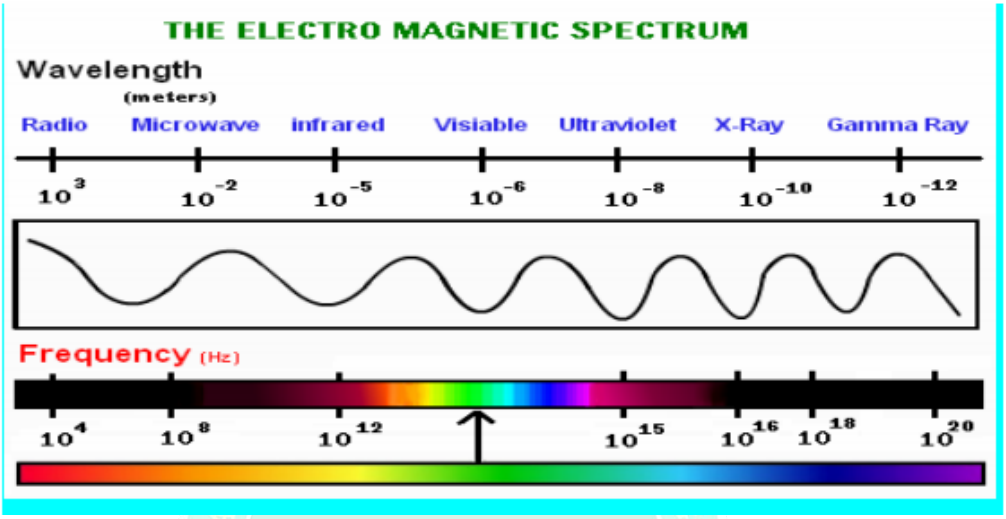
physics of diagnostic x – rays

1- What are X-rays ?

X – rays:- electromagnetic radiation (EMR) of very short wave length (λ= 1-0.1 Ao) & very high penetrating power. It is very useful in diagnosis & radio therapy.



The discovery of X-rays was by a German physicist called Wilhelm Roentgen. In 1895 Roentgen discovered X-rays almost by accident. Whilst doing some experiments in which he passed an electric current through tubes (special tubes containing a cathode and electrode from which the air has been removed), Roentgen noticed that photographic plates nearby began to grow fogged. To discover why this occurred he placed black paper on the tube and then switched on the current. Nearby a screen coated with barium began to glow. This caused Roentgen to believe that unknown rays produced inside the tube were passing through the paper to make this fluorescent substance give out light. These he named X-rays since x is a scientific number for anything that is unknown.

2- Characteristics of X-Rays

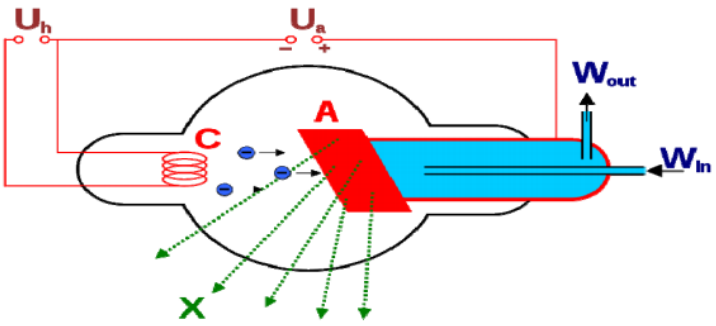
- X-rays are invisible.
- X-rays are electrically neutral. They have neither a positive nor a negative charge. They cannot be accelerated or made to change direction by a magnet or electrical field.
- X-rays have no mass.
- X-rays travel at the speed of light in a vacuum.

- The x-ray beam used in diagnostic radiography comprises many photons that have many different energies.
- X-rays travel in straight lines.

- X-rays cause chemical changes to occur in radiographic and photographic film.
- X-rays can be absorbed or scattered by tissues in the human body.
- X-rays can produce secondary radiation.
- X-rays can cause chemical and biologic damage to living tissue.

