OCR
Oxford Cambridge and RSA

A Level Physics A

H556/02 Exploring physics

Question Set 23

1 This question is about waves.

(a) The **period** of a progressive wave can be determined from Fig. 16.1. Add a correct label to the horizontal axis so that the period can be found. **[1]**

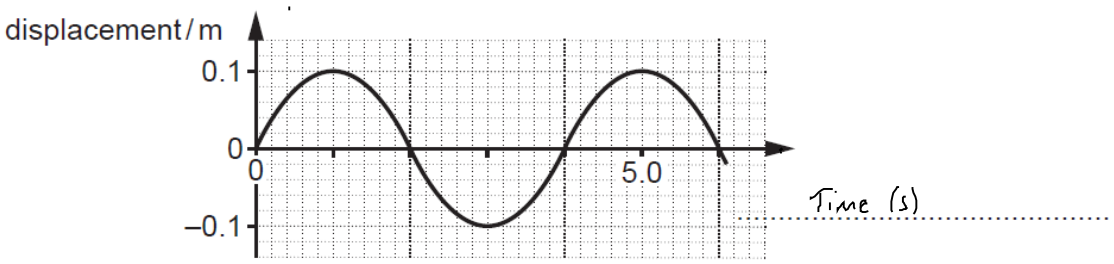

Fig. 16.1

(b) A progressive wave has wavelength λ, frequency f and period T.

Show that the speed v of the wave is given by the equation $v = f\lambda$.

$\text{Speed} = \frac{\text{Distance}}{\text{Time}} \Rightarrow v = \frac{\lambda}{T} = \lambda\left(\frac{1}{T}\right) = f\lambda$ **[2]**

(c) A scientist is investigating the interference of light using very thin transparent material.
A sample of the transparent material is placed in a vacuum.
Fig. 16.2 shows the path of two identical rays of light **L** and **M** from a laser.

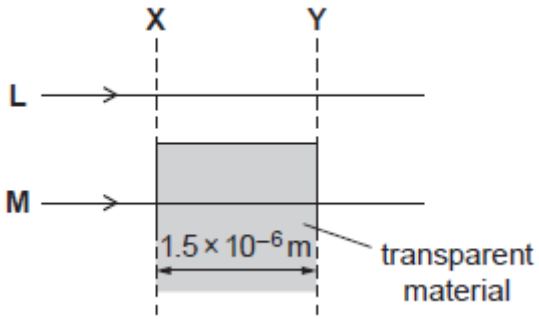

Fig. 16.2

The refractive index of the material is 1.20. The thickness of the material is 1.5×10^{-6} m. The wavelength of the light in vacuum is 6.0×10^{-7} m.

(i) Show that the difference in time t for the two rays to travel between the dashed lines **X** and **Y** is 1.0×10^{-15} s.

Speed of light through material $= 1.2 \times 3 \times 10^8 = 3.6 \times 10^8$ ms^{-1}

$\text{Time} = \frac{\text{Distance}}{\text{speed}} = \frac{1.5 \times 10^{-6}}{3.6 \times 10^8} = 4.17 \times 10^{-15}$ s

Time through vacuum $= \frac{1.5 \times 10^{-6}}{3 \times 10^8} = 5 \times 10^{-15}$ s

$\Delta t = 5 \times 10^{-15} - 4.17 \times 10^{-15} = 8.3 \times 10^{-16} = 0.83 \times 10^{-15} \approx 1 \times 10^{-15}$

$t =$ 0.83×10^{-15} s **[3]**

(ii) Calculate the period T of the light wave.

$T = \frac{1}{f} = \frac{\lambda}{v} = \frac{6 \times 10^{-7}}{3 \times 10^{8}} = 2 \times 10^{-15}$ $T =$ 2×10^{-15} s **[2]**

(iii) The rays of light are in phase at the dashed line **X**.

Use your two answers above to state the phase difference φ in degrees between the light rays at **Y**.

$\frac{2 \times 10^{-15}}{0.83 \times 10^{-15}} = 2.4$ full wave cycles

So phase difference $= 0.4 \times 360^{\circ} = 144^{\circ}$ $\varphi =$ 140 (2 sf) ° **[1]**

(d) The speed v of surface water waves in shallow water of depth d is given by the equation $v = \sqrt{gd}$, where g is the acceleration of free fall.

The speed v is about 1 m s^{-1} for a depth of about 10 cm.

You are provided with a rectangular plastic tray, supply of water and other equipment available in the laboratory.

Describe how an experiment can be conducted in the laboratory to test the validity of the equation above and how the data can be analysed to determine a value for g. **[6]**

- Fill the tray with some water. Measure the depth d with a ruler
- Drop a ball right at one end. Use a slow motion camera to time how long waves take to reach the opposite end. Measure the length using a ruler, and calculate v.
- Allow waves to settle before repeating. Repeat several times to find an average.
- Add more water, re-measure d, and repeat for several set values of d.
- Plot v against $\sqrt{d}$. If relationship correct, should be straight line through origin.
- gradient $= \sqrt{g}$ ⇒ square to find g.

Total Marks for Question Set 23: 15