Revision Questions

MARK SCHEME

Waves + Optics

6 Virtual images may be formed by both plane mirrors and by convex lenses.

Fig. 6.1 shows a plane mirror and a convex lens.

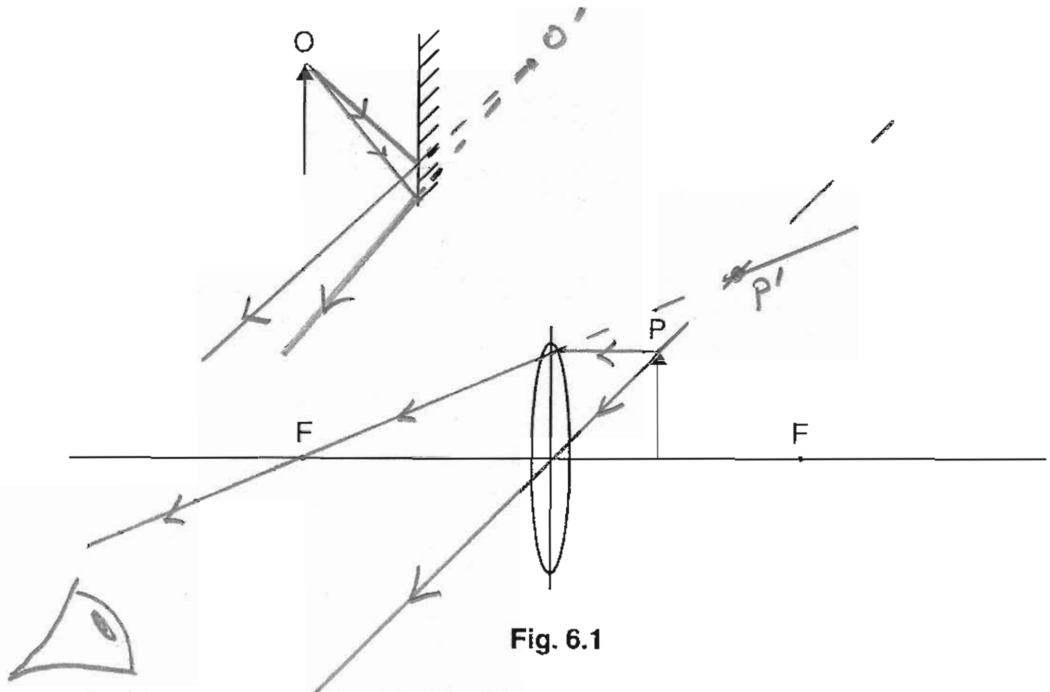

Fig. 6.1

(a) On Fig. 6.1, draw rays to locate the approximate positions of the images of the tops of the two arrow objects O and P.
Label the images. [5]

(b) Both images are virtual.

(i) What is meant by a *virtual image*?

No rays of light actually converge at the virtual image; it just appears to the observer that the light originates from the image. [1]

(ii) State **one** other similarity between the two images.

Both upright [1]

(iii) State **one** difference between the two images.

P' is enlarged (magnified) but O' is not. [1]

[Total: 8]

6 Fig. 6.1 shows a ray of light, from the top of an object PQ, passing through two glass prisms.

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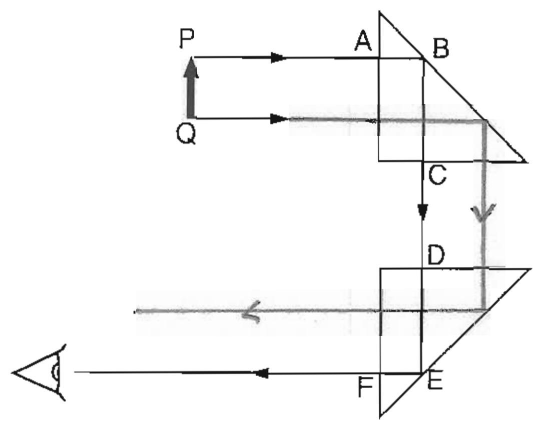


Fig. 6.1

(a) Complete the path through the two prisms of the ray shown leaving Q. [1]

(b) A person looking into the lower prism, at the position indicated by the eye symbol, sees an image of PQ.
State the properties of this image.

