1 **(a)** State **two** properties which distinguish electromagnetic waves from other transverse waves.

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**(b)** **(i)** Describe what is meant by *a plane polarised wave*.

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**(ii)** Light from a filament lamp is viewed through two polarising filters, shown in Fig. 6.1. The arrow beside each filter indicates the transmission axis of that polarising filter.

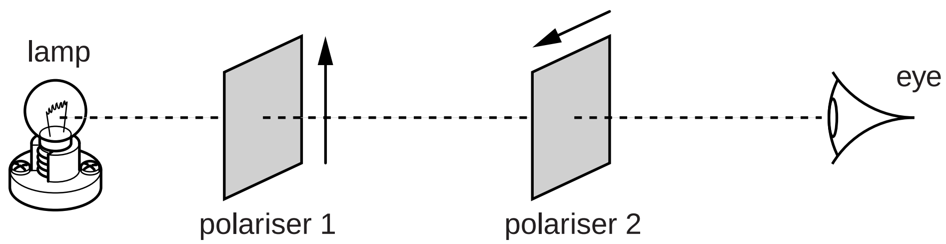


**Fig. 6.1**

Explain why the lamp cannot be seen by the eye.

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**(iii)** A third polarising filter is placed between the first two with its transmission axis at 45° to each of the others as shown in Fig. 6.2.

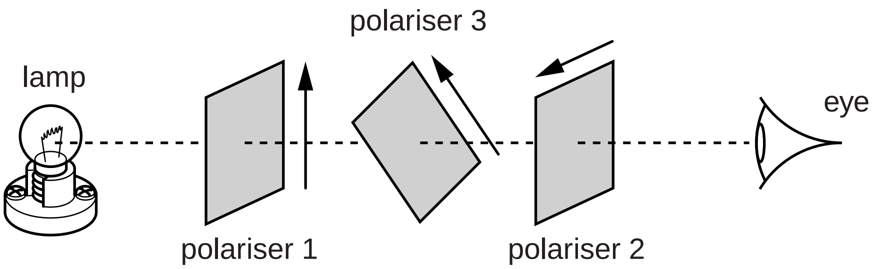


**Fig. 6.2**

Explain whether or not any light reaches the eye through the three filters.

*In your answer you should state clearly the condition for light to be transmitted by a polarising filter.*

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**[Total: 9]**

**2** An estimation of the speed of electromagnetic waves can be made using the hot spots inside a microwave oven. Microwaves are emitted in all directions inside the metal walls of the oven at a frequency of $2.5 \times 10^9$ Hz causing stationary waves to be set up. Fig. 7.1 shows a typical pattern of the centres of the hot spots marked **X** in the central area of the floor of the oven.

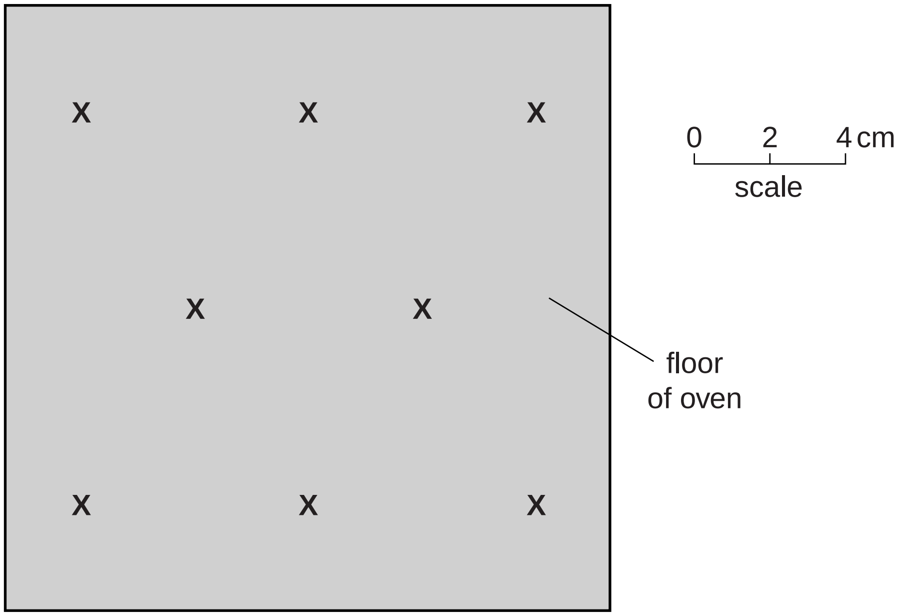


**Fig. 7.1**

These positions can be located to within a few millimetres by melting small areas in a bar of chocolate placed on the floor of the oven for a few seconds.

