromosonal abnormality

(3) Inferlity

(4) Testies in male

(5) Avaries in female.

4.2 Acute Radiation Syndrome:-

Acute radiation syndrome is one of the radiation hazards. It is not seen in X-ray department.

It is more common in nuclear plants and atomatic wars when acute whole body exposure is more than 100^{k} to 1000^{R}.

When acute radiation hazard happenes, patient get.

(1) Fiver with chill

(2) Skin rash

(3) GIT disturbance like dysentery, vommeting.

(4) Infection

(5) Sepsis

(6) Dehydration if not treated early

(7) Death

E.g..1) Bombing on Hiroshima and Nagasaki in 1994 in 2^{nd} World War (In Japan)

2) 1991 – Atomic War between 4 Irea and USA.

4.3 Code of Practice for the radiation :-

The codes of safe practice stipulate minimum legal requirements that must be satisfied compliance with the codes is a condition on licence to use radioactive material or irradiating appratus .Radiation protection and nuclear safety agency is to provide accessible information about radiation ralated issues.A code of practice and corresponding safety guide may be published within a single set of covers.

4.4 Protection, Guidelines From AERB: -

- **Radiation Protection:-**

UNIT:– Units are necessary for quantetive disclibation of any physical concept. The units are devided.

i) Activity:- The activity of radiation sources indicates the out put of radiation from the sources.

ii) Expasure & dose:- The unit of exposure has been named as Roentgen is defind as Roentgen is the amount of radiation absorbed in air at a given point i.e. number of ions produced in IMI of air.

iii) Dose (absorbed dose): It is the amount of radiation energy absorbed from a beam of radiation per units mass of the absorbing material.

- **AIMS & OBJECTIVES:-**

The aim of protection is to protect the patient such an extend that there was not pain in the body.

So radiation can be given by maximum permissible dose (MPD) is defined as the dose of ionizing radiation which may not cause any body injury to the exposed patient.

- **Principal Protection:-**

There are three different ways by which the exposure can be reduced to different level. They are as follows:

(i) By increasing distance between sources area under consideration.

(ii) By providing shielding

(iii) By reducing the duration of exposure.

(i) Distance :- The intensity of radiation where is inversely as the squre of the distance. So to proect the patient from radiation hazards. We can increase the distances between sources the patient.

(ii) Sheilding:- The radiation when they pass through matter loses energy by interacting with the matter so by the shielding we can protect the patient from radiation hazards.

(iii) Time:- As long as the duration of exposure increases the patient can get radiation hazard. So we can reduce the hazard by reducing the duration of the exposure.

- **Methods of Protection:-**

(1) Use of Protective devices:

In case of protective devoice the technician should take his personal care of protection. The technician should position himself behind to the protective shielding. The technician should wear a protective apron of atlist point 25 ml lead equivalence when ever radiologist or technician have to stand close to the machines either in case of special procedures. The apron must be wear.

In case of C.T. scan machine the control panal is located in seprate room, the viewing window should have the lead equiralance such that it may offer the same protection as the rest of the wall.

In case fluoroscopy machine the control should be given to the technician hands by using hands gloves.

(2) Work Practice:-

All steps should be taken to conform that unnecessary exposure are not received by anybody either radiographer technician or patient. Hence all protective advice should be used. All such things should be adopted that the exposures are reduced.

To produce exposure & dose to the patient technician following things should be done.

1) The protective device should be regularly chacked.

2) To avoide necessary exposure that the red light warning singal is made on before giving exposure.

4.5 Lead Shielding :-

Appropriate shielding should be provided for the walls, the cellingand the floor of the X-ray room (floor shielding need not be considered, if the installation is on ground floor.) So that the doses received by the occupation ally exposed are kept well below 50 M 5V and to the population well below 5m Sr. As far as possible door should be so located that it dose not need any lead lining otherwise adequate lead shielding should be provided. In dark room the radiation levels should not more than 1.13 Mr (11.3μSV) per week.

In calculating the shielding of the walls distance of walls from the X-ray machine, "U" the use factor (the fraction of time the beam faces the wall), 'T' the occupancy factor (the fraction of the operating time of the machine for which the area, when the exposure are to be reduced, is occupied and the radiation level to be achieved have to be considered.)

4.6 Personal Radiation Protection:-

In this important is protect the X-ray technician from radiation hazards for this following roles should be used.

(1) Never remain in radiography room when exposure is in process.

(2) Protect yourself as a loaded cassette.

(3) Never hold a patient for radiotherapy.

(4) Always use lead gloves.

(5) Always use lead goggles.

(6) Always use lead shield.

(7) Always use lead apron.

(8) Always use lead screen

(9) Always use film Badge.

- **Assignment**

Q.1. Match the followings.

'A' Group	**'B' Group**
1) Lead Goggles	1) For Thyroid Gland
2) Lead Apron	2) For Hands
3) Lead Gloves	3) For Chest & Abdomen
4) Lead Collor	4) For Eyes

Q.2. Write a short note.

a) Acute radiation Syndrome.
b) Radiation Hazards-Systemic
c) Radiation Hazards-Local
d) Personal Radiation Protection

Unit - 5

Ultrasonography & its principles

- **Objectives :-** At the end of this lesson you will know the Ultrasonography, Its principles, Ultrasound System, Colour Doppler, Basics of Doppler.

5.1 Ultrasonography & its principles :-

- **Ultrasonography :-** All diagnostic ultrasound applications are based on the detection and display of acoustic energy reflected from interfaces within the body. These interactions provide the information needed to generate high-resolution, gray-scale images of the body as well as display information related to blood flow. The unique imaging attributes of ultrasound have made it an important and versatile medical imaging tool. Unfortunately, the use of expensive, state-of - the art ultrasound instrumentation does not guarantee the production of high-quality studies of diagnostic value. Gaining maximum benefit from this complex technology requires a combination of skills, including knowledge of the physical principles that empower ultrasound with its unique diagnostic capabilities. The user must understand the fundamentals of the interactions of acoustic energy with tissue and the methods and instruments used to produce and optimize the ultrasound display. With this knowledge the user can collect the maximum information from each examination, avoiding pitfalls and errors in diagnosis that may result from the omission of information or the misinterpretation of artifacts.

- **Principles of Ultrasonography :-** Ultrasound imaging and Doppler ultrasound are based on the scattering of sound energy by interfaces formed of materials of different properties through interactions governed by acoustic physics. The amplitude of reflected energy is used to generate ultrasound images, and frequency shifts in the backscattered ultrasound provide information relating to moving targets such as blood. To produce, detect, and process ultrasound data, numerous variables, many under direct user control, must be managed. To do this, the user must understand the methods used to generate ultrasound data and the theory and operation of the instruments that detect, display, and store the acoustic information generated in clinical examinations. This chapter will provide an overview of the fundamentals of acoustics, the physics of ultrasound imaging and flow detection, and ultrasound instrumentation with emphasis on points most relevant to clinical practice. Sound is the result of mechanical energy traveling through matter as a wave producing alternating compression and rarefaction. Pressure waves are propagated by limited physical displacement of the material through which the sound is being transmitted.

5.2 Ultrasound System :- Ultrasound scanners are among the most complex and sophisticated imaging devices currently in use. Despite their complexity, all scanners consist of similar basic components to perform key functions --- a transmitter or pulser to energize the transducer, the ultrasound transducer itself, a receiver and processor to detect and amplify the backscattered energy and manipulate the reflected signals for display, a display that presents the ultrasound image or data in a form suitable for analysis and interpretation, and a method to record or store the ultrasound image.

Transmitter :- Most clinical applications use pulsed ultrasound in which brief bursts of acoustic energy are transmitted into the body. The ultrasound transducer that is the source of these pulses is energized by application of precisely timed, high-amplitude voltage. The maximum voltage that may be applied to the transducer is limited by federal regulations that restrict the acoustic output of diagnostic scanners. Most scanners provide a control that permits attenuation of the output voltage. Because the use of maximum output results in higher exposure of the patient to ultrasound

energy, prudent use dictates use of the output attenuation controls to reduce power levels to the lowest levels consistent with the diagnostic problem.

The transmitter also controls the rate of pulses emitted by the transducer or the pulse repetition frequency(PRF).The PRF determines the time interval between ultrasound pulses and is important in determining the depth from which unambiguous data can be obtained both in imaging and Doppler modes. The ultrasound pulses must be spaced with enough time between the pulses to permit the sound to travel to the depth of interest and return before the next pulse is sent. For imaging, PRFs from 1 to 10 kHz are used, resulting in an interval of from 0.1 to 1 ms between pulses. Thus a PRF of 5 kHz permits an echo to travel and return from a depth of 15.4 cm before the next pulse is sent.