3- - X-ray Production :

The production of x-rays requires a rapidly moving stream of electrons that are suddenly decelerated or stopped. The source of electrons is the cathode, or negative electrode. Electrons are stopped or decelerated by the anode, or positive electrode. Electrons move between the cathode and the anode because there is a potential difference in charge between the electrodes. The components of the X-ray tube include a glass envelope containing a high vacuum. A cathode or negative electrode which contains a tungsten filament , which when heated emits electrons in a process called 'thermionic emission'. The cathode also has a focussing cup to better direct the emitted electrons across the vacuum to hit the target. The anode or positive electrode is a thick copper rod with a small tungsten target at the end. Tungsten is required as it has a high atomic number to improve the efficiency of bremsstrahlung x-ray production (see below) , and a high melting point.. , A potential difference , or voltage is applied between the cathode and anode. The tungsten filament (cathode) is heated by an independent current emitted electrons are accelerated across the potential difference to a high velocity before striking the tungsten target. The high vacuum is needed to reduce the electron /atom collisions. The electrons that hit the tungsten target undergo sudden deflection because of the interactions with the tungsten nucleus. Some additions to this basic set up include the anode made of copper. The window is thin and made of beryllium. Beryllium is chosen because it is a metal which has little effect on the photon beam and can effectively maintain the vacuum.



4- Types of X-rays :

There are two types of X-rays, according to their photon energy:

Soft X-rays

These x-rays are defined by having photon energies below 10keV. They have less energy than the hard x-rays , therefore they have higher wavelength. Soft X-rays are used in radiography to take pictures of bones and internal organs. Because they have a relatively low frequency, they do not cause much damage to tissues, unless they are repeated too often .

Hard X-rays

Hard X-rays have photon energies above 10keV. They have smaller wavelength than the soft x-rays. These X-rays are used in radiotherapy, a treatment for cancer. Due to their high frequency, they destroy molecules within specific cells, thus destroying tissue. Another use for these X-rays is airport security. Hard X-rays are used in security scanners to examine baggage.

5- How X- Ray Are Absorbed

X- ray are not absorbed equally well by all materials if they were , they would not be very useful in diagnosis . Heavy elements such as calcium are much better absorbers of x- ray than light elements such as carbon , oxygen , and hydrogen , and as a result , structures containing heavy elements , like the bones . The soft tissues – fat muscles and tumors all absorb about equally well and are thus difficult to distinguish from each other on an x-ray image . of course , air is a poor absorber of x- ray.

6- Uses of X-rays :

The main use of X-rays is in medicine. A common application is in the form of X-ray machines, which take photos of a patient's body. If an arm or leg were broken for example, then this limb would be put in front of the X-ray with a piece of photographic film behind. The X –ray is turned on briefly and goes through to the film. The rays go through the skin and flesh easily, showing up as dark areas on the film, but with more difficulty through bone. They are slowed down and so these areas are much lighter. X-rays can also be used to kill cancer cells, but also kill healthy cells, so must be used with much care. Other uses are in industry, at airports to check customers and baggage. X-ray diffraction is also very important in spectroscopy and as a basis for X-ray crystallography. The diffraction of X-rays by a crystal where the wavelength of X-rays is comparable in size to the distances between atoms in most crystals is used to disperse X-rays in a spectrometer and to determine the structure of crystals or molecules.

About Medical X-Rays

X-rays have two important uses in medicine: imaging and radiation therapy. In X-ray imaging, X-rays are sent through a patient's body to a sheet of film or an X-ray detector. While some of the X-rays manage to pass through tissue, most of them are blocked by bone. The patient's bones form a shadow image on the film behind them. In X-ray radiation therapy, the Xrays are again sent through a patient's body, but now their interaction with diseased tissue is what's important. The X-rays deposit some of their energy in this tissue and kill it.

X-ray of hands and fingers.

Medical x-rays are used to see what is happening inside the body. X-rays pass through objects, including internal organs, body tissue, and clothing , and project a picture onto film or a detector linked to a computer monitor. In general, denser objects , like bones, absorb more radiation, reducing the amount of radiation that passes through to the detector. This is why bones appear white on x-ray images. A conventional (or regular) medical x-ray produces a two-dimensional picture that can help find fractures (broken bones), tumors and foreign objects. Medical x-rays are also used in other types of examinations and procedures, including CT scans and fluoroscopy.

Dental X-Rays :

Dental x-rays let your dentist see the condition of your teeth from the crown to the roots. They also show the bones of the jaw and the overall condition of the bones of your face. During a dental x-ray, radiation passes through your cheek and teeth to strike the special x- ray film clamped between your teeth. Newer x-ray machines use digital imaging instead of film. All types of dental x-rays use a small amount of radiation to take the pictures.