A Level · OCR · Physics

37 mins 5 questions

Structured Questions

Superposition & Stationary Waves

Superposition / Graphical Representation of Superposition / Interference / Two-Source Interference / Young Double-Slit Experiment / Determining the Wavelength of Light / Stationary Waves / Stationary vs Progressive Waves / Nodes & Antinodes / Determining the Speed of Sound in Air in a Resonance Tube / Harmonics

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Total Marks **/37**

1 (a) This question is about investigations involving an electromagnetic wave.

A vertical transmitter aerial emits a **vertically polarised** electromagnetic wave which travels towards a vertical receiver aerial. The wavelength of the wave is 0.60 m.

Fig. 5.1 shows a short section of the oscillating electric field of the electromagnetic wave.

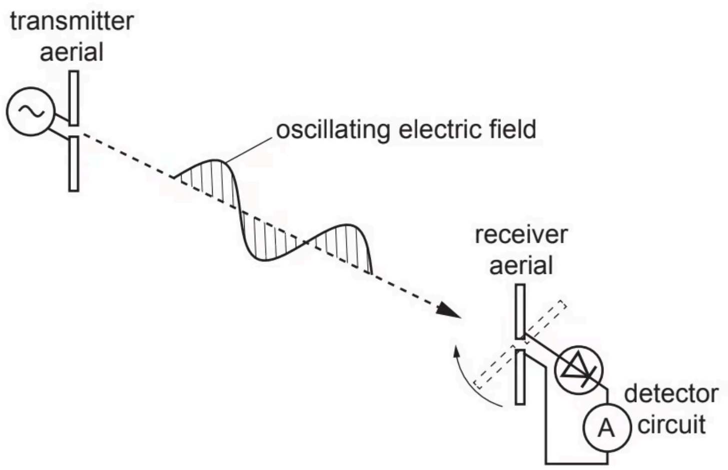

Fig. 5.1

Calculate the frequency *f* of the transmitted wave.

f = ... Hz

....

....

(2 marks)

(b) The electromagnetic wave is caused by electrons oscillating in the transmitter aerial. Each electron oscillates with simple harmonic motion.

Calculate the maximum acceleration a_{max} of an electron which oscillates with an amplitude of 4.0×10^{-6} m.

a_{max} = ... m s^{-2}

....

(3 marks)

(c) Suggest why the diode in **Fig. 5.1** is necessary for an ammeter to detect a signal at the receiver aerial.

(1 mark)

(d) A student carries out two investigations with these electromagnetic waves.

In **investigation 1**, the student rotates the receiver aerial about the horizontal axis joining the two aerials, as shown in **Fig. 5.1**.

In **investigation 2**, the student places a metal sheet behind the receiver aerial. The student moves the sheet backwards and forwards along the horizontal axis joining the two aerials, as shown in **Fig. 5.2**.

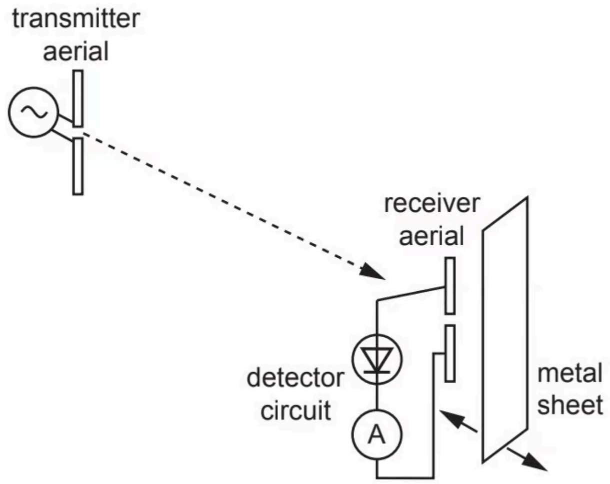

Fig. 5.2

For each of these two investigations:

- Explain why the ammeter sometimes gives a maximum reading and sometimes a zero (or near zero) reading.
- State the orientations of the receiver aerial in **investigation 1**, and the positions of the metal sheet in **investigation 2**, where these maximum and zero readings would

occur.