5.3 Colour Doppler & Basics of Doppler :- Conventional B-mode ultrasound imaging uses pulse echo transmission, detection, and display techniques. Brief pulses of ultrasound energy emitted by the transducer are reflected from acoustic interfaces within the body. Precise timing allows determination of the depth from which the echo originates .When pulsed wave ultrasound is reflected from an interface, the backscattered (reflected) signal contains amplitude, phase, and frequency information. This information permits inference of the position, nature, and motion of the interface reflecting the pulse. B-mode ultrasound imaging uses only the amplitude information in the backscattered signal to generate the image, with differences in the strength of reflectors displayed in the image in varying shades of gray. Rapidly moving targets, such as red cells within the blood stream, produce echoes of low amplitude that are not commonly displayed, resulting in a relatively anechoic pattern within the lumens of large vessels.

Although gray-scale display relies on the amplitude of the backscattered ultrasound signal, additional information is present in the returning echoes that can be used to evaluate the motion of moving targets .When high-frequency sound impinges on a stationary interface, the reflected ultrasound has essentially the same frequency or wavelength as the transmitted sound. If, however, the reflecting interface is moving with respect to the sound beam emitted from the transducer, there is a change in the frequency of the sound scattered by the moving object. This change in frequency is directly proportional to the velocity of the reflecting interface relative to the transducer and is a result of the Doppler effect.

- **Doppler Instrumentation :-** In contrast to A-mode, M-mode, and B-mode gray-scale ultrasonography, which display the information from tissue interfaces, Doppler ultrasound instruments are optimized to display flow information. The simplest Doppler devices use continuous wave rather than pulsed wave ultrasound, using two transducers that transmit and receive ultrasound continuously .The transmit and receive beams overlap in a sensitive volume at some distance from the transducer face.

Unit -6

C. T. Scan

Objectives : At the end of this lesson you will be able to Know Radiation dose, CT image & image display.

State production of CT image, intensity profile.

Know Raw data, convolution & Back Projection.

Know Algoriths & characteristics of image quality.

6.1 CONVENTIONAL C. T.

INTRODUCTION:-

The CT X-ray tube produces X-rays in the same way as conventional X-ray tube X-ray quanta depend on tube voltage (KV) and the product of tube current and scan time (MAS). The X-radiation realeased includes a spectrum of short wave length high energy beam called 'hard radiation' and longer wave length – law energy beam called 'soft radiation'. The higher the tube voltage (KV), the harder is the radiation. Intensity of radiation is directly proportional to tube current (MAS). When passing through an object, X-ray quanta may pass through unaltered, deflected or absorbed fully/partially and also get attenuated. The amount of attenuation depends on the thickness or material (tissue) of the object. The thicker the tissue, the greater is the attenuation.

RADIATION DOSE:

This is the relationship between the energy of X-ray beam absorbed in a body and the mass of the body. The biological effects are more tissue specific and mass size specific.

CT IMAGES:

The system measures density of tissue by using 'attenuation' quantity of x-ray beam. These attenuation values help to reconstruct an image which can be seen on monitor. The calculated attenuation values per pixel are displayed as CT VALUES in terms of "HOUNSFIELD UNITS" (HU) The CT value of water is 0 HU and that of air is -1000 HU, that of bone is between + 150 (cartilage) and + 5000 HU (dense bone).

IMAGE DISPLAY:

The calculated image is displayed on the monitor as a square field of pixels with specific Gray-scale values. Higher CT value tissues are whiter (light), and lower CT value tissues are blacker (dark). This square field is called "matrix"/ "pixels"/ "voxels". This image matrix can be modified from that stored in the processor by "windowing" for changing brightness and contrast, or by changing film exposure techniques.

PRODUCTION OF CT IMAGE:

TOPOGRAM : This is a digital survey image used for selecting the slice planes documented on it. For this, X-ray tube and detectors are kept in fixed position – AP or LAT. According to the topogram length selected, patient is moved with table top into the gantry opening.

TOMOGRAM: When these slices are acquired, tube and detector system rotate continually around the patient's body part. Projections are obtained in quick succession at different angular levels of rotation.

INTENSITY PROFILE:

It is the measurement of attenuated values at the detectors. Each projection has its own intensity profile. About 1000 projections (variable) are made for each slice. Each projection has about 704 sample values (variable). It is double the number of detector elements. About 700,000 sample data are measured for each slice approximately.

PRE-PROCESSING:

The image processor of CT unit reconstructs the CT images in 2 steps from the intensity profiles measured thus far. In the 1st step, the profile is converted into a format needed for image calculation. In the 2nd step, any deviations and alternative values due to physical/ technical reasons are corrected (beam hardening effect and linearity errors.)

RAW DATA:

The results of pre-processing are called "raw data", which can be temporarily or permanently stored in computer and used later for image-reconstruction as required.

CONVOLUTION & BACK PROJECTION:

In this step, the intensity profile can be streatched corresponding to the direction from which the profile was measured (as a projection) at the detector array. This process is called "back projection". If this projection is applied to the intensity profiles measured from various directions, without additional corrections, the details of resultant image are blurred. So a mathematical procedure called "convolution" is used to correct the above problem. It modifies the "raw data intensity profile" in order to determine the new image characteristics, which is sharper.

ALGORITHM:

We can further refine the image by using a parameter called <<algorithm>>. There are five standard setting for algorithms: smooth, standard and sharp. In these, the edges are high-lightended or softended, image sharpness increased or decreased and image noise is increased or decreased in the reconstructed image. Algorithms can be used to influence the contrast and transition from bone and soft tissues. These algorithm setting are organ specific and cannot be used one for the other. (E.g., Skull base/ inner ear). Selection of algorithm is determined by using the so called CONVOLUTION KERNELS (CK). There are 9CK available for each body part; I means very smooth, 9 means very sharp. Prefixes like AB, AH; CH, CB & SP are used with digits 1 to 9 for adult body, head, child head, body and spine.

CHARACTERISTIC OF IMAGE QUALITY OF CT:

The general characteristic that affect image quality of CT are: the noise, contrast, sharpness and artifacts. Too much of noise makes the image look granular and we may miss a small lesion in a given tissue. If the image is blur and not sharp, it is difficult to differentiate between the adjacent tissue details, because they blend with each other. Artifacts are structures seen in the image which do not pertain to normal appearance of that region. (e.g., Beam hardening artifact in posterior fossa). Only when these four diagnostic requirements are fulfilled, then the image is called "GOOD".

FACTORS AFFECTING IMAGE QUALITY:

(1) Thickness of the scanned slice-collimation.
(2) MX x Sec (scan time) product.
(3) Tube voltage (KV)
(4) Algorithm
(5) Patient Size
(6) Image display
(7) Documentation mode.

6.2 SPIRAL C.T.

INTRODUCTION :-

Single slice spiral CT (SSSCT) had a dramatic impact on the approach to CT scanning since its introduction, especially on the 'speed' of scanning. With 'slip ring' technology, improved detectors, x-ray tubes and advanced state of computer hard/soft wares the SCT presents new challenges to the radiologists, who must first of all

understand the fundamental difference between the conventional CT (CCT) and the SCT. This will enable him/ her to maximize its clinical impact.

New terms such as 'pitch' require appreciation as to how this parameter can be varied to optimize various rapid scans to translate as enhanced parenchymal details and thus increased detection of lesions. SCT allows 3D imaging that is useful for vascular imaging especially. The virtual endoscopy has become a reality with SCT. The new hardware and software packages and computer-aided automated dcanning technique (CAST) allows monitoring real time contrast enhancement following administration of IV contrast in the target organs/vessels (not bolus contrast medium advance); which in turn reduces the amount of CM to be used.

SPIRAL CT TECHNIQUES

This is a 'volume' scanning procedure in which patient on the couch moves continuously through the gantry, while the CT x-ray tube and the detector system keep rotating around the patient continuously and acquire data.

(1) As we do in conventional CT system, we have to first determine the slice thickness for any organ of interest.

(2) The rate of (patient-motion) table feed into gantry is pre-determined (pitch ratio 1:1 or 2:1 etc).

(3) 'Scan coverage' is the product of table feed and spiral CT duration (scan time). The faster it is, the better is resolution and longer area of the body can be scanned.

(4) Collimation' is selected according to region of interest (i.e., 5-8 mm for abdomen, 7 to 10 mm. for thorax, 5mm for the neck, 2-3 mm for small structures like blood vessels / lymph nodes).

(5) The data acquisition and processing are the same as in conventional CT, except for slice interpolation for image reconstruction.

(6) Generally complete scanning of a particular region takes about 20 to 60 seconds per acquisition. Data obtained belongs to volume of tissues scanned in given time in given number of spiral turns. The image reconstruction is also faster with SCT.

(7) It is not desirable to reconstruct the images 'directly' from the volume data, as the motion artifacts (if patient is continuously moving) spoil the image. So at first, planar data is taken from the available volume data, then the computer interpolates planar data. The interpolation (IPA) algorithms used are 180 degrees and 360 degrees IPA. By using proper technique, images can be reconstructed in the plane desired.

(8) With very fine inter-slice spacing and by overlap method, we can do 2D or 3D reconstruction of images. 3D image reconstruction is done by using the maximum intensity projection (MIP) & the 'shaded surface display (SSD) techniques.

(9) The MIP is useful for highly enhancing structures like calcific vessel walls or metallic implants visualization (vessel overlap is poorly seen).

