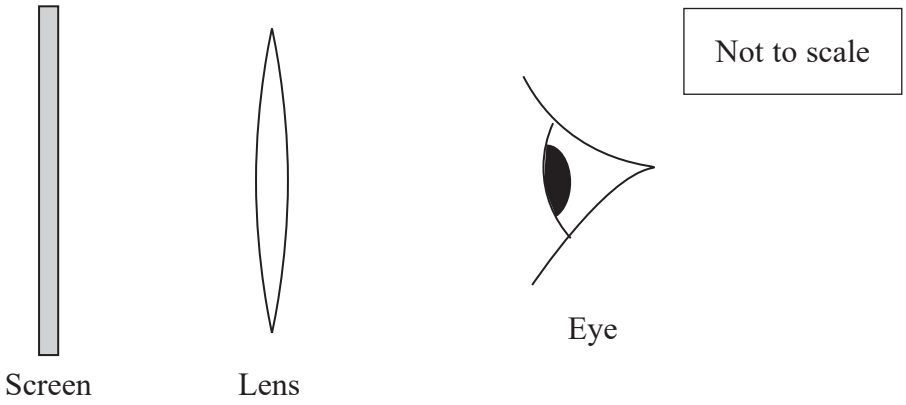
17 The photograph shows a man wearing a virtual reality (VR) headset.

The VR headset gives the illusion of three-dimensional vision.

Inside the VR headset a pair of lenses is used to enable the user to focus on a magnified virtual image of a screen. The lenses can be changed to suit the vision of the user.

(a) In the VR headset the lens is between the eye and the screen, as shown below.

