Q1. The term **ultrasound** refers to vibrations in a material that occur at frequencies too high to be detected by a human ear. When ultrasound waves move through a solid, both longitudinal and transverse vibrations may be involved. For the longitudinal vibrations in a solid, the speed c of the ultrasound wave is given by

$$c = \sqrt{\frac{E}{\rho}}$$

where E is the Young modulus of the material and ρ is the density. Values for c and ρ are given in the table below.

Substance	c / m s^{-1}	ρ / kg m^{-3}
glass	5100	2500
sea water	1400	1000

Ultrasound waves, like electromagnetic radiation, can travel through the surface between two materials. When all the energy is transmitted from one material to the other, the materials are said to be **acoustically matched**. This happens when ρc is the same for both materials.

(a) Calculate the magnitude of the Young modulus for glass.

Young modulus = ...

(1)

(b) State your answer to (a) in terms of SI fundamental units.

(1)

(c) The passage states that 'when ultrasound waves move through a solid both longitudinal and transverse vibrations may be involved'.

State the difference between longitudinal and transverse waves.

PhysicsAndMathsTutor.com

.....

.....

.....

.....

(2)

(d) Show that when two materials are acoustically matched, the ratio of their Young moduli is equal to the ratio of their speeds of the ultrasound waves.

(2)

(e) The wave speed in a material X is twice that in material Y. X and Y are acoustically matched.

Determine the ratio of the densities of X and Y.

X = ... Y = ...

(1)

(f) Ultrasound waves obey the same laws of reflection and refraction as electromagnetic waves.

Using data from **Table 1**, discuss the conditions for which total internal reflection can occur when ultrasound waves travel between glass and sea water.

.....

.....

.....

.....

PhysicsAndMathsTutor.com

.....

.....

.....

.....

(3)
(Total 10 marks)

Q2. Which of the following waves **cannot** be polarised?

A radio ⬭

B ultrasonic ⬭

C microwave ⬭

D ultraviolet ⬭

(Total 1 mark)

Q3. Which one of the following provides direct experimental evidence that light is a transverse wave motion rather than a longitudinal wave motion?

A Two light waves that are coherent can be made to interfere. ⬭

B Light can be diffracted. ⬭

C Light can be polarised. ⬭

D The intensity of light from a point source falls off inversely as the square of the distance from the source. ⬭

(Total 1 mark)

Q4. Ultrasound waves are used to produce images of a fetus inside a womb.

PhysicsAndMathsTutor.com

(a) Explain what is meant by the frequency of a wave.

.....

.....

.....

(1)

(b) Ultrasound is a longitudinal wave. Describe the nature of a longitudinal wave.

.....

.....

.....

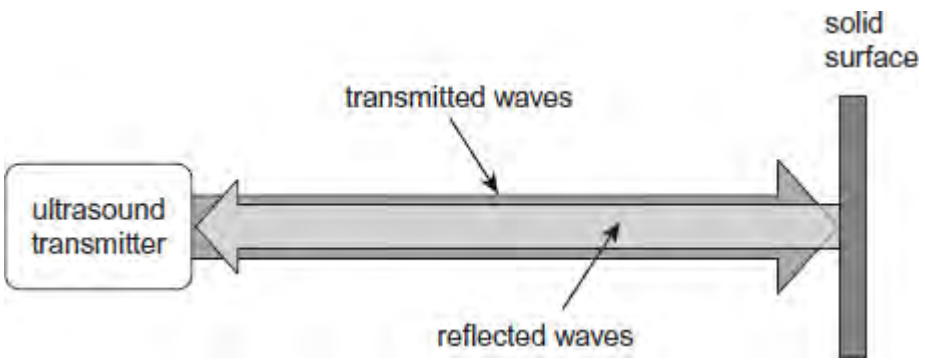
(2)

(c) In order to produce an image with sufficient detail, the wavelength of the ultrasound must be 0.50 mm. The speed of the ultrasound in body tissue is 1540 m s^{-1}.
Calculate the frequency of the ultrasound at this wavelength.
Give your answer to an appropriate number of significant figures.

frequency ..... Hz

(2)

(d) A continuous ultrasound wave of constant frequency is reflected from a solid surface and returns in the direction it came from.