(10) The SSD technique is complimentary to MIP and shows the overlapping vessels very clearly.

(11) The spiral CT has better contrast and spatial resolution than the conventional CT, because of continuous data acquisition along the 'Z' (longitudinal) axis as well as in 'X' axis.

(12) CT angiography has evolved from spiral CT and is replacing conventional angiography methods in many regions of the body.

6.3 Basic Principles & Equipments Description of C.T.Scan :-

It is as simple as passing X-rays through the patient and obtaining information with a detector on the other side. The X-ray source and the detector are interconnected and rotated around the patient during scanning period. Digital computers then assemble the data that is obtained and integrate it to provide a cross sectional image (tomogram) that is displayed on a computer screen. The image can be photographed or stored for later retrieval and use as the case may be.

X-rays are electromagnetic waves. The main reason why X-rays is used in diagnosis is because all substances and tissues differ in their ability to absorb X-rays. Some substances are more permeable to X-rays while some others impermeable. Owing to this difference, different tissues seem different when the X-ray film is developed.

Dense tissues such as the bones appear white on a CT film while the soft tissues such as the brain or kidney appear gray. The cavities filled with air such as the lungs appear black.

CT Scan – Advantages:-

21 Wide field of view, comparatively more information obtained.

22 Detection of even subtle differences between body tissues.

23 Ability of provide cross sectional image of the body.

24 The operator can be outside the examination room after various.

25 Parameters for the examination have been set.

26 Speed.

27 Comparatively less radiation exposure to the patient.

28 Comparatively less radiation exposure to the patient.

29 Relatively low scanning time. The lungs can be imaged in less than a minute.

SINGLE SLICE SPIRAL CT (SSSCT)

Instrumentation OR Equipment:-

Three major components are (Fig. 7.2):

(1) The imaging system located in the scanner room.

(2) Computer system located in the computer room 3. The display, recording and storage system located in the operator's room.

Imaging System

This consists of several components housed in the gantry which work together to obtain patient's images. The gantry and patient couch together are called the scanner.

Gantry

The gantry is a mounted framework that surrounds the patient in a vertical plane. It has a rotating scan frame onto which many components are mounted. Gantry houses imaging components like slip-rings, x-ray tube, high tension generator, collimators, detectors and the (DAS) sata acquiring system (Fig.7.1).

The x-ray tube of SSCT need high and instantaneous power and hence has larger anodes with diameter of 5" or more. There is oil to air heat exchanger to cool the tube during operation.

The generator in the gantry is a small solid-state high frequency type mounted on the rotating scan frame. As it is located close to the x-ray tube, only short HT cable is required to couple the x-ray tube and the generator. The generator power rating varies from 30 to 60 kW depending on the scanner model. These enable a larger range of kV from 80 to 140 kV and also mA range of 30 to 200 mA.

The important features of the gantry include gantry aperture and the tilt ranges. The technologist can approach the patient from either the front or back of the gantry aperture, which is generally 70 cm in diameter. The gantry must be capable of tilting to facilitate all types of clinical examinations.

Patient Couch

This is the platform on which the patient lies during examination. The couch must be rigid and strong enough to support different weights of patients. In addition, it should prove patient safety and comfort during examinations. The couch consists of table top made of carbon fibre resting on a pedestal. The pedestal houses the mechanical and electrical components which help in vertical and horizontal (longitudinal) couch movement ranges for the patient to mount and dismount. The longitudinal movement should enable the patient from head to thighs without repositioning.

SCT Computer and Image Processing System

The Processing Architecture and Hardware

The two main features of the minicomputer system in CT are a large storage capacity and fast processing of various kinds of data.

The basis of different computer architectures include pipeline, parallel and distributed types capable of various tasks such as pre-processing raw data, convolution, back-projection and visualizing tasks like 3D imaging, CT angiography and virtual endoscopic imaging.

An important component of computer processing architecture is the array processor. It is a dedicated electronic circuit. In the state of the art spiral CT units, the large array parallel pipeline (LAPP) architecture is used. Four important features of LAPP architecture include speed, power, flexibility and expandability.

SCT Software

These help the operator to communicate with the scanner system via the keyboard or mouse. They help in selecting pre-stored scan protocols, modify the parameters, or select smooth/sharp/standard algorithms as required for different CT examinations.

Scanner Control & Image Reconstruction by Computer

A wide range of image display and manipulation techniques are afforded by the CT software. Programs that control hardware components and overall operations and enable the computer run other programs are afforded by the operating system.

CT computers use interleaved processing techniques like multitasking, multiprocessing and multiprogramming. This allows the computer to process several programs almost simultaneously so as to handle increased number of jobs in any given time rapidly and efficiently. The operating in many CT units is UNIX.

Image Display, Storage, Recording & Communications

Image display is usually colour or black and white TV monitors. Images are displayed usually in gray scale and other non-image data like texts may be displayed in colour. Image display includes display matrix, pixel size, bit depth, CT value scale, the monitor lines, selectable window width, window centre single and double windowing plus highlighting.

Image Storage: Image data are stored in digital form to preserve the wide dynamic ranges including the capabilities for image processing and intensity transformations and to decrease the possibility of lost records and also to reduce the space for archiving. Digital images are stored m 2D pixel arrays—each pixel point represented by a number of bits, each having been assigned gray scale value. Each CT image matrix is typically of the size of 512 x 512 x 2 bytes = 12 bits requiring 0.5 MB storage space. A study consisting of 40 images would require 20 MB space. If 50

examinations are done in a day, it would require 1 GB space. Storage devices for CT include VTR tapes, optical disks or DVD.

Laser Recording System

This is used for hard copy printing of CT images. This hard copy must have broad gray scale to enable perception of subtle differences in tissue contrast and high spatial resolution to detect the boundaries of different tissues. Laser imager and printer though expensive are required for proper interpretation of CT images film.

On operator's command, the unexposed film is transported to the exposure region of the printer. In the exposure region the film is scanned line by line. The laser receives the signal from the computer to produce a latent image. Later the laser-scanned film is sent to a receiving magazine or chemical processor of the printer for development.

Communications

This refers to electronic networking connectivity using LAN or WAN. This ensures the transfer of data and images from one centre to another via the private network vendor available in the locality to remote areas any where in the world by internet facility. This is possible if only the CT unit has DICOM connectivity.

SCT Operator Console

The multimedia concept of the console helps the operator to control the entire system, and allows realtime processing such as multiplanar reformatting, 3D manipulations, zoom and panzoom.

An integrated console consists of the following components;

(1) Keyboard—Touch panel/floating type ha\mg alphanumencal keys. function keys, window controls, trackball and mouse.

(2) Window width (CT number) and window level (center) controls to alter picture contrast.

(3) Display monitor—CRT or TFT type to.display the CT image and to be manipulated by the operator before archiving.

(4) Archiving disc drive.

(5) Control functions such as auto-archive and auto-window, which allow the operator to devote more time for patient care and scanning examination procedure.

Keyboard Controls

(1) Previous page: Takes back one level of any task like display or function.

(2) Function keys: Help to access and initiate various display functions. The command modes are displayed updated for each of the 8 keys in the main menu bar of the monitor.

(3) Window controls: To set the gray scale for window width and window centre.

(4) Trackball/theta ring: To control the position of x, y and z axes and to position the movable cursor or for various display functions such as image reformatting.

(5) Help: Explains the current function

(6) Main menu: From this various submenus can be selected.

(7) Patient directory: Displays patient list for selection and display.

(8) Enter text: Activates the keyboard to enter patient information.

(9) Up arrow: Moves the directory or menu one step up.

(10) Save display: To save the current image with any graphics thereon on to the disc as a stack or stored image.

(11) Display keys: Masks the menu bar legends appearing on the display for filming.

(12) Down arrow: Moves down one step from current directory or menu.

(13) Data page: Displays data page for the current image.

(14) Prevu: Displays images as they are constructed.

(15) Prior: Displays prior image in the study or prior page in menu.

(16) Next: Displays next image in the study or next page in menu.

Options and Accessories for SCT Systems

Hardware options: include optical disc, optical cartridge tape, remote diagnostic stations. independent work-stations and laser cameras.

Software options: include packages for dynamic scan, 3D image reconstruction s, volumetric multiplanar reformatting, evaluation of regional cerebral blood flow (perfusion CT) and networking etc.

Accessories:

Certain accessories help to immobilize the patient properly to enhance the overall efficiency of the CT scanner during examination. These include:

(1) Paediatric cradle
(2) Aim and leg supports
(3) lahle mattrcss
(4) Side iails
(5) Table extenders
(6) Knee supports
(7) Head pillows with head rests
(8) Axial and coronal head holders
(9) Auto-traction (Velcro) straps

6.4 C. T. ARTIFACTS:-

Those patterns which are not a part of the object displayed are called artifacts. These are classified according to cause / origin/ shape/ system & film orientation.

(1) Beam related: In homogeneity, beam hardening effect, partial volume effect.

