

Name of the Student: _____

Max. Marks : 20 Marks

Time : 20 Minutes

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	$c / \text{m s}^{-1}$	$\rho / \text{kg m}^{-3}$
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.

(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.

$$X = \frac{\rho_X}{\rho_Y} \quad Y = \frac{\rho_Y}{\rho_X}$$

(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.

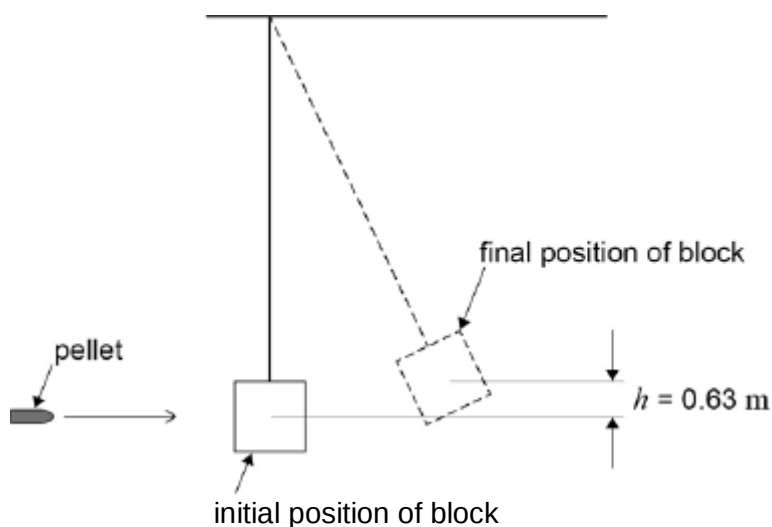
(3)

(Total 10 marks)

Q2.

The speed of an air rifle pellet is measured by firing it into a wooden block suspended from a rigid support.

The wooden block can swing freely at the end of a light inextensible string as shown in the figure below.



A pellet of mass 8.80 g strikes a stationary wooden block and is completely embedded in it. The centre of mass of the block rises by 0.63 m. The wooden block has a mass of 450 g.

- (a) Determine the speed of the pellet when it strikes the wooden block.

speed = _____ m s^{-1}

(4)

- (b) The wooden block is replaced by a steel block of the same mass. The experiment is repeated with the steel block and an identical pellet. The pellet rebounds after striking the block.

Discuss how the height the steel block reaches compares with the height of 0.63 m reached by the wooden block. In your answer compare the energy and momentum changes that occur in the two experiments.

(4)

- (c) Discuss which experiment is likely to give the more accurate value for the velocity of the pellet.

(2)

(Total 10 marks)