MEDICAL PHYSICS

4-3 The MR Scanner

1. MR scanners are used to detect the location of hydrogen nuclei in the body so as to distinguish between different types of body tissue without exposing the patient to ionising radiation and to build up a 3-D image.

2. (a) The radio waves are used to excite the hydrogen nuclei in the patient's tissues (so that they will later emit a radio wave photon which can then be used to form the image).

(b) (i) As an MR scan is carried out, a magnetic field of specific flux density is changed systematically with time.

(ii) The physical property of the hydrogen nuclei that is used in an MR scan is the magnetic moment of the hydrogen nucleus.

3. (a) When hydrogen nuclei absorb radio wave photons they flip up into the higher energy level and thus change its spin axis orientation relative to the magnetic field.

(b) When the pulse ends, nuclei flip back to the lower energy state and emit a radio wave photon, which is detected.

4. (a) The detected signals vary according to the relaxation time, which depends on the type of tissue the hydrogen nuclei are in. The rate of decay of the detected signal depends on the type of molecules around the water molecules containing the hydrogen nuclei.

The type of tissue affects the time, In addition, the strength and length of the pulse applied affects the proportions of excited to unexcited nuclei differently in different tissues, which also affects the relaxation time.

Thus different tissues give rise to different times, enabling them to be distinguished.

(b) (i) An MR scan is:

- non-ionising compared to an X-ray scan

- produces a 3-D image unlike a conventional X-ray

- enables soft tissue types to be distinguished unlike an X-ray

(ii) An MR scan produces an image with more detail in than an ultrasound one.

(ii) n_{core} = 1.60, $n_{cladding}$ = 1.50

Therefore the critical angle i_c is given by $\sin i_c = \frac{1.50}{1.60}$ = 0.9375

I_c =69.635… = 69.6° to 3 sf

Assuming the external medium is air so n = 1.00

$$\sin i_{max} = \frac{1.60}{1.00} \times \sin(90 - 69.6)$$

$$\sin i_{max} = 1.60 \times \sin 20.4°$$

= 0.5577 (0.5568 keeping calculator values)

i_{max} = 33.897… (33.833…)

= 33.9° to 3 sf (33.8°)