(2) Patient related: Motion artifacts, metallic artifacts, patient size artifacts.

(3) System related: Detector error, data conversion error, reconstruction error & sampling error artifacts.

(4) Shape related: Streak artifacts, ring artifacts, CT value artifacts.

(5) Film related: Base fog, brightness error or others.

6.5 CONTRAST MEDIUM USED:-

ORAL CONTRAST:

Patients have to report with empty stomach when they are to get CT of abdomen or pelvis. They should not eat or drink any thing for 4 hours prior to CT examination. Same is the case where chest and abdomen are to be examined subsequently. The best bowel opacification is an important factor for interpreting CT of abdomen and pelvis.

Abdominal and pelvis CT patients must receive approximately 800 to 1000 mL of oral contrast before the start of the CT examination. The choice of contrast medium is between urographic CM diluted with aerated soft drink and commercial barium sulphate preparation in 2% strength. The former is prefered to the latter because of its rapidity of flow through the stomach and bowels. 10 mg Tab. Metachlopromide (Perinorm) should be given along with the first cup of contrast ingestion.

This accelerates the transit of the contrast for about 50 minutes and by the time when patient is scanned (45 minutes from the time of ingestion of CM) the effect of drug would have subsided, at the same time completed the contrast filling of small bowel and rt.colon.

CONTRA INDICATIONS for the use of metaclopromide include phaechromocytoma and glaucoma.

CONTRAST GUIDE LINES FOR CT PATIENTS

a) Oral

Age group	1 dose oral CM 45 min before scan	II dose oral CM 15 min before scan
Less than 1 month	50-80 mL (2%)	20- 30 mL
1 month-1 year	1 00-200 mL (2%)	50-1 00 mL
1 year-5 years	200-300mL (2%)	100-1 50 mL
6 years-12 years	300-400 mL (2%)	1 50-200 mL
13years-18years	400-500 mL (2%)	200-300 mL

Rectal contrast

Rectal contrast is helpful in all "pelvic" examinations (500 mL of water containing 20 mL of urographic contrast is filled via the Rectum by the enema when the patient is supine on scan table. Alternatively air can be insufflated for negative contrast, specially when the vasculature of pelvis is under consideration for CT angiography and reconstruction. (For paediatric patients the contrast quantity varies from 100 mL in newborn, to 400 to 500 mL for child of 3 to 15 years of age).

Vaginal contrast

In married women undergoing CT of pelvis, it is useful to insert a tampoon (opacified with urographic contrast media) into the vagina which will help to identify the relationship of different structures in the CT slice to the vagina.

Intravenous contrast

Precautions : Before a IV contrast medium is injected, it is important to elicit any history of allergy from the patient. Premedications with antihistamines and/or steroids to avoid or minimise any allergic reaction may be considered in appropriate cases (see the guidelines for premidcation).

(LOCM) Non-ionic CM are preferred to ionic CM (HOCM) because of its superior tolerance. Various non-ionic CM are available with varying contents of iodine ranging between 250-350 rng/mL. We can use regularly the CM containing 300 mg iodine/mL.

Whenever available a pressure injector is to be used for IV injection of CM through an intracath of 18-20 G. Intracaths are useful for delivering a maximum of 1 mL/sec of CM. The automatic injector devices can be adjusted to deliver the CM at the rates ranging from 0.5 *mL/sec* to 2 mL/ sec.

These are found to be helpful in standardising the bolus delivery technique and thereafter to predict the arrival rates of the CM to the regions or organs of interest.

Lengthy injection time results in constantly higher vascular contrast compared to the bolus dose with lower "vascular and extravascular phases" if 100 mL is delivered

by power infector. A doctor must be present at the time of CT studies which involve CM injection.

GUIDE LINES FOR IV CONTRAST ADMINISTRATION.

Contra Indications of high osmolar contrast medium (HOCM)

1. Patients with history of a previous adverse reaction to CM flushing/sensation of heat/nausea).
2. Patients with history of asthma/allergy.
3. Patients with known cardiac dysfunction, severe arrhythmias unstable angina, recent myocardial infarction and pulmonary hypertension.
4. Sickle cell disease/multiple myeloma.
5. Patients who request or demand only LOCM..

Pre-requisites for IV contrast administration for patients with contrast allergy.

(1) 12 hours prior to Exam - Prednisolone 40 mg oral or methyl pred-nisolone 32 mg oral.

(2) 2 hours prior to exam - do -.

(3) Immediately prior to exam—Benadryl 50 mg FV

(4) Every time after a & b give oral antacid cemitidine 300 nig or ranitidine 150 mg.

Guidelines for Intrathecal injection

of contrast medium water soluble CM preferably (LOCM) non-ionic is preferred such as IOHEXOL or IOPAMIRO. Contrast may be injected via lumbar or cervical puncture.

The quantity and concentration of contrast medium to be injected depend on how many area(s) of the spine are/is to be studied and the part of the spine of the patient.

As a guideline the following doses can be practiced

Route cervical	Concentration (mg/mL)	Quantity
Via cistenral CT myelography	180	7-10 mL
Cisternal route	200	7-10 mL
Certical (via lumbar route	240	6-12 mL
CT myelography)	300	4-10 mL
Thoracic (via cisternal/lumbar route	200	10-15 mL
CT myelography)	240	6-12 mL
Total CT myelogram	300	6-10 mL
Low dose CT myelogram	200	10-15 mL
(For immediate scanning after	300	6-10 mL
IT injection for CT cisternography	240	6-12 mL
via lumbar route	300	10-12 mL
	180	4-6 mL
	200	4-6 mL
	240	4-6mL

Guidelines for admission of IV/IT contrast vary in relation to Bio-chemical parameters of renal functions.

- **Assignment**

Q.1. Fill in the blanks with proper word.

1) Higher C.T value tissues are _____.
   (Whiter, blacker, redish).
2) Generally complete scanning of a perticular region takes about_____ sec.per acquisition.
   (20 to 60, 10 to 20, 60 to 80).
3) Bones appear _____ on a C.T film.
   (white, black, gray).
4) Brain appear _____ on a C.T film.
   (gray,black,white).
5) If 50 examinations are done in a day,it would require_____ space. (1GB, 2GB, 3GB).

Q.2. Match the followings.

'A'Group	'B'Group
1) Topogram	1) The results of pre-processing.
2) Raw Data	2) Digital Survey Image.
3) Tube Voltage (KV)	3) The gantry & patient couch.
4) Scanner	4) Factor affecting image quality.
5) Patient Couch	5) The platform on which patient lies during examination.

7. M.R.I.

- **Objectives:** At the end of this lesson you will be able to

  know the basic principles of MRI & Equipments.

7.1 Basic Principles & Equipments:

The MRI machine is a giant cube, measuring about 2m by 2m by 3m. they may vary in size and shape. Some models have a degree of openness around the sides, but basic design remains the same. When the body part to be scanned is kept in the exact centre of the magnetic field, the scan is started. A horizontal tube called. 'bore of the magnet'. That tuns from front to back. The patient lies supine, and slides into the 'bore' on a special 'Couch'. Head first or feet first, and how far in the magnetic patient will go, is determined by the type of exam performed.

The MRI system goes through the patient's body point by point, building up a 2-D or 3-D map of tissue types. It then integrates all of this information together to create 2-D images or 3-D models. MRI has the ability to tailor the exam to the particular medical question. By changing exam parameters, the MRI system and cause tissues in the body to take on different appearances. This is very helpful to the radiologist in determining of something seem is normal or not. MRI system can also image the flowing blood in any part of the body. This allows us to perform studies an arteria system in the body, without a contrast injection, which is required in vascular radiology.

7.2 MRI Artifacts:

PRELIMINARY CONSIDERATIONS :-

Numerous kinds of artifacts can accur in MRI. Some affect the quality of the MRI exam. While others do not affect the diagnostic quality but may be confused with pathology.

(1) Chemical Shift Artifacts
(2) Aliasing.
(3) Block Boundary Artifacts.
(4) Gibbs or Truncation Artifacts.
(5) Zipper Artifacts.
(6) Phase – encoded Motion Artifacts.
(7) Entry Slice Phenomenon.
(8) Slice – overlap Artifacts.
(9) Magic Angle Effects.
(10) Moire Tringes.
(11) RF Overflow Artifacts.
(12) Central Point Artifact
(13) Susceptibility Artifacts.
(14) Zero – fill Artifact (Zebra Artifact)

(1) CHEMICAL SHIFT ARTIFACTS:-

The chemical shift artifact is commonly noticed in the spine at the vertebral body end plates, in the abdomen, and in the orbits where fat and other tissues from borders. In the frequency direction, the MRI scanner uses the frequency of the signal to indicate spatial position.

This artifact is greater at higher field. Strengths and lesser at higher gradient strengths. Kindly has bright border along the top, and dark border along the bottom represents the artifact.

Solution:- Practical way to eliminate this artifact is to use a fat suppression technique.

(2) ALIASING OR "WRAP-AROUND" ARTIFACTS:-

Aliasing or wrap – around is a common artifact that occurs when the field of view (FOV) is smaller than the body part being imaged.

