1 **(a)** **(i)** Explain what is meant by a *progressive wave*.

....

....

....

.... **[2]**

(ii) State **two** differences between a *progressive* and a *stationary* wave.

1 ....

....

2 ....

....

[2]

(b) Fig. 4.1 shows, at time t = 0, the shape of a section of stretched cord along which a transverse wave is **travelling** from left to right. **W**, **X**, **Y** and **Z** are four marked points on the cord.

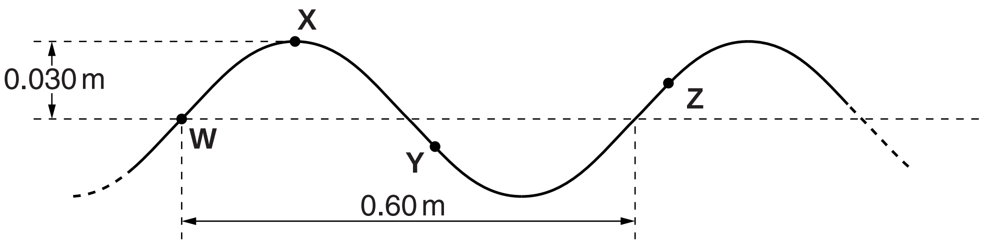

Fig. 4.1

A mechanical oscillator is causing the wave by oscillating the end of the cord at a steady frequency of 5.0 Hz. The wave has a wavelength of 0.60 m and amplitude of 0.030 m.

(i) On the axes of Fig. 4.2 sketch the graph of the displacement of point **X** over the period t = 0 to 0.40 s. Add suitable scales to the axes. **[4]**

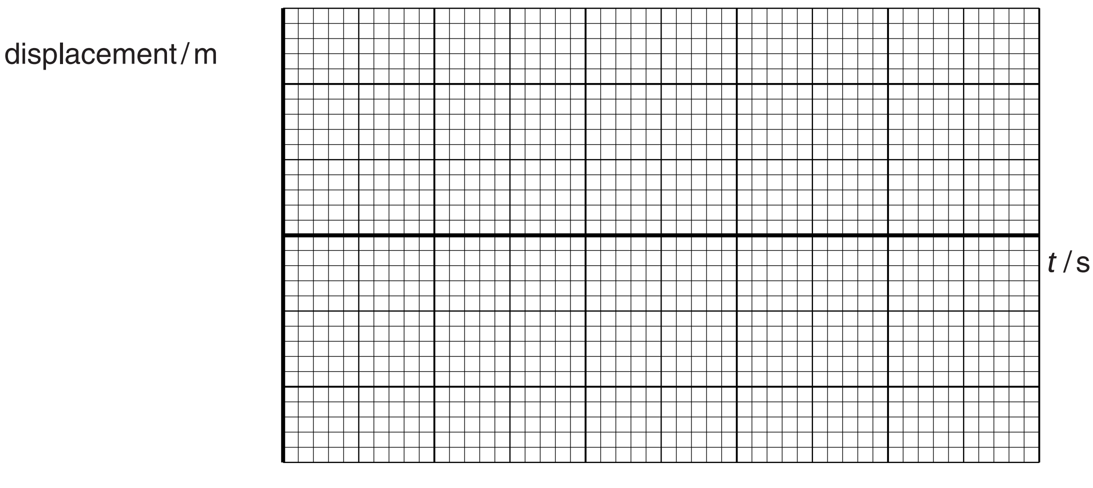

Fig. 4.2

(ii) State which of the points **W**, **X**, **Y** and **Z** at $t = 0$

1 is instantaneously at rest ....

2 has the greatest speed ....

3 are moving 90° out of phase with each other. ....
[3]

(iii) On Fig. 4.1 draw arrows to show the directions in which the points **Y** and **Z** are moving. **[2]**

(c) The speed v of the wave on the stretched cord is given by the formula

$$v = k\sqrt{T}$$

where T is the tension in the cord and k is a constant.

Calculate the wavelength λ of the wave after the tension in the cord has been **quadrupled** (×4) but the frequency of oscillation is unchanged.

