10 (a) Define specific acoustic impedance.

....

....

.... [2]

(b) Explain how ultrasound waves are detected by a piezoelectric crystal.

....

....

.... [2]

(c) Table 10.1 shows the specific acoustic impedance Z for body tissue, water and steel.

Table 10.1

material	Z / kg m^{-2} s^{-1}
body tissue	1.38×10^6
water	1.48×10^6
steel	4.04×10^7

(i) Calculate the intensity reflection coefficient for ultrasound incident on a water–steel boundary.

intensity reflection coefficient = ... [2]

(ii) Explain, without calculation, what is likely to happen when ultrasound is incident on a body tissue–water boundary.

....

....

.... [2]

[Total: 8]

10 (a) Describe how the piezoelectric crystal in a transducer generates ultrasound waves for use in medical diagnosis.

....

....

....

....

.... [3]

(b) A parallel ultrasound beam is incident on the boundary between two media, as illustrated in Fig. 10.1.

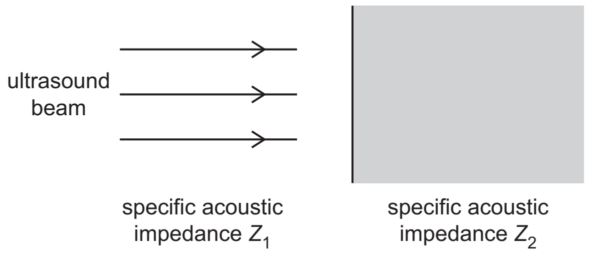

Fig. 10.1

The media have specific acoustic impedances Z_1 and Z_2.

At the boundary, a fraction α of the incident intensity of the ultrasound beam is reflected. The remainder is transmitted.

(i) State what is meant by specific acoustic impedance.

....

....

.... [2]

(ii) Describe how α depends on the relative values of Z_1 and Z_2.

....

....

....

.... [2]

(c) A parallel ultrasound beam of intensity I_0 enters a region of soft tissue. After passing a distance of 2.1 cm through this tissue, the intensity of the ultrasound is $0.62 I_0$.

Calculate the linear attenuation coefficient μ of ultrasound in the soft tissue. Give a unit with your answer.

μ = ... unit .... [2]

[Total: 9]

8 **(a)** Table 8.1 shows some data relating to the properties of air, gel and body tissue. The data are given to three significant figures.

Table 8.1

material	density / $kg\,m^{-3}$	speed of sound / $m\,s^{-1}$	specific acoustic impedance / $kg\,m^{-2}\,s^{-1}$
air		340	440
gel	1200	1400	
tissue	1090		1.68×10^6

(i) Show that the specific acoustic impedance of gel is $1.68 \times 10^6\,kg\,m^{-2}\,s^{-1}$.

[1]

(ii) Complete Table 8.1 by calculating the missing values to three significant figures. Use the space below for any working that you need.

[2]

(b) Use the information in **(a)** to calculate the intensity reflection coefficient for:

(i) an air–tissue boundary

intensity reflection coefficient = ... [2]

(ii) a gel–tissue boundary.

intensity reflection coefficient = ... [1]

(c) Use your answers in **(b)** to explain why gel is applied to the skin during ultrasound scanning.

....

....

.... [2]

[Total: 8]

9 Ultrasound is used to produce diagnostic information about internal body structures.

(a) Explain how ultrasound waves are detected.

....

....

....

.... [3]

(b) An alternating voltage V varies with time t according to

$$V = V_o \sin \omega t.$$

The voltage is applied to an ultrasound probe.

The root-mean-square (r.m.s.) voltage is 66 V. The frequency of the ultrasound generated by the probe is 4.3 MHz.

Determine the values of

(i) V_o

V_o = ... V [1]

(ii) ω.

ω = ...rad s^{-1} [1]

(c) Table 9.1 contains information about air and soft tissue.

Table 9.1

	density / kg m^{-3}	speed of ultrasound / m s^{-1}	specific acoustic impedance / ....
air	1.30	330	4.3×10^2
soft tissue		1600	1.7×10^6

(i) Determine the unit for the specific acoustic impedance values shown in Table 9.1. [1]

(ii) Calculate the density of soft tissue.

density = ... $kg\,m^{-3}$ [1]

(iii) Use data from Table 9.1 to explain why ultrasound cannot be used to produce an image inside an air-filled cavity such as the lungs.

....

....

....

.... [2]

[Total: 9]