Solution:- Over-sampling is used in the frequency direction to eliminate the aliasing.

(3) BLACK BOUNDARY ARTIFACT:-

Black boundary artifact is an artificially created black line located at fat – water interfaces such as muscle – fat interfaces which results in a sharp delineation of the muscle – fat boundary that is sometimes visually appealing but not an anatomical structure. A block line in seen surrounding the muscles of the shoulder girdle as well as around the liver.

Solution:- To avoid this artifact, It's close to 4.5ms, 9ms, 13.6ms… should be chosen.

(4) GIBBS OR TRUNCATION ARTIFACTS:-

Gibbs or truncation artifacts seen as bright or dark lines paroled and adjacent to the borders of abrupt intensity change when going from bright CSF to dark spinal cord on a T2 – weighted image. In the spinal card, this artifact can simulate a small syringe to the unaware it is also seen in other locations as at the brain / caldarium interface. This artifact is related to the finite number of encoding steps used by the Fourier transform to reconstruct an image with the use of small acquisition matrix.

Solution:- This artifact can be avoided by the use of large acquisition matrices and lesser encoding steps.

(5) ZIPPER ARTIFACTS:-

Most of the zipper artifacts are related to hardware or software problems beyond the radiologist immediate control. RF from some radio transmitters will cause zipper artifacts that are oriented perpendicular to the frequency axis of your image. Other equipment and software problems can cause zippers in either axis. The scanner room door if left open during the acquisition can cause the zipper artifacts.

Solution:- The zipper artifacts that can be controlled easily are those due to RF entering the scanning room when the door is open during acquisition of images.

(6) PHASE – ENCODED MOTION ARTIFACTS:-

Phase-encoded motion artifacts appear as bright noise or repeating densities oriented in the phase direction, occurring as the results of motion during acquisition of a sequence. These artifacts may be seen from arterial pulsations, swallowing, breathing, peristalsis, and physical movement of a patient. Phase-encoded artifacts can be reduced by various techniques depending on their cause and location.

Solution:- Arterial pulsation artifacts can be reduced by 'Spatial Prostration Pulses' prior to entry of the vessel into the slices.

(7) ENTRY SLICE PHENOMENAN ARTIFACT:-

Artifact from 'Entry slice phenomenon' occurs when unsaturated spins in blood first enter into a slice or slices. It is characterized by bright signal in a blood vessel (artery or vein) at the first slice that the vessel enters. Usually the signal is seen or more than one slice, fading with distance. This artifact has been confused with thrombosis with disastrous results.

Solution:- The characteristic location and if necessary, the use of gradient each flow techniques can be used to differentiate entry slice artifacts from occlusions.

(8) SLICE – OVERLAP ARTIFACTS:-

The Slice-overlap artifact is a name given to the loss of signal seen in an image from a multi – angle, multi-slice acquisition, as is obtained. Commonly in the lumbar spine. The dark horizontal bands in the bottom of the following axial image through the lumbar spine demonstrate this artifact. If the slices obtained at different disk spaces are not parallel, them the slices may overlap. If two levels are done at the same time. E.g. L4 – L5 and L5 – S1, then the level acquired second will include spins that have already been saturated.

Solution:- Obtain the slices of different disc spaces separately, if this artifact occurs.

(9) MAGIC ANGLE EFFECTS:-

Magic angle effects are seen most frequently in tendons and ligaments that are oriented at about a 55 degree angle to the main magnetic field. Signal from water molecules associates with the tendon collagen fibers is not normally seen because of dipolar interactions that result in very short T2 times. A bright signal from this artifact is commonly seen in the hotator cuff and occasionally in the patellar tendon and elsewhere.

Solution:- Change of the flip angle minimally will reduce or eliminate this artifact.

(10) MOIRE FRINGES ARTIFACT:-

Moire fringes are an interference pattern most commonly seen when doing gradient echo images with the body coil as shown in the figure 3.14. i.e. aliasing of one side of the body to the other results in superimposition of signals of different phases which alternatively add and cancel. This causes the banding appearance.

Solution:- Adjusting the body coil will eliminate this artifact.

(11) RF OVERFLOW ARTIFACTS:-

RF overflow artifacts cause a nonuniform, washed- out appearance to an image as shown in the axial image of a head in fig. 3.15. This artifact occurs when the signal received by the scanner from the patient is too intense to be accurately digitized by the anolog to digital converter.

Solution:- Autoprescanning usually adjusts the receiver gain to prevent this from occurring but if the artifact still occurs, the receiver gain can be decreased manually.

(12) CENTRAL POINT ARTIFACT:-

The central point artifact is a facal dot of increased signal in the center of an image. It is caused by a constant offset of the DC voltage in the receiver. After fourier transform, this constant offset gives the bright dot in the center of the image.

Solution:- Adjusting the DC voltage in the receiver can eliminate this artifact.

(13) SUSCEPTIBILITY ARTIFACTS:-

These occur as the result of microscopic gradients or variations in the magnetic field strength near the interfaces of substance of substance of different magnetic susceptibility. These gradients cause dephasing of spins and frequency shifts of the surrounding tissues, causing bright and dark aheas with spatial distortion. These artifacts are worst with long echo times and with gradient echo sequences.

Solution:- Reduce longer echo times and use gradient sequence.

(14) ZERO – FILL ARTIFACTS:-

Occasionally, data in the K-space array will be missing or will be set to zero by the scanner as shown in the figure. Abrupt changes from signal to no signal at all result in artifacts in the images such as zebra stripes and other anomalies.

Solution:- Correct the k-space, data array.

7.3 Magnets, Powers, Nuclear Spin, Proton density, Larmer Equation :

- **Objectives:** All the end of this lesson you will be able to State types of Magnets.

Identify Temporary Magnets, Permanent Magnets.

State Magnetic Intensity

State Nuclear Spin & Proton Density.

State Lerner Equation.

Magnets & Magnetism:-

Magnetism is force field that acts on some materials & not on other materials. Physical devices which possess this force are called magnets. Magnets attract iron & steel & when free to rotate, they will move to a fixed position relative to the north pole.

Kind of Magnets:-

Magnets are classified into two groups.

- Natural Magnets.
- Artificial Magnets.

Loadstone (an iron compound) is a natural magnet which was discovered centuries ago there are two types of artificial magnets. Temporary and Permanent magnets.

30 Temporary Magnets or Electromagnets:-

It a piece of magnetic material, say, soft iron is placed in a strong magnetic field of a solenoid it becomes magnetized by induction. The soft iron itself becomes a temporary magnet as long as the current continues to flow in the solenoid. As soon as the source producing the magnetic field is removed, the soft iron piece will loose its magnetism.

31 Permanent Magnetic:-

If steel is substituted for soft iron in the same inducing field as in the previous case, due to the residual magnetism. The steel will become a permanent magnet even after the magnetizing field is removed. This property of retention is termed retentivences. Thus permanent magnets are made from steel, nickel, ALNICO, TUNGSTEN all of which have higher retentiveness.

MAGNETISM:-

Magnetism is a property of matter that is a result of 'protons' in atoms. The arbiting protons cause the atoms to have a magnetic moment associate with an intrinsic angular momentum called 'spin'. Magnetic field. Strengths are measured in units of gauss (G) and tesla (T). One tesla is equal to 10,000 guass. The earth's magnetic field is about 0.5 gauss. The field strength of supercon MRI machines is 1.5 - 2.0. The four terms describing the magnetic properties are ferromagnetism, paramagnetism, superparamgnetism and diamagnetism.

Ferromagnetism

Paramagnetism

Superparamgnetism

Diamagnetism

Ferromagnetism:-

Ferromagnetism materials generally contain iron, nicket or cobalt, e.g. eneurysmal clips. These materials have a large positive magnetic susceptibility. Ferromagnetcs materials contain clusters of atoms called 'magnetic domains', having their magnetic moments pointing in the same direction. The ferromagnetic substances remain magnetized even when an external magnetic field is removed.

Paramagnetism:-

Paramagnetic materials include oxygen and ions of various metals like. Fe, Mg, and Gd. These ions have unpaired electrons, resulting in a positive magnetic susceptibility.

Superparamagnetism:-

Superparamagnetic materials consist of individual domains of elements that have ferromagnetic properties in bulk. E.g. of super paramagnetic materials include iron containing contrast agents for bowel, liver and lymph node imagine.

Diamagnetic:-

Diamagnetic materials have no intrinsic atomic magnetic moment, but when placed in a magnetic field weakly repel the field, resulting in a small negative magnetic susceptibility. Materials like water, copper, nitrogen, barium sulfate, and most tissues are diamagnetic.

Magnetic Intensity:-

The magnet is the biggest and most important component in an MRI system. The magnet is rated using a unit of measure known as a 'tesla'. Another unit of measure commonly used with magnets is the 'gauss' (1 tesla = 10,000 gauss). The magnets in present day MRI are guass in the range of 0.5 tesla to 2.0 tesla or 5,000 to 20,000 gauss. Compared with the earth's o.5 – gauss magnetic field, the MRI magnetic are in credibly powerful.