Inverted, virtual [2]

(c) Explain why there is no change in direction of the ray from P at points A, C, D and F.

The light is entering normal to the surface

(i.e. at 90° to the surface) [1]

(d) The speed of light as it travels from P to A is 3×10^8 m/s and the refractive index of the prism glass is 1.5.
Calculate the speed of light in the prism.

$n = \frac{c_{vacuum}}{c_{glass}} \Rightarrow c_{glass} = \frac{c_{vacuum}}{n} = \frac{3 \times 10^8 \text{ m/s}}{1.5}$

speed = 2×10^8 m/s [2]

(e) Explain why the ray AB reflects through 90° at B and does not pass out of the prism at B.

✓① The angle of incidence is greater than the critical angle

✓① and so there is total internal reflection [2]

6 Fig. 6.1 shows an optical fibre. XY is a ray of light passing along the fibre.

For Examiner's Use

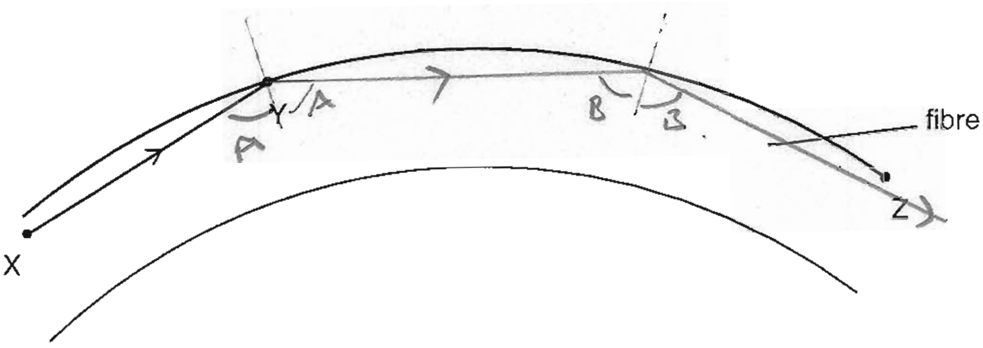


Fig. 6.1

(a) On Fig. 6.1, continue the ray XY until it passes Z. [1]

(b) Explain why the ray does **not** leave the fibre at Y.

There is total internal reflection ① since the angle A is more than the ~~critical~~ critical angle for the boundary ....[2]

(c) The light in the optical fibre has a wavelength of 3.2 x 10^{-7} m and is travelling at a speed of 1.9 x 10^{8} m/s.

(i) Calculate the frequency of the light.

$v = f\lambda$

$\Rightarrow f = \frac{v}{\lambda} = \frac{1.9 \times 10^{8} m/s}{3.2 \times 10^{-7} m}$

frequency = 5.9×10^{14} Hz

(ii) The speed of light in air is 3.0 x 10^{8} m/s.
Calculate the refractive index of the material from which the fibre is made.

$n = \frac{3.0 \times 10^{8} m/s}{1.9 \times 10^{8} m/s} = 1.58$ or 1.6 to 2 sig figs.

refractive index = ...

[4]

6 Fig. 6.1 shows a ray PQ of blue light incident on the side of a rectangular glass block.

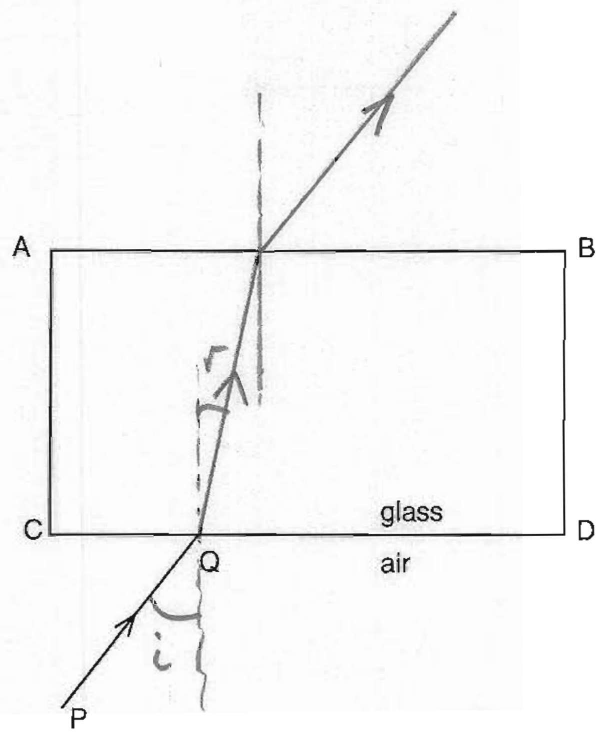


Fig. 6.1

(a) **(i)** By drawing on Fig. 6.1, continue the ray PQ through and beyond the block.

