

24.1 Production and use of ultrasound

Name: _____ Class: _____ Date: _____

Total: 14 marks

Objective

Build the skills to answer exam questions on **ultrasound** in medicine.

You must be able to:

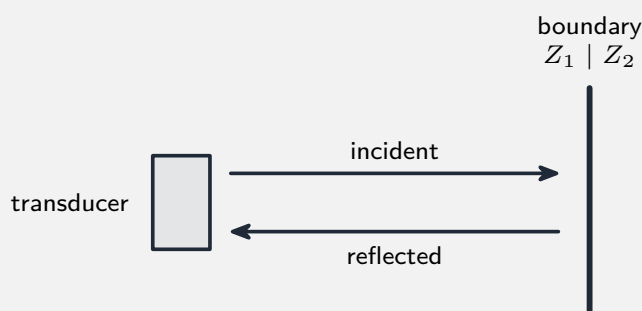
- explain the **piezo-electric** transducer (send and detect)
- use **acoustic impedance** $Z = \rho c$ and the **reflection coefficient**
- use the attenuation $I = I_0 e^{-\mu x}$

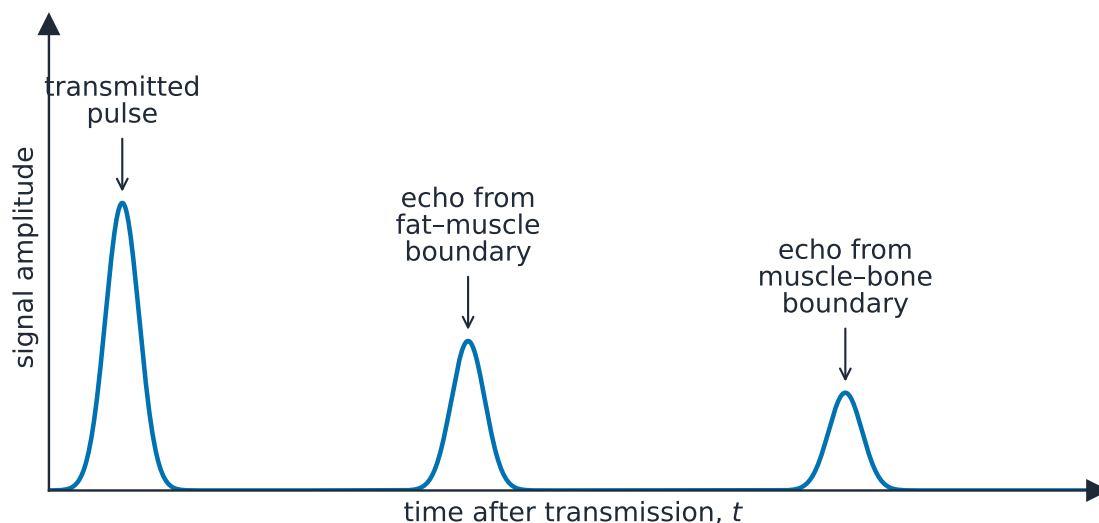
1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Transducer and pulse-echo

A **piezo-electric** crystal changes shape when a p.d. is applied (to **emit** ultrasound) and produces an e.m.f. when squeezed (to **detect** it) —so one transducer both sends and receives. A pulse partly **reflects** at a boundary between tissues:





An ultrasound A-scan trace

$$Z = \rho c, \quad \frac{I_R}{I_0} = \frac{(Z_1 - Z_2)^2}{(Z_1 + Z_2)^2}, \quad I = I_0 e^{-\mu x}.$$

A large impedance **mismatch** reflects strongly —which is why a **coupling gel** removes the air gap (air's Z is very different).

2 Practice

Now apply the methods above.

2.1 Describe the **piezo-electric effect**.

[2]

2.2 Define the **specific acoustic impedance** of a medium.

[1]

2.3 Explain how **one** transducer can both send and detect ultrasound.

[2]

2.4 Write the equation for the **attenuation** of ultrasound.

[1]

3 Exam-style questions

3.1 For a **strong** reflection at a tissue boundary, the two acoustic impedances must be:[1]

- **A** equal
 - **B** very different
 - **C** both zero
 - **D** both very large
-

3.2 Calculate the intensity reflection coefficient for a boundary where $Z_1 = 1.6 \times 10^6$ and $Z_2 = 1.7 \times 10^6$ (SI units). [3]

3.3 Explain why a **coupling gel** is used between the transducer and the skin. [2]

3.4 Ultrasound of intensity I_0 passes through 5.0 cm of tissue with $\mu = 23 \text{ m}^{-1}$. Calculate I/I_0 . [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **24.1 Production and use of ultrasound** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/41 N25 —Q10 (acoustic impedance; reflection coefficient)
- 9702/43 N25 —Q10 (ultrasound, structured)
- 9702/44 J25 —Q10 (piezo-electric detection; attenuation)

Solutions

2.1 Applying a p.d. across the crystal makes it **change shape**; changing its shape makes it produce an **e.m.f.**.

2.2 $Z = \rho c$, the product of the medium's density and the speed of sound in it.

2.3 An alternating p.d. makes the crystal **vibrate**, emitting ultrasound; a returning pulse makes it vibrate and produce an **e.m.f.**, which is detected.

2.4 $I = I_0 e^{-\mu x}$.

3.1 **B** —very different.

3.2 $\frac{I_R}{I_0} = \frac{(1.6 - 1.7)^2}{(1.6 + 1.7)^2} = \frac{(0.1)^2}{(3.3)^2} = 9.2 \times 10^{-4}$.

3.3 Without gel there is an **air gap**, whose acoustic impedance is very different from skin, so almost all the ultrasound would be reflected; the gel removes the air gap so the ultrasound enters the body.

3.4 $I/I_0 = e^{-\mu x} = e^{-(23)(0.050)} = e^{-1.15} = 0.32$.