MR. SAFETY CHECK:-

Prior to allowing a patient or support staff member into the scan room, he or she is thoroughly screened for metal object. Up to this point, we have only talked about external objects.

Metallic fragments in the eye are very dangerous because moving those fragments could cause eye damage or blind ness.

People with 'pacemakers' cannot be scanned or even go near the scanner because the magnet can cause the pacemaker to malfunction. Aneurysm clips in the brain can be very dangerous as the magnet can move them, causing them to tear the very artery they were placed an to repair. Some dental implants are also magnetic.

Most orthopedic implants, even though they may be ferromagnetic, are fine because they are finally embedded in bone. Even metal staples in most parts of the body are fine – once they have been in a patient for a few weeks enough scar tissue has formed to hold them in place.

Each time we encounter patients with an implant or metallic object inside their body we investigate thoroughly to make sure it is safe to scan them, some patients are turned away because it is too dangerous. The decision of whether or not to scan a pregnant patient is made a case – by – case basic with consultation between the MRI radio logic and the patients obstetrician. The benefit of performing the scan must out weigh the risk, however small, to the fetus and mother.

Three basic types of magnets are used in MRJ systems.

(1) Resistive Magnets:-

These consist of many windings or coils of wire wrapped around a cylinder through which an electric current is passed. This electric current generates a magnetic field.

(2) Permanent Magnet:-

Permanent magnet field is always there permanently and always on full strength, so it costs nothing to maintain the field. The major drawback is that these magnets are extremely heavy and it would be difficult to construct.

(3) Superconducting Magnet:-

A super conducting magnet is somewhat. Similar to a resistive magnet coils or windings of wire through which a current of electricity is passed create the magnetic field. The important difference is that the wire is continually bathed in liquid helium at 452.4 degrees below zero.

THE SPIN:-

'Spin' is a fundamental property of nature like electrical charge or mass. Spin comes in multiples of 1/12 and can be (t) or (-). Protons, electrons, and neutrons all possess spin. Individual unpaired electrons, protons, and neutrons each possess 1/2 spin. For example, in the deuterium atom (2H), with one unpaired electron, one unpaired proton, and one unpaired neutron, possesses total electronic spin = 1/2 and the total nuclear Spin = 1.

To or more particles with spins having opposite signs can pair up to eliminate the abservable manifestations of spin. An example is helium. In nuclear magnetic resonance, it is unpaired nuclear spins that are of importance.

PROPERTIES OF SPIN:-

When placed in magnetic field of strength B, a particle with a net spin can absor b a photon, of frequency V. The frequency V depends on the gyromagnetic ratio, Y of the particle. V=Y B. For hydrogen, Y = 42.58 MHz / T.

NUCLEI WITH SPIN:-

Nuclei are compased of 'positively charged' protons and 'uncharged neutrons' held together by nuclear forces. Neutrons and protons are referred to collectively as 'nucleons'. Both protons and neutrons have approximately the same mass. Which is about 1840 time as large as the mass of an electron. Because, nucleons have spin, just like electrons do, their spin can 'pair-up' when the orbitals are being 'filled' and 'cancle out'. NMR can only be performed on 'isotopes', whose natural abumadance high enough to be detected, however, some the nuclei which are of interest in MRI are 1H, 2H, 3'P, 23Na, 14N, 13C, and 19F.

Energy Level:-

The spin of this proton is a magnetic moment rector, causing the proton to behave like a tiny magnet with a north & south pole. When 'proton' is placed an external magnetic field, the 'Spin' vector of the particle aligns itself with the external field, just like a magnet would. There is a low energy configuration or state where the poles are aligned N.S.S.S. and a high energy state N.N.S.S.

TRANSITIONS:-

A problem can undergo a transition between two energy states by the absorption of a photon. A particle in the lower energy state absorbs a photon and ends up in the upper energy state. The energy of this photon must exactly match the energy different between the tow states. The energy E, of a photon is related to its frequency, V, by plancks constant ($h = 6.62 \times 10^{34}$ Js) $E = hv$

In NMR and MRI, the quantity v is called the 'resonance frequency' or the 'Larmor frequency'.

7.4 RADIO FREQUENCY (RF) :

MRI machine applies an RF (radio frequency pulse that is specific only to hydrogen. The system directs the pulse toward the area of the body that is to be examined. The pulse causes the protons in that area to absorb the energy required making them spin, or process, in a different direction. This is the "resonance" part of MRI. The RF pulse forces them to spin at a particular direction. The specific frequency of resonance is called the 'Larmor frequency' and is calculated based on the particular tissue being imaged and the strength of the main magnetic field.)

These RF pulses are usually applied through a coil. MRI machines come with many different coils designed for different parts of the body: knees, shoulders, wrists, need, neck and so on. These coils usually conform to the contour of the body part being imaged, or at least reside very close to it during the exam.

At approximately the same time, the three gradient magnets jump into the act. They are arranged in such a manner inside the main magnet that when they are turned on and off very rapidly in a specific manner, they alter the main magnetic field on a very local level. What this means is that we can pick exactly which area we want a picture of. In MRI we can 'Slice' any part of the body in any direction, giving us a huge advantage over any other imaging modality. The machine can manipulate everything with the gradient magnets. When the RF pulse is turned off, the hydrogen protons begin to return to their natural alignment within the magnetic field and release their excess stored energy. Released excess energy gives off a signal that the coil now picks up and sends to the computer system. What the system receives is mathematical data that is converted, through the use of a fourier transform, into a picture that we can put on film. That is the "imaging" part of MRI.

RADIO FREQUENCY AND SAFETY:-

The radio frequency power that is capable of being produced matches that of many small radio stations (15-20 kw) As a result there is the presence of heating effects from the RF. In most pulse sequences the heating is in signification and does not exceed the EDA guidelines.

New pulse sequences such as for echo planar imaging and some spectroscopy localization techniques are capable of exceeding the EDA guidelines. Monitoring of the power deposition in patients is a requirement for FDA approval of clinical MRI scanners. Potential for electrical shock exists with RF coils, so proper grounding and insulation of coils is necessary. Any damage to coils or their cables needs prompt attention. Also looping of the cables to a coil can result in burns to patients who come into contact with them. It is best to avoid all contact with the RF Coil cables.

7.5 MR CONTRAST AGENTS :

- **INTRODUCTION:-**

MRI contrast agents in many cases improve our sensitivity and / or specificity. Paul Lauterbur and his associates were the first to demonstrate the feasibility of using paramagnetic contrast agents to improve tissue discrimination in MRI. The MRI contrast agents are classified as follows:

(1) Gastrointestianal Contrast (oral) agents.
(2) Intravenous Contrast Agents.
(3) Intravascular (blood pool) Contrast agents.
(4) Tumor – specific agents.
(5) Helpatobiliary Contrast Agents.
(6) Reticuloendothelial Contrast Agents.

(2) Gastrointestianal MRI Contrast Agents (Oral):-

MR in abdominal imaging has been limited in part due to difficulty in distinguishing bowel from intra – abdominal masses and normal organs. The use of enteric contrast agents can settle this problem. The GI contrast agents can be divided into positive agents (appearing dark on MRI). There is currently one agent that has FDA approval for this use, a perfluorochemic

Positive Contrast Agents.

Negative Contrast Agents.

Positive vs Negative GI Contrast Agents.

- **Assignment**

Q.1. Answer in one sentence.

1) What are the types of magnet used in MRI system ?

2) What is magnetism ?

3) Write the names of any five MR Artifacts.

4) Write down the classification of MRI contrast agents.

5) What is Larmor Frequency ?

Q.2. Match the following.

'A' Group	'B'Group
1) Fat suppession technique.	1) Nucleons
2) Adjust the DC voltage in the receiver.	2) Practical way to eliminate chemical shift artifact.
3) Protons	3) Solution for central point artifact
4) Neutrons	4) Positively Charged.
5) Neutrons & Protons	5) Uncharged.

Unit-8

PET Scan & Nuclear Medicine

• **Objectives :-** At the end of this lesson you will be able to know Definition, Radionuclides, Basic Principles & Equipment Description.

8.1 PET Scan Definition 1. -" A PET Scan uses a radioactive drug (tracer) to show this activity. The tracer may be injected, swallowed or inhaled, depending on which organ or tissue is being studied by the PET Scan.

The tracer collects in areas of your body that have higher levels of chemical activity, which often Correspond to areas of disease."

Definition 2. - "A Positron emission tomography (PET) Scan is an imaging test that helps reveal how your tissues and organs are functioning. A PET Scan uses a radioactive drug (tracer) to show this activity ."

8.2 Radionuclides :- A radionuclide or radioactive nuclide is a nuclide that is radioactive". also referred to as a 'radioisotope' or radioactive isotope ,it is an isotope with an unstable nucleus, characterized by excess energy available to be imparted either to a newly created radiation particle within the nucleus or via internal Conversion. During this process, the radionuclide is said to undergo radioactive decay,resulting in the emission of gamma ray(s) and/or subatomic particles such as alpha or beta particles. These emissions Constitute ionizing radiation many radionuclides occur naturally, and others are produced artificially, for examples in nuclear reactors and cyclotrons.