(ii) Mark the angle of incidence at CD with the letter *i* and the angle of refraction at CD with the letter *r*.

[3]

(b) The speed of light in air is 3.0 x 10^8 m/s and the speed of light in glass is 2.0 x 10^8 m/s.

(i) Write down a formula that gives the refractive index of glass in terms of the speeds of light in air and glass.

refractive index = $\dfrac{\text{speed of light in air}}{\text{speed of light in glass}}$

(ii) Use this formula to calculate the refractive index of glass.

refractive index = ...1.5..........

[2]

(c) The frequency of the blue light in ray PQ is 6.0 x 10^{14} Hz.
Calculate the wavelength of this light in air.

$$\lambda = \frac{v}{f} = \frac{3.0 \times 10^{8}\,\text{m/s}}{6.0 \times 10^{14}\,\text{Hz}}$$

wavelength = 5.0×10^{-7} m [2]

(500 nm).

(I'd have thought this was green actually).

6 Fig. 6.1 shows white light incident at P on a glass prism. Only the refracted red ray PQ is shown in the prism.

For Examiner's Use

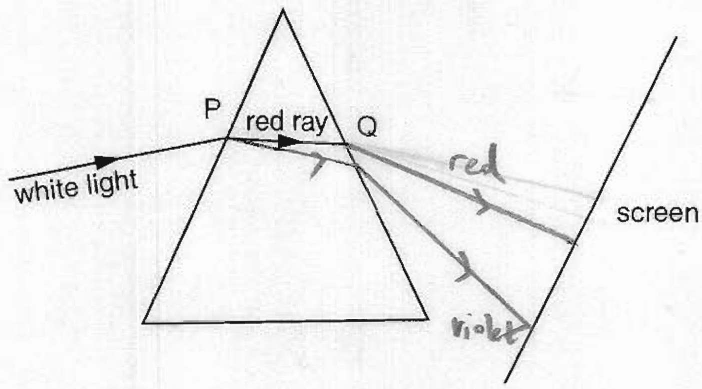


Fig. 6.1

(a) On Fig. 6.1, draw rays to complete the path of the red ray and the whole path of the violet ray up to the point where they hit the screen. Label the violet ray. [3]

(b) The angle of incidence of the white light is increased to 40°. The refractive index of the glass for the red light is 1.52.
Calculate the angle of refraction at P for the red light.

$n = \frac{\sin i}{\sin r}$ ∴ $\sin r = \frac{\sin i}{n}$

∴ $r = \sin^{-1}\left(\frac{\sin 40°}{1.52}\right) = 25°$

angle of refraction = 25° [3]

(c) State the approximate speed of

(i) the white light incident at P, speed = 3.0×10^8 m/s [1]

(ii) the red light after it leaves the prism at Q. speed = 3.0×10^8 m/s [1]