Assuming there is no significant loss in amplitude upon reflection, describe and explain the effect the waves have on the particles in the medium between the

PhysicsAndMathsTutor.com

transmitter and the solid surface.

.....

.....

.....

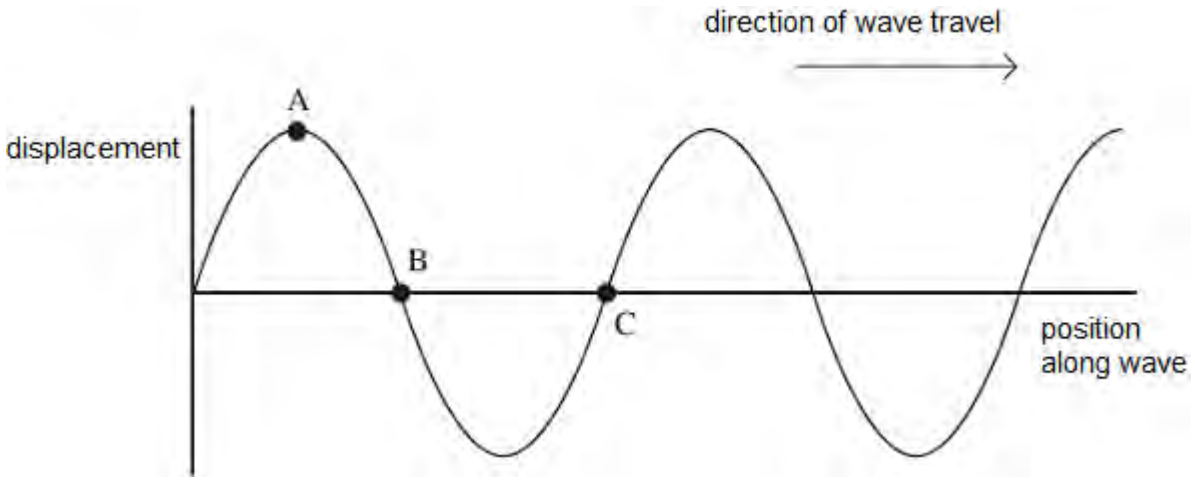
.....

.....

.....

(3)
(Total 8 marks)

Q5. Earthquakes produce transverse and longitudinal seismic waves that travel through rock. The diagram below shows the displacement of the particles of rock at a given instant, for different positions along a transverse wave.



(a) State the phase difference between

(i) points **A** and **B** on the wave .....

(ii) points **A** and **C** on the wave .....

(2)

(b) Describe the motion of the rock particle at point **B** during the passage of the next complete cycle.

.....

.....

.....

.....

PhysicsAndMathsTutor.com

.....

(2)

(c) A scientist detects a seismic wave that is polarised. State and explain what the scientist can deduce from this information.

.....

.....

.....

(2)

(d) The *frequency* of the seismic wave is measured to be 6.0 Hz.

(i) Define the frequency of a progressive wave.

.....

.....

(1)

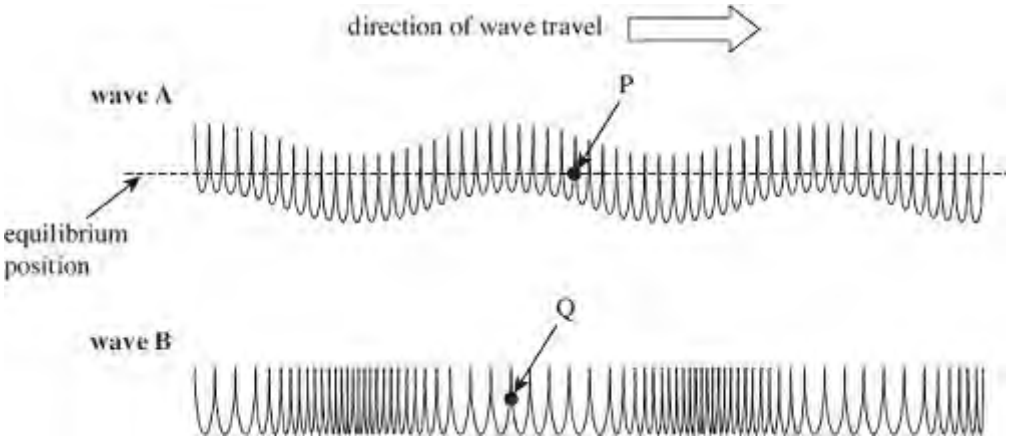
(ii) Calculate the wavelength of the wave if its speed is 4.5×10^3 m s^{-1}.

wavelength ..... m

(2)
(Total 9 marks)

Q6. The figure below shows two ways in which a wave can travel along a slinky spring.