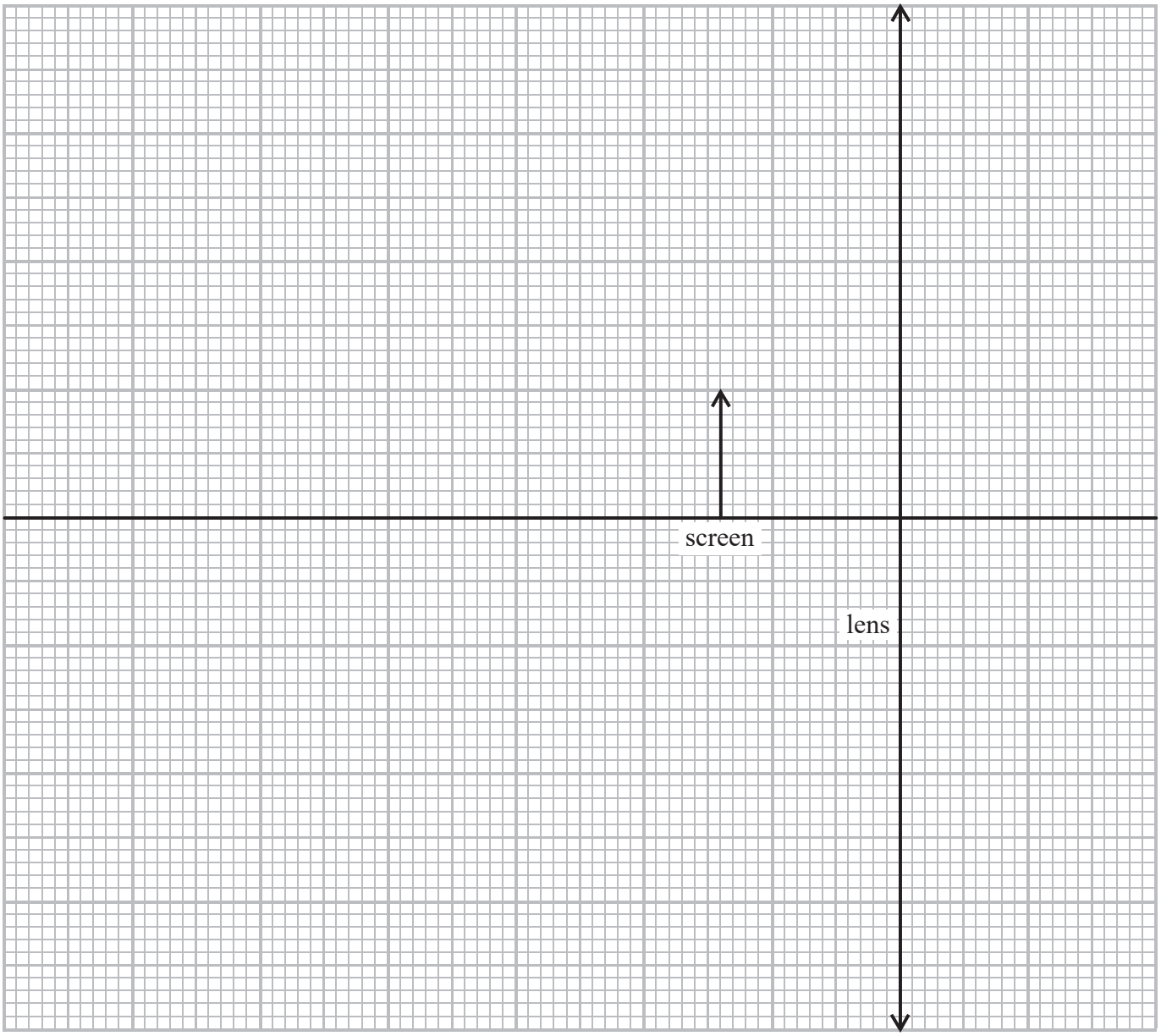


For a particular user of the headset, the image of the screen must be at least 16 cm from the eye and have a magnification of at least 3.0.

Determine whether this would be possible with a lens of focal length 3.8 cm.
Your answer should include a full-scale ray diagram drawn on the grid provided.

(4)

distance from screen to lens = 2.8 cm
distance from lens to eye = 2.2 cm



(b) Plastic Fresnel lenses are used in the VR headset because they are thinner and lighter than traditional glass lenses.

Instead of the continuous curved surface of a converging lens the Fresnel lens has circular ridges, each with an edge at a different angle to the adjacent ridge, as shown in the simplified cross-section in Figure 1. Figure 2 shows a ray of light entering a section of the lens.

Figure 1

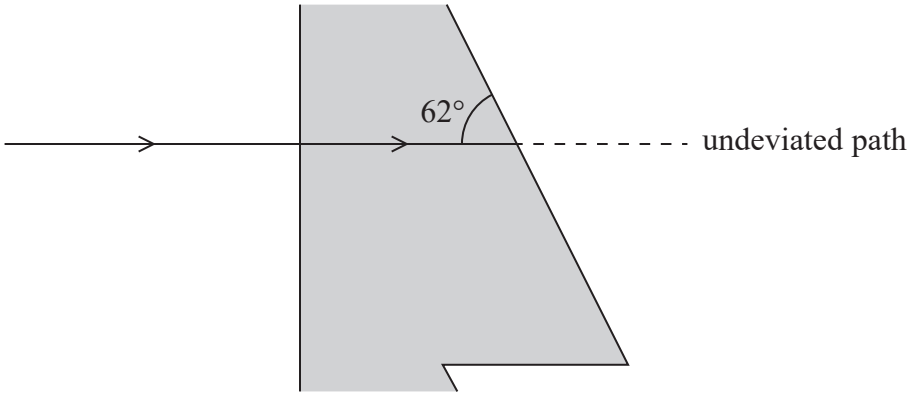


Figure 2

(i) Calculate the angle through which the ray has been deviated as it emerges from the plastic.

(4)

refractive index of plastic = 1.47

Angle = ...

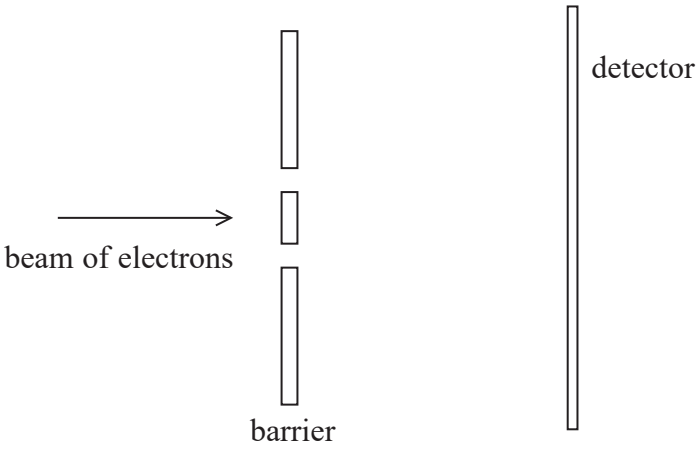
(ii) Explain how the lens focuses a beam of light travelling parallel to the principal axis.