λ = ... m **[2]**

(d) The speed of point **W** on the cord at $t = 0$ is $0.94\,\text{m}\,\text{s}^{-1}$. With the cord at its original tension, the frequency of oscillation is now **doubled** to 10 Hz. The amplitude is kept at 0.030 m. Calculate the new speed of point **W** at $t = 0$. Explain your reasoning.

speed = ... $\text{m}\,\text{s}^{-1}$ **[2]**

[Total: 17]

2 This question is about the superposition of electromagnetic waves.

(a) (i) State the *principle of superposition of waves*.

....

....

.... **[2]**

(ii) State **one** property of electromagnetic waves that distinguishes them from **all** other waves.

....

.... **[1]**

(iii) State why electromagnetic waves can be polarised but sound waves cannot be polarised.

....

.... **[1]**

(b) In Fig. 5.1 $\mathbf{T_1}$ and $\mathbf{T_2}$ are two adjacent transmitters 1.0 m apart with a receiving aerial **R** halfway between them. The transmitters are set up to emit coherent electromagnetic waves of wavelength 3.0 cm.

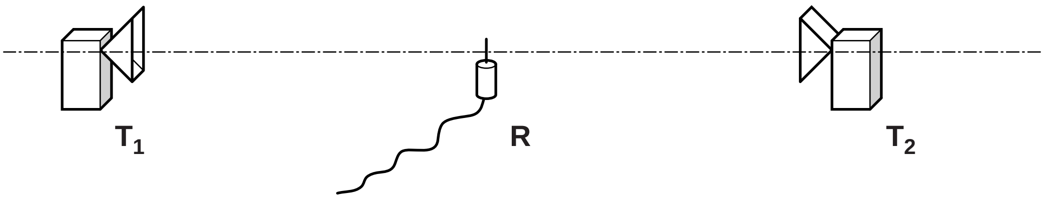

Fig. 5.1

(i) The student finds that the signal at the receiver **R** falls from maximum to zero when **R** is moved 0.75 cm towards a transmitter. Explain this observation.

In your answer you should make clear how the signal can be zero and why the distance moved should be 0.75 cm.

....

....

....

....

....

....

....

.... **[4]**

(ii) With **R** at the mid-point between $\mathbf{T_1}$ and $\mathbf{T_2}$, the student rotates $\mathbf{T_2}$ through 90° about an axis through $\mathbf{T_1}$ and $\mathbf{T_2}$. See Fig. 5.2.

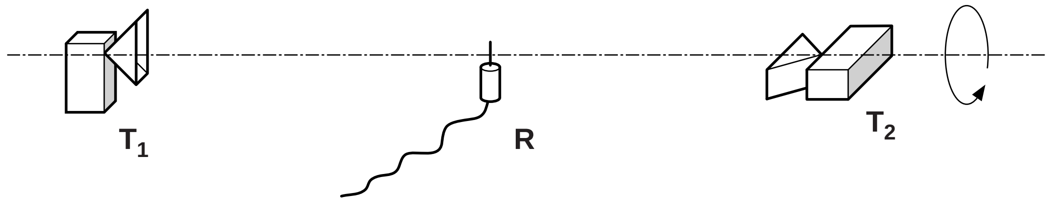

Fig. 5.2

The student finds that the amplitude of the signal at **R** falls to about one half. The detected signal now remains the same when **R** is moved 0.75 cm. Explain these observations.

....

....

....

....

....

....

....

.... **[3]**

[Total: 11]

3 This question is about the Young double slit experiment. See Fig. 7.1. The fringe pattern seen on the screen is shown to the right.