(6 marks)

2 (a) Hydrogen atoms excited in a discharge tube only emit four different discrete wavelengths of visible photons.

In a semi-darkened room, a single slit is placed in front of the discharge tube. A student holds a diffraction grating which has 300 lines per millimetre.

The student looks through the grating at a 15cm plastic ruler placed 0.50m away, as shown in Fig. 5.1.

The paths of the different colours of light from the slit to the student's eye are shown in Fig. 5.2.

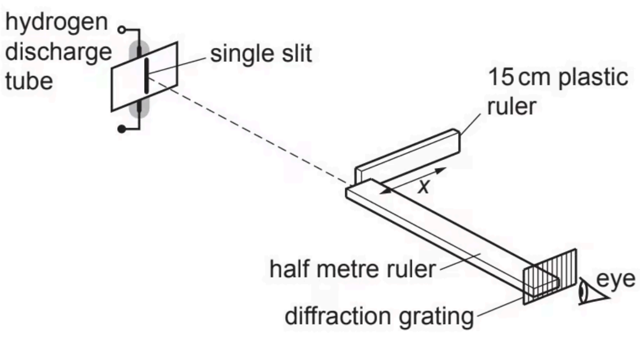

Fig. 5.1 (not to scale)

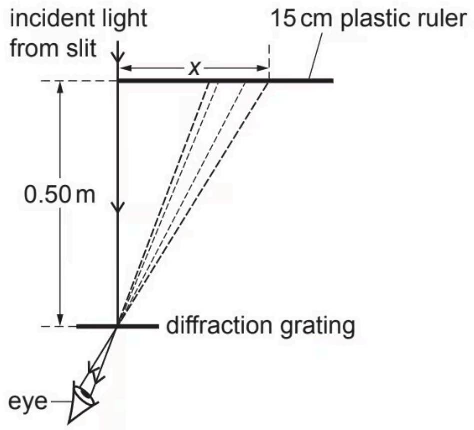

Fig. 5.2 (not to scale)

Four **first** order images of the slit, one at each photon wavelength, are observed as vertical lines against the background of the plastic ruler, as shown in Fig. 5.3.

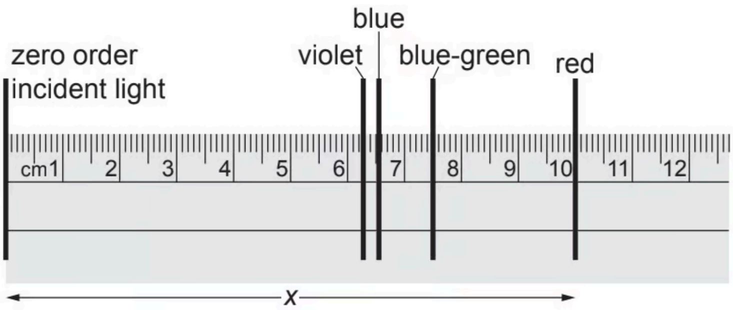

Fig. 5.3

The student decides to determine the wavelength of the photons which form the **red** line observed at x = 10 cm on the ruler.

- Describe how the information that has been given can be used to determine the wavelength of the red photons.
- Estimate the percentage uncertainty in the measured value of the wavelength.

(6 marks)

(b) i) Show that the energy of a photon of wavelength 486 nm is 4.09×10^{-19} J.

[1]

ii) Fig. 5.4 shows some of the energy levels of an electron in a hydrogen atom.