There are about 650 radionuclides with half-lives longer than 60 min. of these, 34 are primordial radionuclides that existed before the creation of the solar system, and there are another 50 radionuclides detectable in nature. There is a much longer number of radionuclides, more than 2400, with decay half-lives shorter than 60 min. Most of these are only produced artificially, and have very short half-lives. There are about 254 stable nuclides. All Chemical elements have radionuclides .Even the lightest element, hydrogen, has a well-known radionuclide, tritium. Elements heavier than lead, and the elements technetium and promethium, exist only as "radionuclides" Radionuclides is called as a radiopharmaceutical, and an imaging tracer made with radionuclides is called a radioactive tracer. Nuclear medicine makes use of these drugs and tracers for radiation therapy such as brachytherapy and medical imaging.

Radionuclides can also present both real and perceived dangers to health.

•**Origin :-** Naturally occurring radionuclides fall into three categories : Primordial radionuclides, Secondary radionuclides, and cosmogenic radionuclides. Primordial radionuclides ,such as uranium and thorium, originate mainly from the interiors of stars and are still present as their half-lives are so long they have not yet completely decayed. Secondary radionuclides are radiogenic isotopes derived from the decay of Primordial radionuclides .They have shorter half-lives than Primordial radionuclides, Cosmogenic isotopes, such as Carbon-14, are present because they are continually being formed in the atmosphere due to cosmic rays.

Artificially produced radionuclides can be produced by nuclear reactors, particle accelerators or by radionuclide generators :

Radioisotopes produced with nuclear reactors exploit the high flux of neutrons activate elements placed within the reactor. A typical product from a nuclear reactor is thallium-201 and iridium -192. The elements that have a large propensity to take up the neutrons in the reactor are said to have a high neutron cross-section.

Radionuclides are produced as an unavoidable side-effect of nuclear and thermonuclear explosions.

Particle accelerators such as cyclotrons accelerate particles to bombard a target to produce radionuclides. Cyclotrons accelerate protons at a target to produce positron-emitting radionuclides, e.g., fluorine-18.

Trace radionuclides are those that occur in tiny amounts in nature either due to inherent narity or due to half-lives that are significantly shorter than the age of the Earth. Synthetic isotopes are inherently not naturally occurring on Earth, but can be created by nuclear reactions.

- **Uses :-** 1) Radionuclides are used in a two major ways : for their chemical properties. and as sources of radiation. Radionuclides of familiar elements such as carbon because they are chemically very similar to the non-radioactive nuclides. So most chemical, biological, and ecological processes treat them in a nearly identical way.

2) In nuclear medicine, radioisotopes are used for diagnosis, treatment, and research. Radioactive chemical tracers emitting gamma rays or Positrons can provide diagnostic information about a persons internal anatomy .and the functioning of specific organs .this is used in some forms of tomography'.

3) In biochemistry and genetics, radionuclides label molecules and allow tracing chemical and physiological processes occurring in living organisms, such as DNA replication or amino acid transport.

4) In food preservation, radiation is used to stop the sprouting of root crops after harvesting to kill parasites and pests, and to control the ripening of stored fruit and vegetables.

5) In industry, and in mining, radionuclides examine welds to detect leaks.

6) In Particle Physics, radionuclides help discover new Physics (physics beyond the standard model) by measuring the energy and momentum of their beta decay products.

8.3 Basic Principles & Equipment Description :-

The pet is based on the detection of very small quantities of biological substances which are labelled with a positron emitters. Most commonly used are Carbon-11, oxygen-15, Nitrogen-13 & Fluorine-18.

Advantages of positron labelled substances are their very high specificity (molicular targeting)the posibility of using biological active substances without changing their behaviour by the label & fullfillment of the tracer principle thus the process of interest remains unchanged during the measurement. Target structures of these molecules are i.e. Glucose metabolism, Receptor binding potential, Catecholamine transport, Aminoacid transport, or protein synthesis. All the above mentioned neuclides have very short radioactive half-lives. (2 min for 0-15,109 min for F-18) which necessitates a near by cyclotron & Radio-chemistry Facility.

- **Equipment Description :-**

A pet scanner is a large machine with a round, doughnut shaped hole in the middle, similar to a C. T. or M.R.I. Unit within thin machine are multiple rings of detectors that records the emission of energy from the radio-tracer in your body .The C.T. Scanner is typically a large, box like machine with a hole or short tunnel in the center. You will lie on narrow examination table that slides into and out of this tunnel, rotating arround you the x-ray tube & electronic X-ray. detectors are located opposite eachother in a ring, called a 'Gantry'. The computer work station that processes the imaging information is located in a seperate control –room,where the technologist operates the scanner & monitors your examination in direct visual contact & usually with the ability to here & talk to you with the use of speaker & microphone.

Combined PET/CT Scanners are combinations of both scanners & look similar to both the PET & C.T. Scanners.

A computer aids in creating the images from the data obtained by the gamma camera.

- **How It Works :-**

With ordinary X-ray examinations an image is made by passing x-rays through the patients body in contrast nuclear medicine procedures use a radioactive material, called a “radiopharmaceutical” or “radio tracer” which is injected into the blood streem, swallowed or inhaled as a gas. This radioactive material accumulates in the organ or area of your body being examined where it gives off a small amount of energy in the form of gamma rays special cameras detect this energy & with help of a computer create pictures offering details on both the structure & function of organs & tissues in your body.

Unit-9

Interventional Radiology

- **Objectives :-** At the end of this lesson you will be able to know Defination, Names of different type of procedures, Equipments Required for various procedures, Orientation of Cath Lab.

9.1 Definition :- Interventional radiology (abbreviated IR or sometimes VIR) is a field of medicine in which minimally invasive procedures are performed using image guidance(e.g. CT, fluoroscopy, ultrasound).Some of these procedures are done to diagnose illness while others are done for treatment purposes. Different imaging modalities available to interventional radiologists enable them to manipulate and guide tiny instruments throughout the body which in many instances avoids more invasive open surgery.

Vascular and Interventional Radiology is one of the most rapidly expanding areas in medicine and has led the current movement toward minimally invasive therapy.Our patient population ranges from infancy to the elderly and includes procedures spanning the full range of the field. We perform both vascular and non-vascular interventions such as angioplasty, stenting,atherectomy, cryoplasty, thrombolysis, and embolization as well as biliary,renal, enteric, pulmonary, and transplant related interventions. We have a robust interventional oncology practice as well, which includes chemoembolization and radioembolization.

We function both as an admitting service and in a consulting role. A subset of our patients is seen longitudinally in our clinic. Our section also interprets the non-invasive vascular studies such as MRA and 256-slice CTA. These are performed with state –of-the- art equipment which rates the best in the region. By utilizing the most sophisticated equipment and continuing to perform procedures which are at the leading edge of the field, we continue to maintain and demand the highest quality in patient care.

9.2 Names of Different Types Of Procedures :-

- **IR Procedures :**

Minimally –invasive treatments performed by interventional radiologists :

Interventional radiologists can treat many conditions without surgery.

Interventional radiology is a radiological sub-discipline providing minimally invasive treatments performed under image guidance. As technology advances and high-quality imaging equipment becomes more widely available, interventional radiology is able to offer patients and referral physicians a growing number of new treatment options. These procedures are typically guided by x-ray fluoroscopy, ultrasound or computed tomography.

- **Common Interventional Procedures** :-

1. Angiography :- An X-ray exam of the arteries and veins to diagnose blockages and other blood vessel problems ; uses a catheter to enter the blood vessel and a contrast agent(X-ray dye)to make the artery or vein visible on the X-ray.

2. Balloon angioplasty :- Opens blocked or narrowed blood vessels by inserting a very small balloon into the vessel and inflating it. Used by IRs to unblock clogged arteries in the legs or arms(called peripheral vascular disease or PVD), kidneys, brain or elsewhere in the body.

3. Biliary drainage and stenting :- Uses a stent (small mesh tube) to open up blocked ducts and allow bile to drain from the liver.

4. Central venous access :- Insertion of a tube beneath the skin and into the blood vessels so that patients can receive medication or nutrients directly into the blood stream or so blood can be drawn.

5. Chemoembolisation :- Delivery of cancer –fighting agents directly to the site of a cancer tumor; currently being used mostly to treat cancers of the endocrine system, including melanoma and liver cancers.

6. Embolisation :- Delivery of clotting agents (coils, plastic particles, gelfoam etc.) directly to an area that is bleeding or to block blood flow to a problem area, such as aneurysm or a fibroid in the uterus.

7. Fallopian tube catheterisation :- Uses a catheter to open blocked fallopian tubes without surgery ; a treatment for infertility.

8. Gastrostomy tube :- Feeding tube inserted into the stomach for patients who are unable to take sufficient food by mouth.