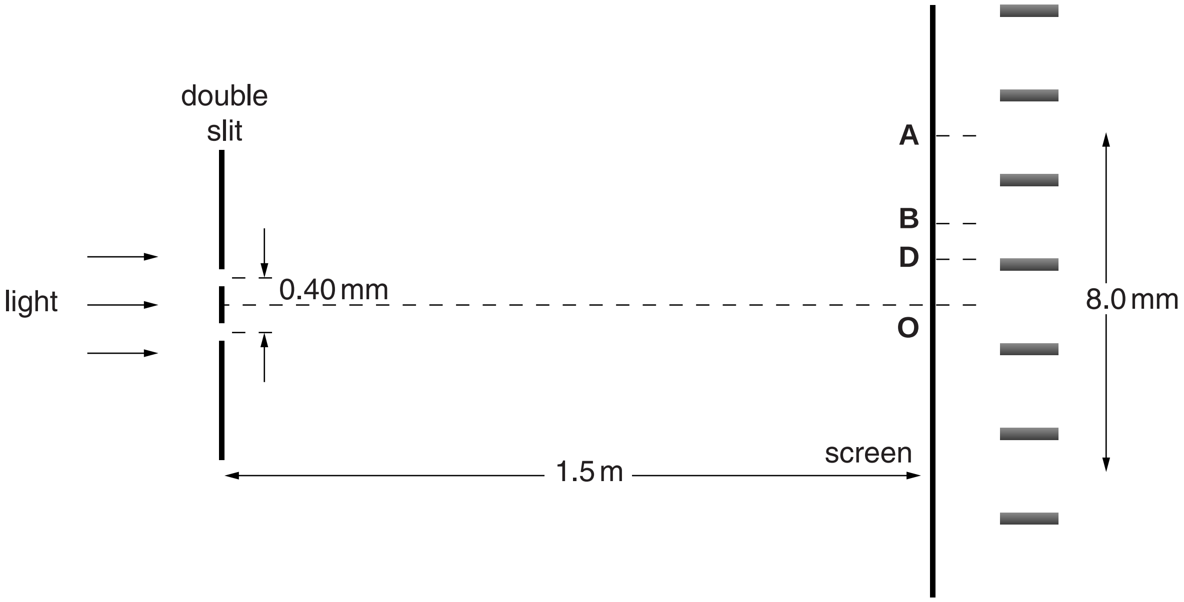

Fig. 7.1

Two parallel clear lines are scratched on a darkened glass slide 0.40 mm apart. When a beam of monochromatic visible light is shone through these slits, interference fringes are observed on a screen placed 1.5 m from the slide. The fringe at point **B** is bright and the fringe at point **D** is dark.

(a) Explain why this arrangement with two slits is used to produce visible fringes on the screen rather than two separate identical light sources.

....

....

.... **[2]**

(b) State the **phase difference** between the light waves from the two slits that meet on the screen in Fig. 7.1 at point

D ....

B .... **[2]**

(c) **(i)** Use Fig. 7.1 to calculate the separation of adjacent bright fringes, the distance between **O** and **B**.

fringe separation = ... m **[1]**

(ii) Show that the wavelength λ of the monochromatic light is about 5×10^{-7} m.

[3]

(d) Calculate the **path difference**, in nanometres, between the light waves from the two slits that meet on the screen in Fig. 7.1 at point **A**.

path difference = ... nm **[2]**

(e) The energy level diagram of Fig. 7.2 is for the atoms emitting photons in the light source. Electron transitions between the three levels shown produce three photons of different wavelength. The energy E of an electron bound to an atom is negative.

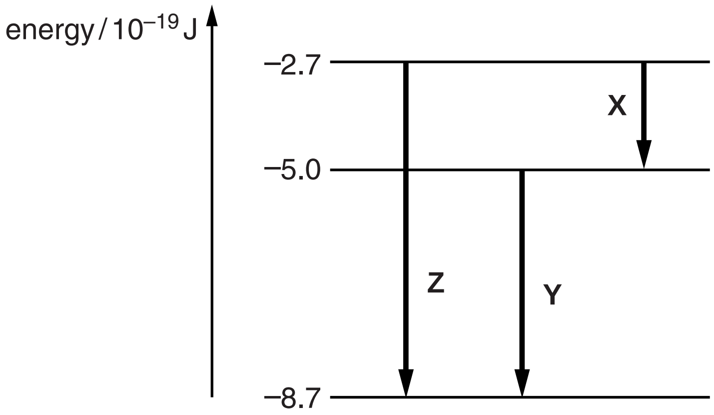

Fig. 7.2

(i) Use data from Fig. 7.2 to justify that the arrow labelled **Y** produces the photons of wavelength about 5×10^{-7} m used in the interference experiment.

[4]

(ii) Neither of the photons shown by the other transitions can be used for the experiment because they are not visible. State in which region of the electromagnetic spectrum each photon is produced, by the other transitions, **X** and **Z**.

X ....

Z .... **[2]**

[Total: 16]