**(a)** Explain how a stationary microwave pattern is set up in the oven.

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**(b)** Explain whether the points marked **X** on Fig. 7.1 are at nodes or antinodes in the wave pattern.

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**(c)** Fig. 7.1 is drawn to **half scale**. By using measurements taken from the diagram make an estimate of the speed *c* of the microwaves. Make your reasoning clear.

*c* = ............................................... $m\,s^{-1}$ **[4]**

**[Total: 9]**

**3** **(a)** Define the following terms as applied to wave motion

**(i)** *displacement* and *amplitude*

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**(ii)** *frequency* and *phase difference*.

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**(b)** Fig. 6.1 shows a transverse pulse on a *slinky*, an open wound spring, at time $t = 0$. The pulse is travelling at a speed of $0.50\,\mathrm{m\,s^{-1}}$ from left to right. The front of the pulse is at point **X**, 0.25 m from the point **P**.

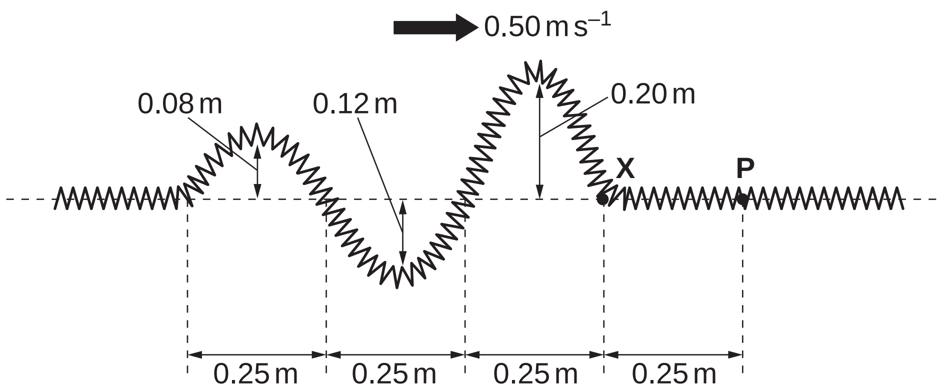


**Fig. 6.1**

On Fig. 6.2 draw a displacement *y* against time *t* graph of the motion of point **P** on the slinky from $t = 0$ to $t = 2.5$ s.

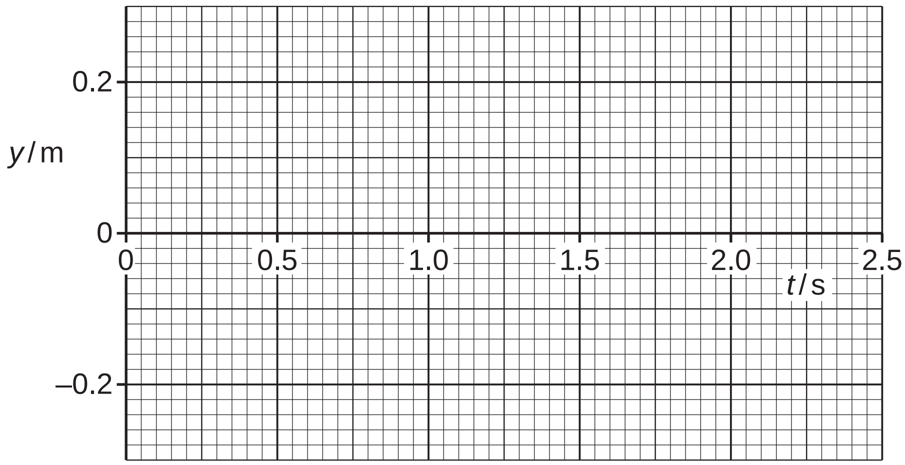


**Fig. 6.2**

**[4]**

**[Total: 8]**

4 **(a)** State **two** properties shared by all electromagnetic waves which distinguish them from all other waves.