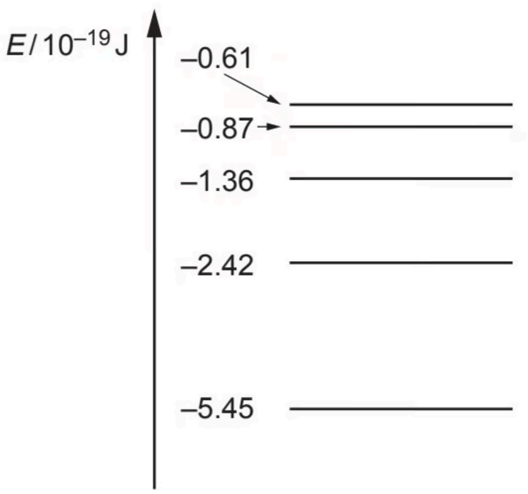

Fig. 5.4 (not to scale)

Draw an arrow on Fig. 5.4 to show an electron transition which would cause the **emission** of a photon of wavelength 486 nm.

[2]

(3 marks)

3 (a) Fig. 17.1 shows the variation with distance of the displacement of a **stationary** wave at time $t = 0$.

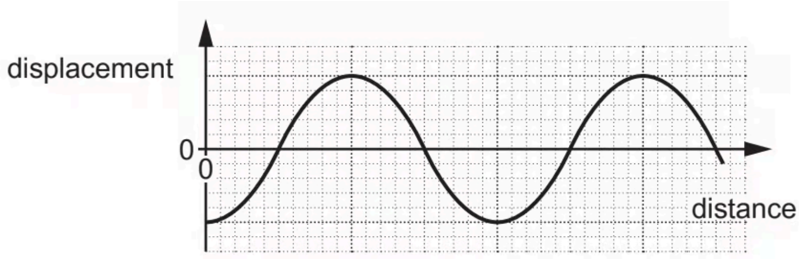

Fig. 17.1

The period of the wave is T.

i) On Fig. 17.1, sketch a graph to show the variation of the displacement at time $t = \frac{T}{2}$.

[1]

ii) On Fig. 17.1, show the positions of **all** the nodes. Label each node **N**.

[1]

....

....

(2 marks)

(b) Stationary sound waves are formed in a tube closed at one end.

Fig. 17.2 shows three stationary wave patterns formed in the air column of the tube.

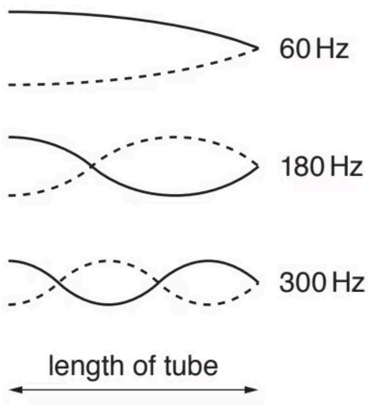

Fig. 17.2

The frequency *f* of the oscillations for each stationary wave is shown in Fig. 17.2.

Use Fig. 17.2 to explain how the frequency *f* of the sound wave depends on the wavelength λ.

....

....

....

(3 marks)

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

....

(1 mark)

(b) Fig. 16.1 shows an arrangement to demonstrate the interference of monochromatic light.

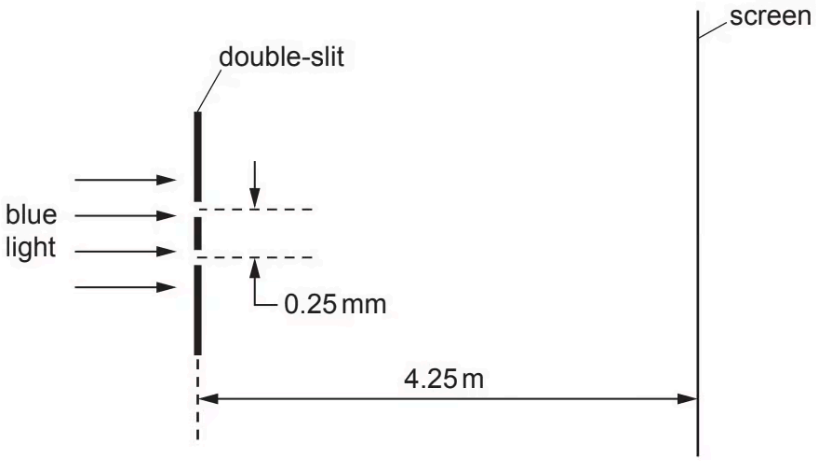

Fig. 16.1

Coherent blue light from a laser is incident at a double-slit. The separation between the slits is 0.25 mm. A series of dark and bright lines (fringes) appear on the screen. The screen is 4.25 m from the slits.