7 Fig. 7.1 shows how the air pressure at one instant varies with distance along the path of a continuous sound wave.

For Examiner's Use

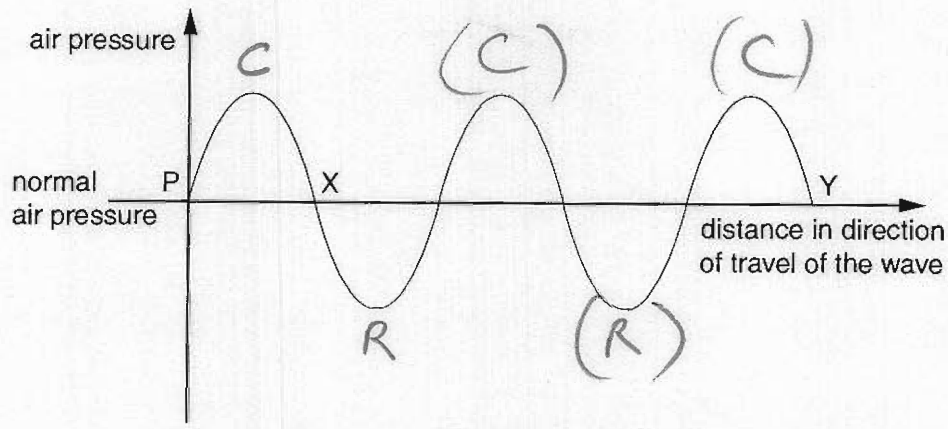


Fig. 7.1

(a) What type of waves are sound waves?

Longitudinal waves. [1]

(b) On Fig. 7.1, mark on the axis PY

(i) one point C where there is a compression in the wave, [1]

(ii) one point R where there is a rarefaction in the wave. [1]

(c) Describe the motion of a group of air particles situated on the path of the wave shown in Fig. 7.1.

The particles move back and forth, i.e. parallel to the direction of travel of the wave.

[2]

(d) The sound wave shown has speed of 340 m/s and a frequency of 200 Hz. Calculate the distance represented by PX on Fig. 7.1.

$PX = \frac{1}{2}\lambda$

$\lambda = \frac{v}{f} = \frac{340\ m/s}{200\ Hz} = 1.70\ m$

thus $PX = 0.85\ m$

distance = 0.85 m [2]

7 Fig. 7.1 is a drawing of a student's attempt to show the diffraction pattern of water waves that have passed through a narrow gap in a barrier.

For Examiner's Use

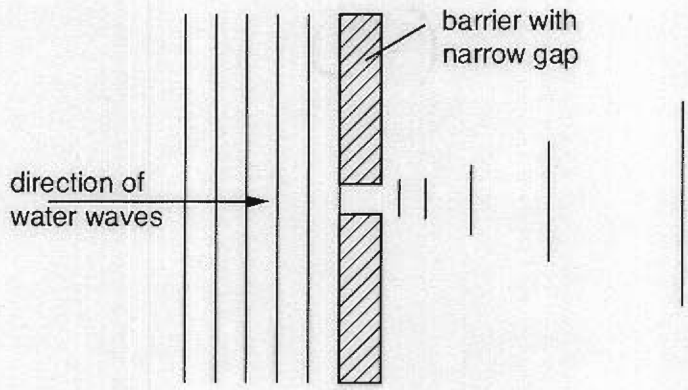


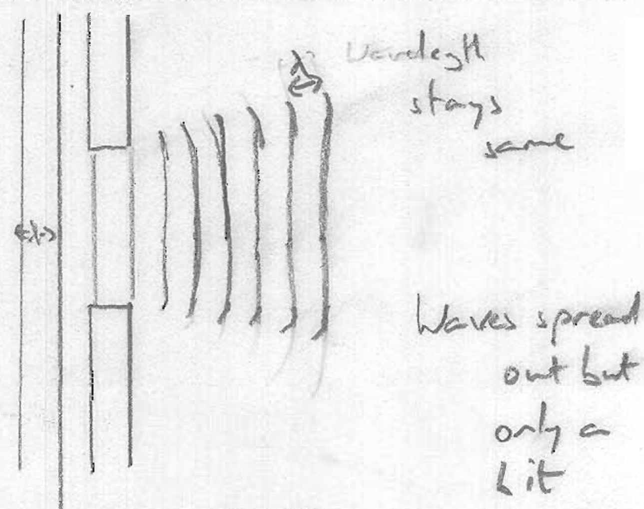
Fig. 7.1

(a) State two things that are wrong with the wave pattern shown to the right of the barrier.

1. Wavelength is increasing: should be same as original.

2. Wavefronts should be curved. [2]

(b) In the space below, sketch the wave pattern when the gap in the barrier is made five times wider.



A little curved at the edges. [2]

(c) The waves approaching the barrier have a wavelength of 1.2 cm and a frequency of 8.0 Hz.
Calculate the speed of the water waves.

$v = f\lambda = 8.0\,Hz \times 1.2\,cm = 9.6\,cm/s$ or

speed = 0.096 m/s [2]