5 **(a)** **(i)** State what is meant by the *specific acoustic impedance* of a medium.

....

....

.... [2]

(ii) The density of a sample of bone is $1.8\,\mathrm{g\,cm^{-3}}$ and the speed of ultrasound in the bone is $4.1 \times 10^{3}\,\mathrm{m\,s^{-1}}$.

Calculate the specific acoustic impedance Z_B of the sample of bone.

Z_B = ... $\mathrm{kg\,m^{-2}\,s^{-1}}$ [1]

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(b) A parallel beam of ultrasound passes normally through a layer of fat and of muscle, as illustrated in Fig. 5.1.

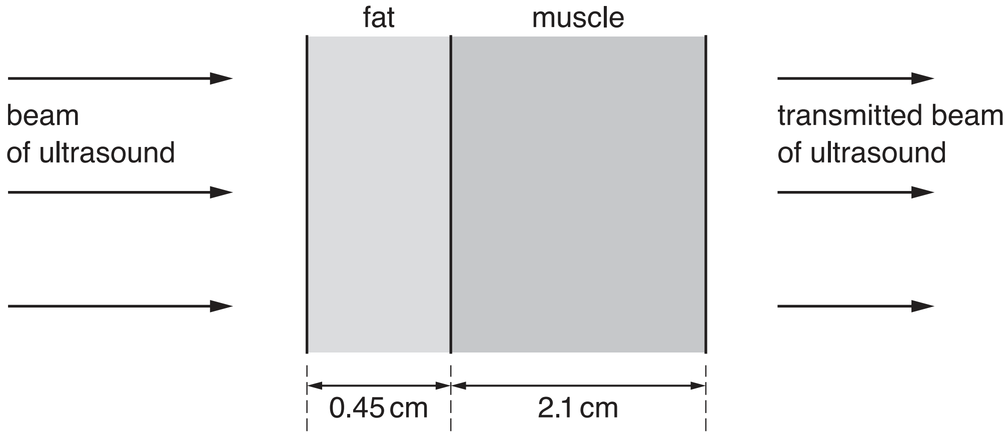

Fig. 5.1 (not to scale)

The fat has thickness 0.45 cm and the muscle has thickness 2.1 cm.

Data for fat and for muscle are given in Fig. 5.2.

	specific acoustic impedance $Z / 10^6\,\mathrm{kg\,m^{-2}\,s^{-1}}$	linear attenuation (absorption) coefficient $\mu / \mathrm{cm^{-1}}$
fat muscle	1.3 1.7	0.24 0.23

Fig. 5.2

The intensity reflection coefficient α at a boundary between two media of specific acoustic impedances Z_1 and Z_2 is given by the expression

$$\alpha = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}.$$

Calculate the fraction of the intensity of the ultrasound that is **transmitted** through the boundary between the fat and the muscle.

fraction transmitted = ... [1]

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(c) **(i)** State what is meant by *attenuation* of an ultrasound wave.

....

....

.... [2]

(ii) Data for linear attenuation coefficients are given in Fig. 5.2.

Determine the ratio

$$\frac{\text{intensity of ultrasound transmitted through the medium}}{\text{intensity of ultrasound entering the medium}}$$

for:

1. the layer of fat of thickness 0.45 cm

ratio = ...

2. the layer of muscle of thickness 2.1 cm.

ratio = ...
[3]

(d) Use your answers in **(b)** and **(c)(ii)** to determine the fraction of the intensity entering the layer of fat that is transmitted through the layer of muscle.

fraction transmitted = ... [1]

[Total: 10]

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