PhysicsAndMathsTutor.com



(a) State and explain which wave is longitudinal.

.....

.....

(2)

(b) On the figure above,

(i) clearly indicate and label the wavelength of **wave B**

(1)

(ii) use arrows to show the direction in which the points **P** and **Q** are about to move as each wave moves to the right.

(2)

(c) Electromagnetic waves are similar in nature to **wave A**.

Explain why it is important to correctly align the aerial of a TV in order to receive the strongest signal.

.....

.....

.....

.....

(2)

(Total 7 marks)

PhysicsAndMathsTutor.com

Q7. (a) Define the amplitude of a wave.

.....

.....

(1)

(b) (i) Other than electromagnetic radiation, give **one** example of a wave that is transverse.

.....

(1)

(ii) State **one** difference between a transverse wave and a longitudinal wave.

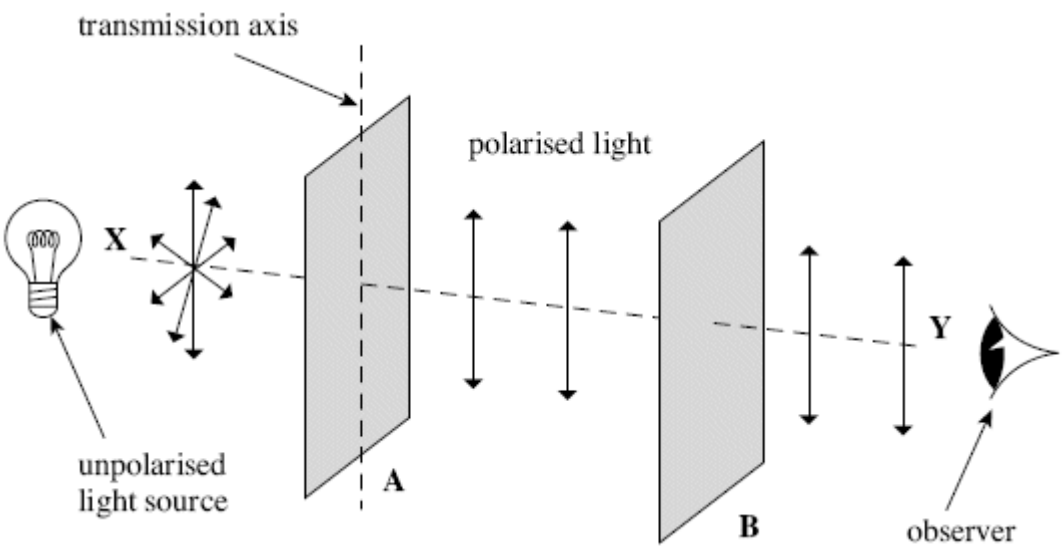
.....

.....

(1)

(c) The figure below shows two identical polarising filters, **A** and **B**, and an unpolarised light source. The arrows indicate the plane in which the electric field of the wave oscillates.

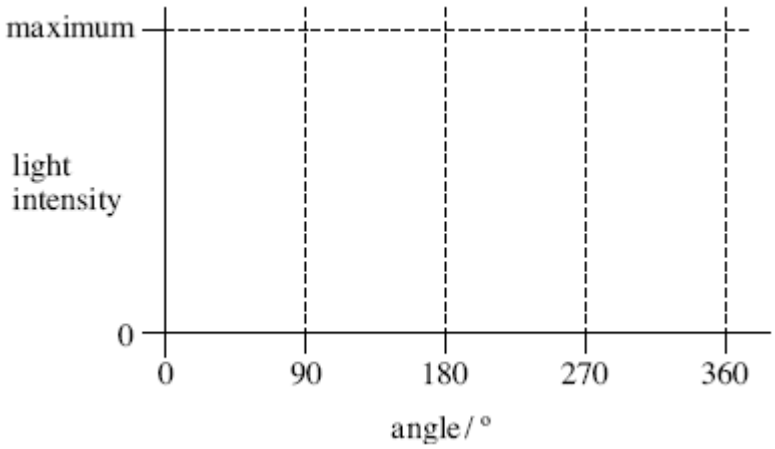
(i) If polarised light is reaching the observer, draw the direction of the transmission axis on filter **B** in the figure below.



