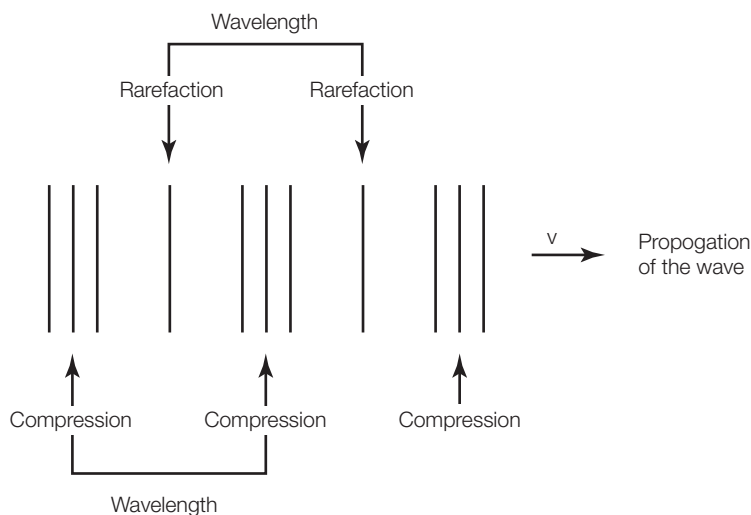


CHAPTER 18

Ultrasound

Answers to revision questions

1.



2. (a) Piezoelectric materials are crystals that are able to convert mechanical vibrations into electric signals and vice versa.
- (b) Quartz and barium titanate.
- (c) In an ultrasound scanner, the roles of the piezoelectric crystal are to both produce and receive ultrasound. When producing ultrasound waves, the piezoelectric crystal converts electric signals (voltages) to mechanical vibrations, hence sound. When receiving ultrasound waves, the crystal resonates with the waves to produce electric signals.

3. (a)
$$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$

Z_1 = acoustic impedance of muscle $(1.06 \times 10^3) \times (1.57 \times 10^3)$

Z_2 = acoustic impedance of fat tissues $(953) \times (1.48 \times 10^3)$

$$\begin{aligned} \frac{I_r}{I_o} &= \frac{[(953 \times 1.48 \times 10^3) - (1.06 \times 10^3 \times 1.57 \times 10^3)]^2}{[(953 \times 1.48 \times 10^3) + (1.06 \times 10^3 \times 1.57 \times 10^3)]^2} \\ &= 6.81 \times 10^{-3} \\ &= 0.681\% \end{aligned}$$

(b)
$$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$

Z_1 = acoustic impedance of liver $(1.07 \times 10^3) \times (1.55 \times 10^3)$

Z_2 = acoustic impedance of fat tissues $(953) \times (1.48 \times 10^3)$

$$\frac{I_r}{I_o} = \frac{[(953 \times 1.48 \times 10^3) - (1.07 \times 10^3 \times 1.55 \times 10^3)]^2}{[(953 \times 1.48 \times 10^3) + (1.07 \times 10^3 \times 1.55 \times 10^3)]^2}$$

$$= 6.53 \times 10^{-3}$$

$$= 0.653\%$$

Therefore, the percentage of the penetrated waves will be:

$$= 1 - 0.653\%$$

$$= 99.3\%$$

4. In A-scans, the reflected ultrasound waves are displayed using wave amplitudes, which are plotted as a function of time. The amplitudes will provide information about the nature of the organ, whereas the position of the peaks will provide information about the location and dimension of the target organ.
5. B-scans display the reflected ultrasound waves as fluorescent dots. They form the basis of sector scans: when many B-scans are created and placed adjacent to each other, a sector scan is produced.
6. (a) Thyroid cysts or thyroid tumours.
(b) Ultrasound is cheaper than other imaging methods. Ultrasound may also guide biopsy of the lump in order to provide tissue diagnosis.
7. Ultrasound scans do not use ionising radiation and therefore are safe for the growing fetus, who is susceptible to the harmful effects of the ionising radiation.
8. Detect gall bladder and kidney stones.
9. Doppler effect is the apparent change in the frequency of the sound when the source of the sound is moving relative to its receiver.
10. The Doppler effect is used in Doppler ultrasound to study the movement of blood in the body. Ultrasound is sent towards and then reflected off the moving red blood cells, and in doing so undergoes a Doppler shift. This will result in the returning echo having a different frequency compared to the original wave. Such a difference is used to calculate the velocity of the flowing blood. This information is displayed using either audible sounds or visual images.
11. (a) In a duplex ultrasound scanner, pulse Doppler ultrasound is combined with the standard pulse-echo grey scale ultrasound to allow blood flow and anatomy to be studied simultaneously. The pulse Doppler displays the information about blood flow using audio, visual spectral or colour codes. The pulse Doppler also enables the selection of range gating so that the blood flow at a specific depth can be selectively studied. The pulse-echo ultrasound displays the anatomical structures using grey scales in a sector form, with or without the use of phase.
(b) Duplex scans are frequently performed in cardiology to assess heart muscle movements; abnormal blood flows through the heart due to either a stenosed or incompetent valve. Duplex ultrasound scans are also frequently used to assess the level of blood flow through an artery or a vein.
12. (a) See Chapter 18.
(b) Ultrasound bone density scans have started to lose favour in recent years because of their lack of accuracy. It is also more cost effective to send patients directly to have a DEXA scan, as the small amount of ionising radiation is unlikely to do any significant harm, and the results are much more accurate.