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**(b)** The two columns below list four regions of the electromagnetic spectrum and four orders of magnitude of wavelength in m.

| **region** | **wavelength / m** |
|---|---|
| microwaves | $10^{-12}$ |
| ultra violet light | $10^{-8}$ |
| gamma rays | $10^{-6}$ |
| infra red light | $10^{-4}$ |

Draw a straight line from each **region** box to the corresponding **wavelength** box. **[2]**

**(c)** Fig. 8.1 shows a microwave receiver **R** placed between a microwave transmitter **T** and a flat metal sheet.

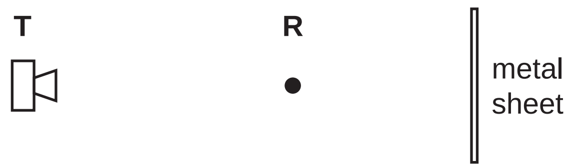


**Fig. 8.1**

**(i)** Explain why **R** receives two signals of different amplitude but of the same frequency.

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**(ii)** Explain why the strength of the detected signal varies between maximum and minimum values as **R** is moved towards or away from the metal sheet.

*In your answer you should make clear how the maxima and minima occur.*

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**(iii)** Determine the wavelength of the microwaves given that the distance between adjacent positions of maximum and minimum signal strength is 7.5 mm.

wavelength = ................................................. mm **[1]**

**(iv)** The amplitude of the signal from the transmitter is *a*. The amplitude of the two signals detected at **R** are 0.8*a* and 0.6*a*. The changes in amplitude of the detected signals are negligible as **R** moves 7.5 mm. Show that the ratio

$$\frac{\text{maximum intensity of detected signal}}{\text{minimum intensity of detected signal}}$$

is about 50.

**[3]**

**[Total: 13]**

**5** In Fig. 5.1 the solid line on the graph represents the displacement $y$ against position $x$ of a **progressive** transverse wave on a stretched wire at time $t = 0$. The dotted line shows the displacement at a later time $t = 0.75$ ms, where the wave has moved to the right.

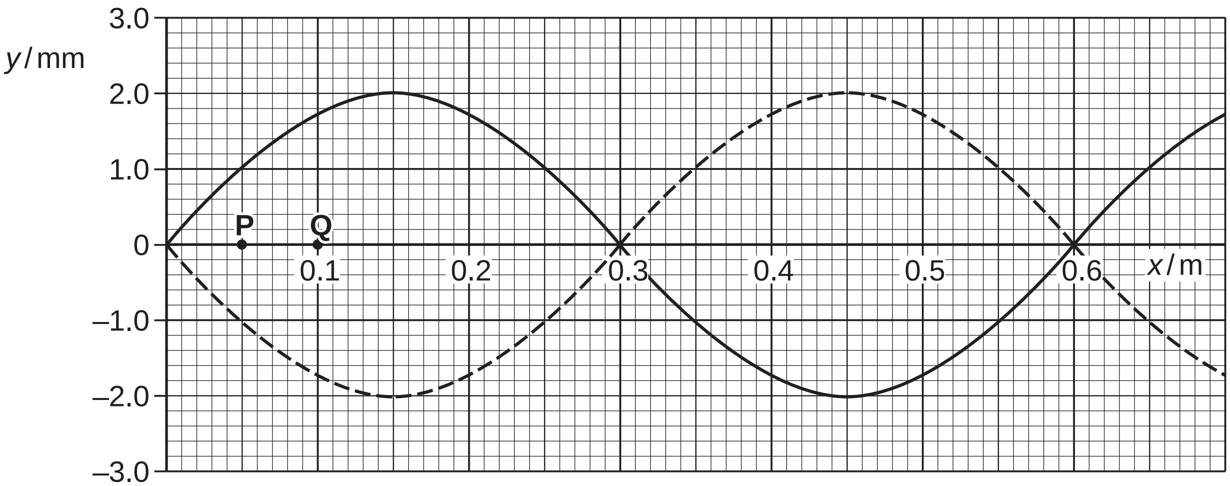


**Fig. 5.1**

**(a)** **(i)** Determine the wavelength of the wave.

wavelength = .................................................... m **[1]**

**(ii)** **1** Explain how Fig. 5.1 shows that the period of the wave is 1.5 ms.

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**2** Calculate the speed of the wave along the wire.

