



QUESTION WORKBOOK

Ultrasound imaging

Medical physics · Year 13

AQA 3.10.4 · CIE 24.1 · OCR A 6.5.3

12 questions · 32 marks

PRINT EDITION

SECTION A · Warm-up

A1 Describe how a piezoelectric transducer both generates and detects ultrasound. [2]

A2 An echo returns $90\text{ }\mu\text{s}$ after a pulse enters soft tissue, where ultrasound travels at 1540 m s^{-1} . Calculate the depth of the reflecting boundary. [2]

A3 State what is meant by the acoustic impedance of a medium, and give its defining equation. [2]

SECTION B · Standard

B1 Calculate the acoustic impedance of liver tissue, of density 1075 kg m^{-3} , in which sound travels at 1590 m s^{-1} . [2]

- B2** A boundary lies 3.5 cm below the skin. Calculate the time after the pulse enters the tissue at which its echo returns (speed of sound in tissue 1540 m s^{-1}), and state why the scanner must finish listening before it sends the next pulse. [3]

- B3** Distinguish between an A-scan and a B-scan. [2]

- B4** Ultrasound meets a boundary between muscle ($Z = 1.70 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$) and liver ($Z = 1.63 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$). Calculate the fraction of the incident intensity that is reflected. [3]

- B5** Explain, in terms of acoustic impedance, why coupling gel is needed between the transducer and the skin. [3]

SECTION C · Stretch

- C1** The acoustic impedance of air is about $430 \text{ kg m}^{-2} \text{ s}^{-1}$ and of soft tissue about $1.63 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$. Calculate the fraction of intensity reflected at an air-tissue boundary, and comment on the result. [3]

- C2** In an A-scan of an organ, echoes return $52 \mu\text{s}$ and $78 \mu\text{s}$ after the pulse enters the tissue ($c = 1540 \text{ m s}^{-1}$). Calculate the depth of each surface of the organ and hence its thickness along the beam. [4]

- C3** A student says higher-frequency ultrasound always gives a better scan. Discuss whether this is true. [3]

- C4** Give two reasons why ultrasound, rather than X-rays, is used for antenatal scanning, and one limitation of ultrasound imaging.

[3]