PhysicsAndMathsTutor.com

(1)

(ii) The polarising filter **B** is rotated clockwise through 360º about line **XY** from the position shown in the figure above. On the axes below, sketch how the light intensity reaching the observer varies as this is done.



(2)

(d) State **one** application, other than in education, of a polarising filter and give a reason for its use.

.....

.....

.....

.....

(2)
(Total 8 marks)

Q8. Complete the first column in the table to show which of the waves listed are transverse and which are longitudinal.
Complete the second column to show which waves can be polarised.

type of wave	transverse or longitudinal	can be polarised (answer yes or no)

PhysicsAndMathsTutor.com

light		
microwaves		
ultrasound		

(Total 3 marks)

Q9. The sound quality of a portable radio is improved by adjusting the orientation of the aerial. Which statement is a correct explanation of this improvement?

A The radio waves from the transmitter are polarised.

B The radio waves from the transmitter are unpolarised.

C The radio waves become polarised as a result of adjusting the aerial.

D The radio waves become unpolarised as a result of adjusting the aerial.

(Total 1 mark)

Q10. By approximately how many times is the wavelength of audible sound waves greater than the wavelength of light waves?

A 10^{2}

B 10^{6}

C 10^{10}

D 10^{14}

(Total 1 mark)

Q11. Which one of the following properties of light waves do polarising sunglasses depend on for their action?

Light waves may

A interfere constructively.

PhysicsAndMathsTutor.com

B interfere destructively.

C be polarised when reflected from a surface.

D be polarised by the lens in the eye.

(Total 1 mark)

Q12. Which line, **A** to **D**, in the table shows correct relationships for the respective wavelengths, λ_L, λ_S, and frequencies, f_L, f_S, of light waves and sound waves?

	wavelengths	**frequencies**
A	$\lambda_L << \lambda_S$	$f_L >> f_S$
B	$\lambda_L << \lambda_S$	$f_L << f_S$
C	$\lambda_L >> \lambda_S$	$f_L >> f_S$
D	$\lambda_L >> \lambda_S$	$f_L << f_S$

(Total 1 mark)

Q13. (a) State the characteristic features of

(i) longitudinal waves,

.....

.....

(ii) transverse waves.

.....

.....

(3)

(b) Daylight passes horizontally through a fixed polarising filter **P**. An observer views the light emerging through a second polarising filter **Q**, which may be rotated in a

PhysicsAndMathsTutor.com

vertical plane about point **X** as shown in **Figure 1**.

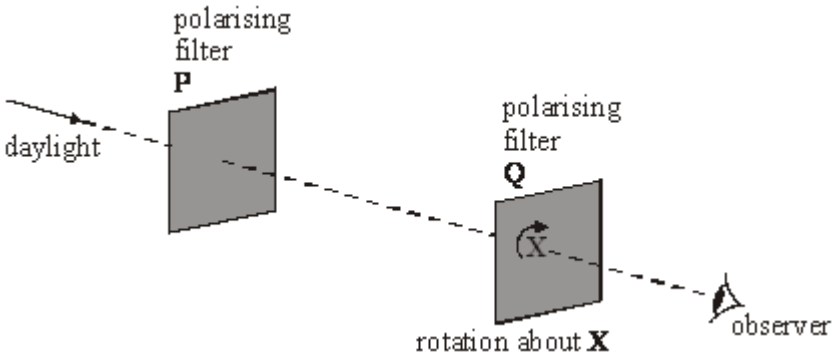


Figure 1

Describe what the observer would see as **Q** is rotated slowly through 360°.

You may be awarded marks for the quality of written communication provided in your answer.

.....

.....

.....

.....

.....

.....

(2)
(Total 5 marks)

PhysicsAndMathsTutor.com