Fig. 16.2 shows the dark and bright fringes observed on the screen.

Fig. 16.2

The pattern shown in Fig. 16.2 is **drawn to scale**.

i) Use Fig. 16.2 to determine accurately the wavelength of the blue light from the laser.

wavelength = ... m **[3]**

ii) The blue light is now replaced by a similar beam of red light.

State and explain the effect, if any, on the fringes observed on the screen.

[2]

(5 marks)

5 (a) Fig. 19.1 shows the image from an experiment using a ripple tank.

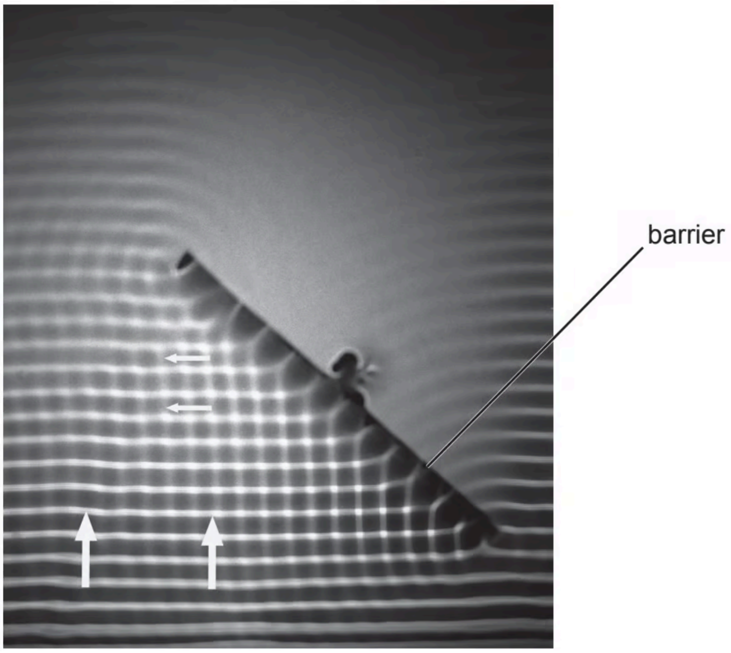

Fig. 19.1

A straight ruler repeatedly hits the surface of water. Waves on the surface of the water travel in the direction shown by the two large upward white arrows. The waves are incident at a solid barrier.

Closely examine the image shown in Fig. 19.1.

State **two** wave phenomena (properties) that can be observed in this image. You may annotate Fig. 19.1 to support your answer.

....

....

(2 marks)

(b) Two transmitters, **A** and **B**, emit coherent microwaves in all directions. A receiver is moved at constant speed along the line from **P** to **Q** which is parallel to the line joining the two transmitters, as shown in Fig. 19.2.

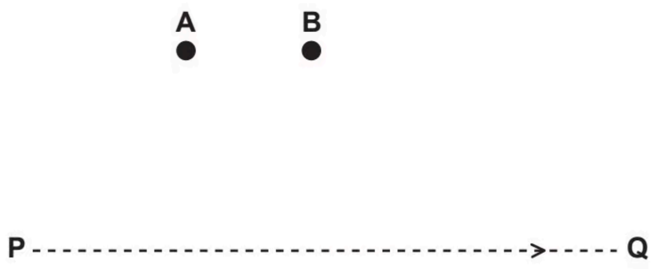

Fig. 19.2

Explain why the output signal from the receiver fluctuates between minimum and maximum values as the receiver moves from **P** to **Q**.

....

....

....

(3 marks)