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

**(b)** Consider the oscillations of the wire at positions **P** ($x = 0.05$ m) and **Q** ($x = 0.10$ m). See Fig. 5.1. For the **progressive** wave on the wire state the difference, if any, in **amplitude** of the oscillations of the wave at **P** and **Q**.

difference = ................................................. mm **[1]**

**(c) (i)** Describe the diference between the *displacement* and the *amplitude* of a wave.

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**(ii)** Describe how a *stationary* wave is different from a *progressive* wave.

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**(d)** Fig. 5.2 shows the wire of Fig. 5.1 under tension fixed at points $x = 0$ and 0.60 m. The frequency of the mechanical oscillator close to one end is varied so that a **stationary** wave is set up on the wire.

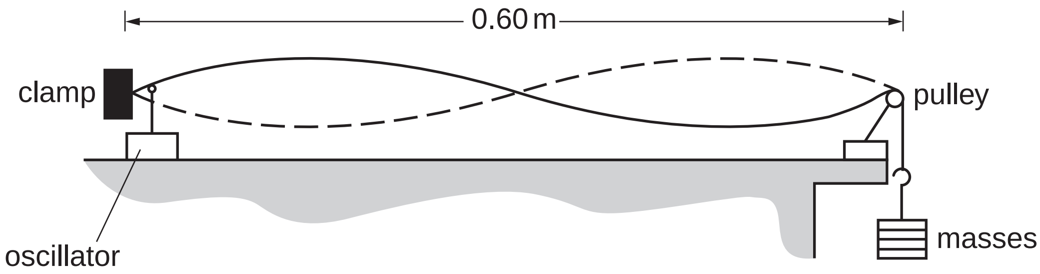


**Fig. 5.2**

**(i)** By considering the motion of progressive waves on the wire, explain how the stationary wave is produced.

*In your answer you should make clear how the stationary wave arises.*

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**(ii)** In Fig. 5.3 the solid line on the graph represents the displacement $y$ against position $x$ of the **stationary** wave on the stretched wire at time $t$ = 0. The dotted line shows the displacement at a later time $t$ = 0.75 ms.

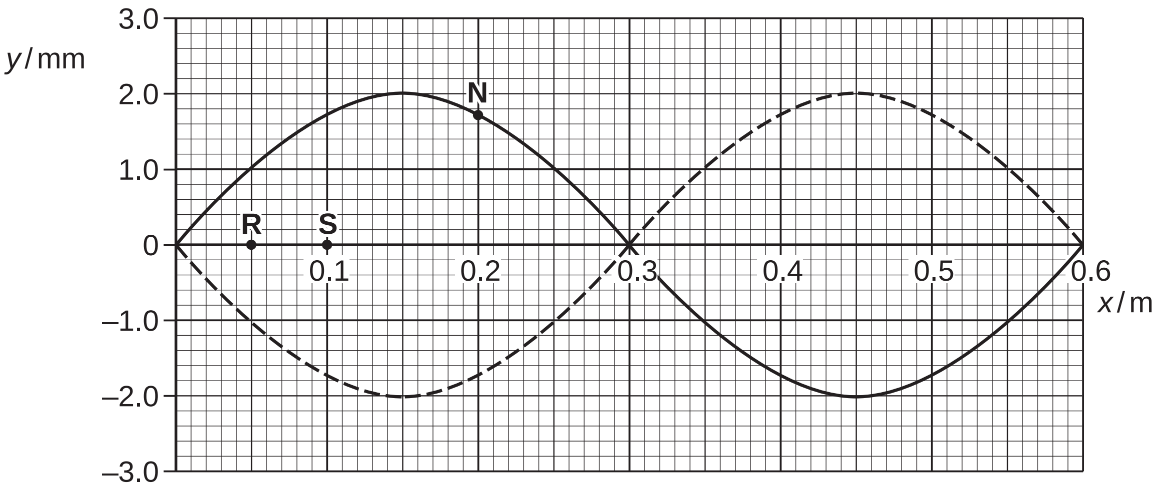


**Fig. 5.3**

For the **stationary** wave on the wire

**1** state the difference, if any, in **amplitude** of the oscillations at **R** and **S**

difference = ................................................. mm **[1]**

**2** mark with an **X** the position of one antinode **[1]**

**3** mark with a **Y** on the dotted line on Fig. 5.3 where the point **N** on the wave is at $t$ = 0.75 ms. **[1]**

**[Total: 15]**