9. Hemodialysis access maintenance :- Use of angioplasty or thrombolysis to open blocked grafts for hemodialysis ,which treats kidney failure.

10. Hereditary Hemorrhagic Telangiectasia(HHT) :- Hereditary Hemorrhagic Telangiectasia (HHT) also called Morbus Osler is an inborn genetic disorder of small blood vessels that affects about one in 2.500-40.000 people in Europe with regional differences and causes arterial blood to flow directly into the veins, creating weakened ballooned vessels that can rupture in various locations.

11. Needle biopsy :- Diagnostic test for breast, lung and other cancers ;an alternative to surgical biopsy.

12. Radiofrequency ablation (RFA) :- Use of radiofrequency (RF) energy to cook and kill cancers tumors.

13. Stent :- A small flexible tube made of plastic or wire mesh, used to treat a variety of medical conditions(e.g., to hold open clogged blood vessels or other pathways that have been narrowed or blocked by tumors or obstructions).

14. Stent – graft :- Reinforces a ruptured or ballooning section of an artery (an aneurysm) with a fabric – wrapped stent(a small ,flexible mesh tube used to "patch" the blood vessel).Also known as an endograft.

15. Thrombolysis :- Dissolves blood clots by injecting clot-busting drugs at the site of the clot.

16. Transjugular Intrahepatic Portosystemic Shunt (TIPS) :- A life -saving procedure to improve blood flow and prevent hemorrhage in patients with severe liver dysfunction.

17. Uterine artery embolisation :- An embolisation procedure of uterine arteries to stop life threatening postpartum bleeding ,potentially preventing hysterectomy. The same procedure is used to treat fibroid tumors and is then called UFE (uterine fibroid embolisation).

18. Uterine fibroid embolisation :- An embolisation procedure of uterine arteries to shrink painful, enlarged ,benign tumors in the uterus,also called UAE (uterine artery embolisation).

19. Vertebroplasty :- Vertebroplasty is an outpatient procedure performed using conscious sedation. An interventional radiologist inserts a needle through a small incision in the back ,directing it under fluoroscopy (continuous, moving X-ray imaging)into the fractured vertebra .The physician then injects a medical–grade bone cement into the vertebra. The cement hardens within about 15 minutes and stabilizes the fracture.

- **Interventional radiologists can treat many conditions without surgery**

1. Aneurysms :- Sections of blood vessels that bulge or ballooon out abnormally (aneurysms),often may be treated without surgery by interventional radiologist . The doctor threads a thin tube(catheter)into the blood vessel and inserts a device that blocks off the supply of blood to the aneurysm.

2. Arteriovenous Malformations (AVM) :- are blood vessel abnormalities in the brain or elsewhere. If untreated ,AVMs can rupture ,causing life-threatening bleeding. Interventional radiologists can often treat these abnormalities without surgery by guiding thin tubes (catheters)to the site and injecting a substance that blocks the supply of blood to the affected blood vessels.

3. Bleeding Internally :- When a patient is bleeding inside the body due to injured blood vessels after an accident or other trauma ,the interventional radiologist pinpoints the area of injury with angiography. The doctor injects a clotting substance ,such as a gel, foam ,or tiny coils, through a thin tube(catheter)to stop the bleeding.

4. Blood Clots :- that form in the deep veins of the lower legs(known as deep vein thrombosis or DVT)can cause chronic swelling and leg pain when walking. There is a risk that the clots will move to the lung (pulmonary embolism) or heart –a potentially life –threatening complication .Interventional radiologists treat DVT by dissolving the clot with thrombolytic therapy. This treatment opens up blood flow and may prevent permanent damage to the blood vessels, a common side effect of DVT.

5. Blood Clot Filters :- Patients with certain chronic illnesses or other conditions that require prolonged periods of inactivity , are at risk of forming blood clots that can travel to the heart or lungs. The interventional radiologist can insert a small filter (called a vena cava filter) into a blood vessel to catch and break up blood clots.

6. Cancer Treatments :- Some types of cancers**,** such as those of the endocrine system that have spread to the liver , can be treated by delivering cancer-fighting agents directly to the site of a tumor in a procedure known as chemoembolisation.

7. High Blood Pressure :- In some patients with high blood pressure, the condition is caused by a narrowing of the arteries in the kidneys. The problem, called renal hypertension, often can be treated with angioplasty.

8. Infection and Abscess Drainage :- Patients with a variety of illnesses may develop an area of persistent infection (abscess) in the body. The infection can be drained by inserting a thin tube (catheter) through a small nick in the skin and to the site of the infection.

9. Urinary Tract Obstruction :- The ureter - - the tube that carries urine from the kidneys to the bladder - - sometimes becomes blocked by kidney stones or other obstructions. The interventional radiologist inserts a thin tube (catheter) through a small nick in the skin and into the blocked kidney to drain.

9.3 Equipments required for various procedures :-

Over the last decade, Interventional Radiology (IR) has had a dramatic change in the world of surgery and cardiology. Siemens, Toshiba, Philips and GE have all made major investments in developing flat panel, digital solutions.

With names, models and distinctions changing all the time, we want to highlight the differences between each model of the GE Innova Interventional family. Use this as a tool when buying an Interventional Radiology system.

- **GE Innova 2100 :**

The Innova 2100 has the smallest detector at just 20 cm square and is designed specifically for cardiac and carotid procedures. Devices in the entire coronary anatomy can be visualized in one view and the reconstruction of 3D cardiac images can be accomplished with the tableside controls. The 2100 is ideally suited for diagnostic angiograms, angioplasties, carotid stenting, and cardiac catheterization.

- **GE Innova 4100 :**

The Innova 4100 has a 40 cm square digital detector and provides the largest field of view not only in the GE line but in the marketplace at large. This allows for great images with fewer runs,less dosing and faster exams. The 4100 is an ideal solution for oncology/tumor embolization,ablation techniques, run-offs and vein embolization.

- **GE Innova 3100 :**

The Innova 3100 is known as the "swing" lab of the series. By blending the 2100 and 4100 , the 30 cm detector allows for excellent cardiac , vascular and neurological imaging. The 3100 combination lab allows for diagnosis and treatment of a wide range cardiology related conditions, all in one system.

Lastly, each of these systems is equipped with an exclusive revolution flat panel detector which boasts a 15% increase in image quality for coronary , peripheral and neurological procedures and furthermore assists physicians in clearly visualizing fine vessels and more accurate stent placement.

9.4 Orientation of Cath Lab :- Cath lab is an examination room in a hospital or clinic. diagnostic imaging equipment used to visualize the arteries of the heart & the chambers of the heart.& treat any stenosis or abnormality found. Equipment most catheterization laboratories are 'single plane' facilities. those that have a single X-ray generator source & an image intensifier, older cath labs used cine film to record the information obtained, but since 2000, most new facilities are digital. The latest digital cath labs are biplane(have two x-ray sources)& digital flat panel labs. A typical 'Cath-Lab' will consist of :-

- Patient Couch
- A floor or Ceiling mounted image intensifier ,set of viewing monitors.
- Realtime ECG/Blood Pressure/Oxygen Saturation measurements with software to record & measure these when needed,
- Injector pump used for imaging the left ventricle or Aorta
- X-ray software for the recording & playback of fluoroscopy runs aquired during the procedure.
- Diagnostic Catheters ,Guide Catheters,Guide wires.
- Angioplasty ballons.
- Stents
- Sheath Closure devices.
- General Nursing supplies Defibrilator,Drug Recovery bags Reporting Station
- Scrub area.

A wire & catheter is passed into coronary artery & catheter & Selectively injecting contrast media into coronary arteries & the image is interpreted & diagnosis is made by cardiologist.

- **Procedures :-**
    1) Cardiac catheterization
    2) Coronary Angiography/Coronary Catheterization
    3) Coronary angioplasty or Percutaneous coronary intervention (P.C.I.)
    4) Closure of some congenital heart defect.
    5) Treatment of stenotic heart volves
    6) Permanent & temporary pacemaker implantations
    7) Electrophysiological studies such as AV node ablation.
    8) Rotablation of heavily calcified vessels.
    9) Left & Right sided pressure Studies
    10) Radiofrequency Catheter Ablation.
- **Projections :-**

    1) PA (Postero-Antero) 90 degree

    2)RAO (Rt.Anterior Oblique) 30 degree

    3) RAO Cranial PA Cranial

    4) LAO Cranial LAO(Left Anterior Oblique)

    5) LAO Caudal (Spider View)

    6) PA Caudal RAO Caudal.

    Cranial view are best used to demonstrate the Left anterior Descending Artery or LAO & Caudal views are best used to demonstrate the circumflex Artery.
- **Reference Books :-**
    1) Physics –jones,advanced physics -gibbs.
    2) Nuclear physics –Kaplan.
    3) Radiophysics and darkroom –gupta.
    4) Radiographic imaging–bal.
    5) Practical Guide to CT Technologist –C Ramamohan
    6) Practical Guide to M R Technologist-C Ramamohan
- Websites :-
    1) Wikipedia.org.com
    2) horiba.com
    3) health.govt.nz

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