X-ray imaging

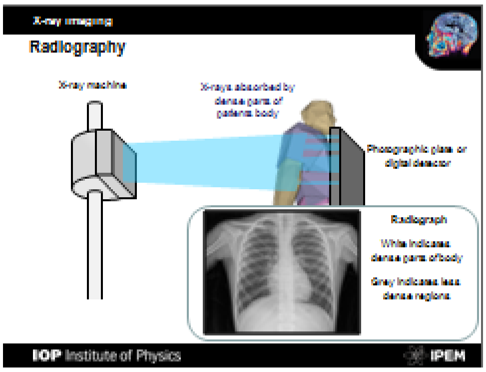
Curriculum links

- Electromagnetic spectrum
- Background radiation

Introduction

X-ray imaging utilises the ability of high frequency electromagnetic waves to pass through soft parts of the human body largely unimpeded. For medical applications, X-rays are usually generated in vacuum tubes by bombarding a metal target with high-speed electrons and images produced by passing the resulting radiation through the patient's body on to a photographic plate or digital recorder to produce a radiograph, or by rotating both source and detector around the patient's body to produce a "slice" image by computerised tomography (CT). Although CT scans expose the patient to higher doses of ionising radiation the slice images produced make it possible to see the structures of the body in 3D.

Lesson notes



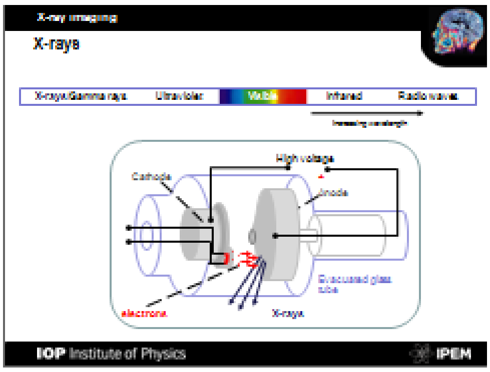
Radiography

In X-ray radiography images are produced by casting an X-ray shadow onto a photographic film or digital detector:

Like gamma rays, X-rays can travel through soft tissues in body with little attenuation and are only "stopped" by high density tissues such as bone.

Radiograph:

- Fully exposed areas of film/detector appear black.
- Dense objects block more X-rays and so appear white.
- Soft tissues like fat and muscle result in intermediate exposure and so appear grey.

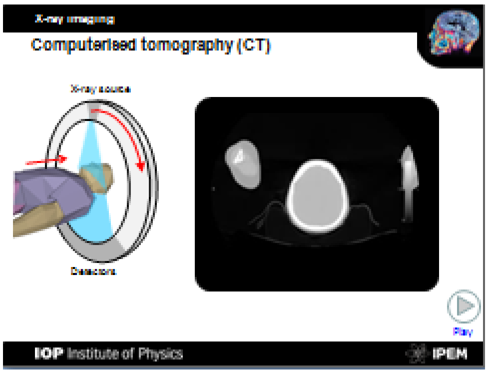


X-rays

In the high- frequency/short-wavelength part of the electromagnetic spectrum the distinction between X-rays and gamma-rays is made by the origin of the waves: X-rays are emitted (by definition) by electrons outside the nucleus, while gamma rays are emitted by the nucleus.

For most medical application X-rays are produced using evacuated tubes in which the electrons are accelerated up to high speed using large voltages. The X-rays are produced when the electrons hits a metal target.

Computerised tomography (CT)



X-ray source and detector rotated around body as patient moves through scanner

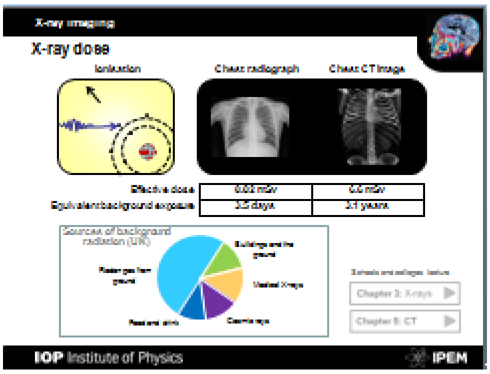
The data collected can be processed using a computer to produce a slice or 3D image.

Compared to radiography, CT imaging better for:

- imaging of soft tissues
- differentiating between overlying structures in the body.

➢ ***PLAY***: *Scan of person moving through scanner (head to legs). Lungs and other major organs can be seen.*

X-ray dose



CT scans require exposing the patient to higher dose of ionising radiation than radiographs which increases patient risk of cancer. Consequently, the additional risk associated with a CT scan must be weighed up against benefits of enhanced diagnostic capabilities (e.g. the ability to manipulate the data to produce 3D simulations)

Exposure is measured in milliSievert (mSv) and is often expressed in equivalent background-radiation exposure time. Over a lifetime, medical X-rays contribute approximately 20 % of background level for the average person in UK.

➢ ***Chapter 3***: *launch chapter 3 of schools lecture 2011 on X-rays.*

➢ ***Chapter 5***: *launch chapter 5 of schools lecture 2011 on CT scanning.*

Worksheet Mark scheme

1.

a) black; white ✓

b) *Any one from:*
Images can be produced and checked immediately;
OR
There is no need for a developing film and disposing of expensive chemicals;
OR
Image can be manipulated to get the clearest possible picture;
OR
Image can be stored easily. ✓

2.

a) X-rays can pass through (soft tissues in) the body/have different frequency ✓

b) (high-speed) electrons (hit) metal target ✓

c) ultraviolet/UV [*accept* gamma-rays] ✓

3.

a) (X-rays cause) ionisation/changes in cells/damage DNA/ cancer. ✓

b) (CT scans) better at mapping soft tissues/ differentiating between overlying structures in the body/making 3D images ✓

c) Radon gas/ground/food/drink/cosmic rays ✓

d) *Calculation of daily or annual background count rate:*
0.0057 (mSv/day) or 2.1 (mSv/year) ✓

Answer:
246 days/0.67 years ✓

Total 10 marks