(3)

(Total for Question 17 = 11 marks)

14 In 1965, Richard Feynman proposed a double slit experiment to investigate the wave properties of electrons.

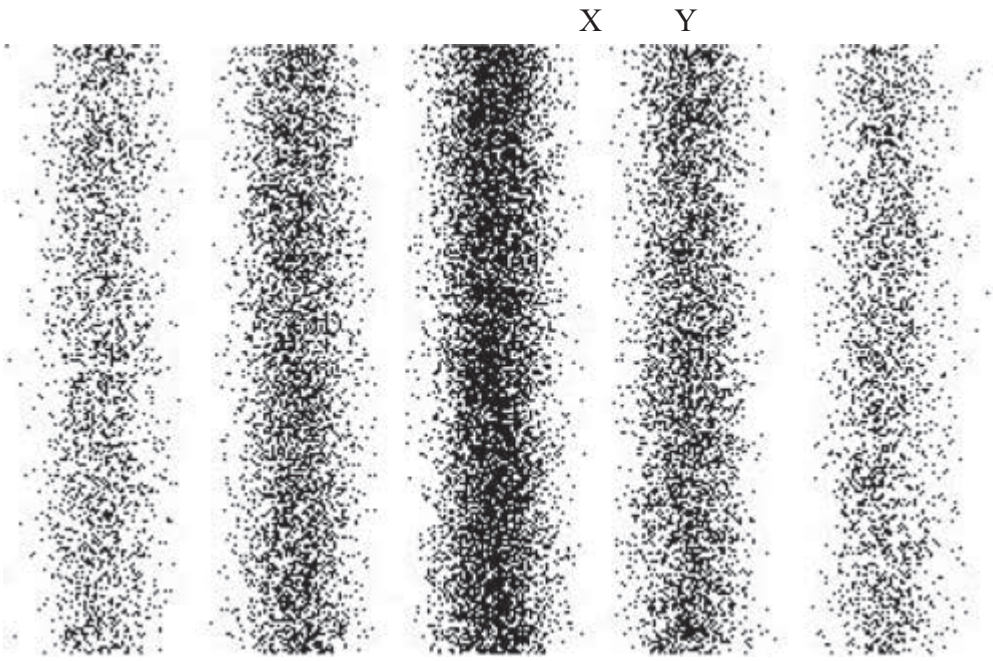
The experiment was later carried out using the arrangement shown.



A beam of electrons was directed at a barrier with two slits.

The detector recorded the positions where electrons arrived after passing through the slits.

The following pattern was obtained. Black dots represent points where electrons were detected. A band where electrons were not detected has been labelled X and a band where electrons were detected has been labelled Y.



The path difference for electrons arriving at band X from the separate slits was 2.5×10^{-11} m. For electrons arriving at band Y the path difference was 5.0×10^{-11} m.

Explain why this pattern is observed when the electron energy is 9.6×10^{-17} J.

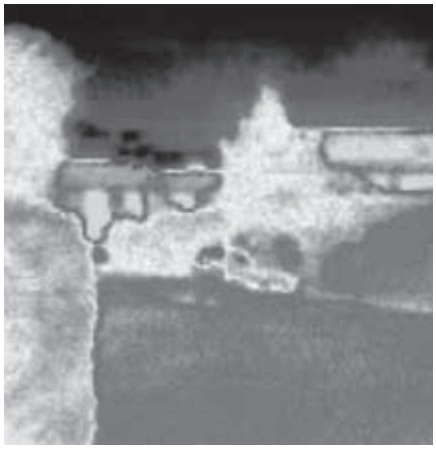
The electrons are travelling at non-relativistic speeds.

(6)

(Total for Question 14 = 6 marks)

12 Infrared cameras are used to create images that show the infrared radiation emitted by objects.

The photographs show the same scene taken first with an ordinary camera and then with an infrared camera.



(a) Deduce whether the objects shown in the photographs would be expected to have peak emissions at infrared wavelengths. Your answer should include a calculation.

(4)

longest wavelength of visible red light ≈700 nm

(b) The photograph shows the result when someone tries to take an infrared photograph of the same scene through a window. The image does not show the outdoor scene but does show an image of the photographer.

State what can be concluded about glass and infrared radiation.

(2)

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(Total for Question 12 = 6 marks)