

Ultrasound

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Waves
Sub Topic	Ultrasound
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: 51 minutes

Score: /42

Percentage: /100

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 (a) State what is meant by the *acoustic impedance* Z of a medium.

.....
 [1]

(b) Two media have acoustic impedances Z_1 and Z_2 .
 The intensity reflection coefficient α for the boundary between the two media is given by

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

Describe the effect on the transmission of ultrasound through a boundary where there is a large difference between the acoustic impedances of the two media.

.....

 [3]

(c) Data for the acoustic impedance Z and the absorption coefficient μ for fat and for muscle are shown in Fig. 10.1.

	$Z/\text{kgm}^{-2}\text{s}^{-1}$	μ/m^{-1}
fat	1.3×10^6	48
muscle	1.7×10^6	23

Fig. 10.1

The thickness x of the layer of fat on an animal, as illustrated in Fig. 10.2, is to be investigated using ultrasound.

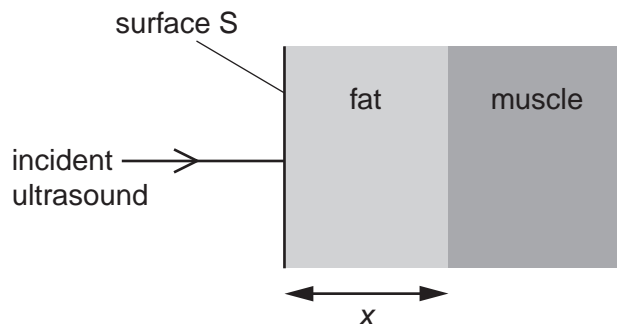


Fig. 10.2

The intensity of the parallel ultrasound beam entering the surface S of the layer of fat is I .
The beam is reflected from the boundary between fat and muscle.
The intensity of the reflected ultrasound detected at the surface S of the fat is $0.012 I$.
Calculate

- (i) the intensity reflection coefficient at the boundary between the fat and the muscle,

coefficient = [2]

- (ii) the thickness x of the layer of fat.

$x = \dots\dots\dots$ cm [3]

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

.....
 [1]

(ii) Data for some media are given in Fig. 10.1.

medium	speed of ultrasound / ms ⁻¹	acoustic impedance / kg m ⁻² s ⁻¹
air	330	4.3 × 10 ²
gel	1500	1.5 × 10 ⁶
soft tissue	1600	1.6 × 10 ⁶
bone	4100	7.0 × 10 ⁶

Fig. 10.1

Use data from Fig. 10.1 to calculate a value for the density of bone.

density = kg m⁻³ [1]

(b) A parallel beam of ultrasound has intensity I . It is incident at right-angles to a boundary between two media, as shown in Fig. 10.2.

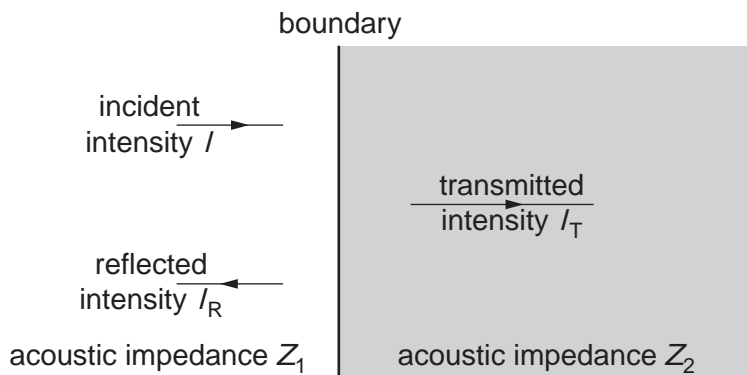


Fig. 10.2

The media have acoustic impedances of Z_1 and Z_2 . The transmitted intensity of the ultrasound beam is I_T and the reflected intensity is I_R .

(i) State the relation between I , I_T and I_R .

..... [1]

(ii) The reflection coefficient α is given by the expression

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

Use data from Fig. 10.1 to determine the reflection coefficient α for a boundary between

1. gel and soft tissue,

$\alpha = \dots\dots\dots$ [2]

2. air and soft tissue.

$\alpha = \dots\dots\dots$ [1]

(c) By reference to your answers in (b)(ii), explain the use of a gel on the surface of skin during ultrasound diagnosis.

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.....
.....
..... [3]

The ultrasound is reflected at a muscle-bone boundary and returns to the surface of the muscle.

Calculate

- (i) the intensity reflection coefficient at the muscle-bone boundary,

coefficient = [2]

- (ii) the fraction of the incident intensity that is transmitted from the surface of the muscle to the surface of the bone,

fraction = [2]

- (iii) the intensity, in terms of I , that is received back at the surface of the muscle.

intensity = / [2]

5 (a) State what is meant by *acoustic impedance*.

.....
.....[1]

(b) Explain why acoustic impedance is important when considering reflection of ultrasound at the boundary between two media.

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.....[2]

(c) Explain the principles behind the use of ultrasound to obtain diagnostic information about structures within the body.

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.....[5]