Extension Worksheet – Option I, Worksheet 1

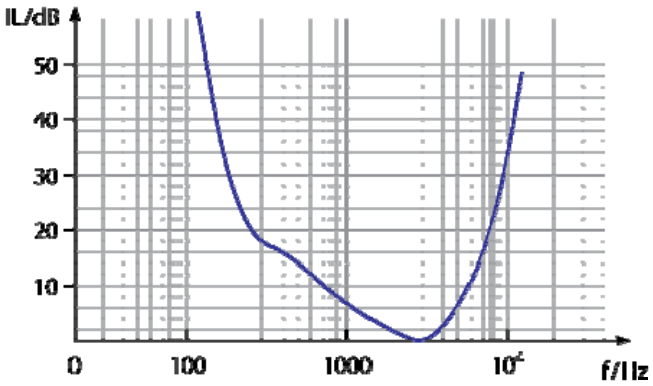
1 Sound of power 48 μW is incident on the ear. The area of the eardrum is 54 mm^2.

a Calculate the sound intensity level at the eardrum. [2]

b Comment on your answer to **a**. [2]

2 A patient has a hearing loss of 15 dB at 500 Hz. Calculate the ratio $\frac{I_{\text{healthy}}}{I_{\text{patient}}}$ of the intensities of sound that can just be heard by the healthy person and the patient at a frequency of 500 Hz. [3]

3 The graph shows the variation with frequency of the threshold of hearing for a healthy young adult.



On the axes above draw the variation with frequency of the threshold of hearing for an elderly person. [2]

4 **a** State the part of the ear where frequency discrimination takes place. [1]

b Suggest why loss of hearing at higher frequencies is more likely to affect speech recognition than hearing loss at low frequencies. [2]

5 When a wave travelling in a medium of impedance Z_1 is incident on a medium of impedance Z_2 the fraction of the incident intensity that is reflected (the reflection coefficient) is given by $R = \left(\frac{Z_1 - Z_2}{Z_1 + Z_2}\right)^2$. The acoustic impedance of air is 430 $\text{kg m}^{-2}\text{ s}^{-1}$ and that of tissue is 1.6×10^6 $\text{kg m}^{-2}\text{ s}^{-1}$.

a Use this formula to calculate the fraction of the incident intensity of ultrasound that gets transmitted into tissue from air. [2]

b Explain why it is necessary to put gel in between the skin of the patient and the ultrasound transducer. [2]

6 Increasing the frequency of ultrasound used in medical diagnosis increases the resolution. Explain why the frequency of the ultrasound is limited to no more than 15 MHz. [2]

7 In nuclear magnetic resonance imaging (NMRI), photons emitted by protons inside hydrogen nuclei in the patient's body are detected and analysed.

a State the part of the electromagnetic spectrum that these photons belong to. [1]

b Outline the physical mechanism that leads to the photon emissions. [2]

8 Outline the principles behind nuclear magnetic resonance imaging. [5]

9 Outline the principles behind CT scanning. [4]

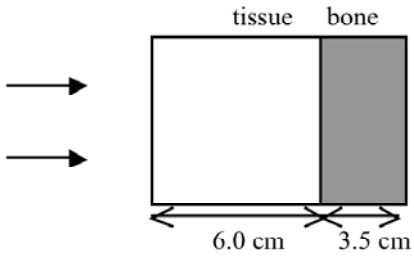
10 A person is accidentally exposed to ionising radiation.

a Explain what is meant by **ionising radiation**. [1]

b Describe the effects of ionising radiation on living tissue. [3]

c Suggest why it is not possible to assess the effects of this radiation on the person's health immediately after the exposure. [2]

11 A mono-energetic beam of X-rays of intensity I_0 is incident on tissue.



After travelling through 6.0 cm of tissue the beam is incident on bone of thickness 3.5 cm. The attenuation coefficient for tissue is 0.14 cm^{-1} and that for bone is 0.74 cm^{-1}.

a State one source of attenuation of X-rays in tissue. [1]

b Calculate the fraction of the X-ray intensity after the beam exits the bone. [2]

c Suggest what feature of the answer to **b** indicates that an X-ray image of a bone fracture will be possible. [2]

d Explain the use of an intensifying screen in X-ray imaging. [3]