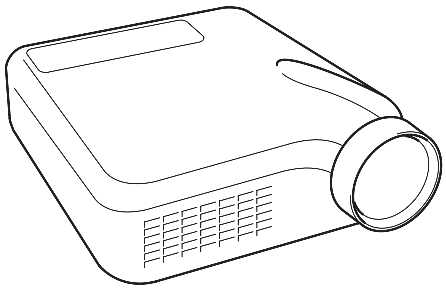
6 Inside a data projector the illuminated object display is 45 mm wide.
The focused real image on a distant screen is 1.35 m wide.



(a) Calculate the linear magnification of the image.

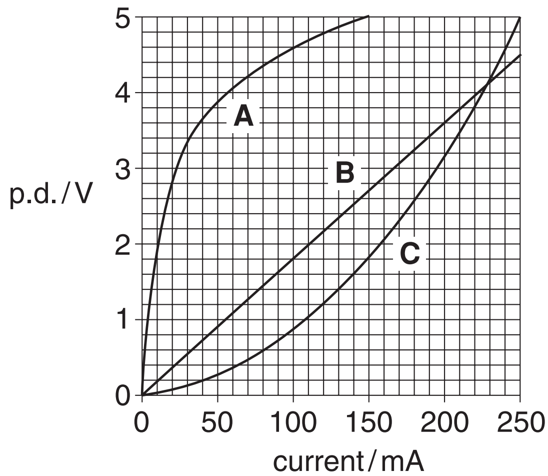
magnification = ... **[1]**

(b) The image distance *v* from the projector lens is 2.10 m.

Calculate the object distance *u* and hence show that the power of the projector lens is about 15 D.

[3]

7 The graph shows the characteristics of 3 different electrical conductors **A**, **B** and **C**.



(a) State which conductor obeys Ohm's Law. .... **[1]**

(b) State which graph shows decreasing resistance at higher current. .... **[1]**

[Section A Total: 23]

For Examiner's Use

4 Jon measures the focal length f of a convex lens. He repeats the measurement several times. The mean value of the measurement is 0.125 m. The range over which the measurements vary due to experimental uncertainty is $\pm$ 0.005 m.

Jon correctly records the final result with the equation

$$f = 0.125 \pm 0.005\,\text{m}.$$

(a) The minimum value for f indicated by this equation is 0.120 m.

Write down the maximum value for f indicated by this equation.

maximum value for f = ...m [1]

(b) Jon calculates the power P of the lens using the relationship

$$P = \frac{1}{f}.$$

For the mean value $f = 0.125$ m $\quad P = 8.00$ D.

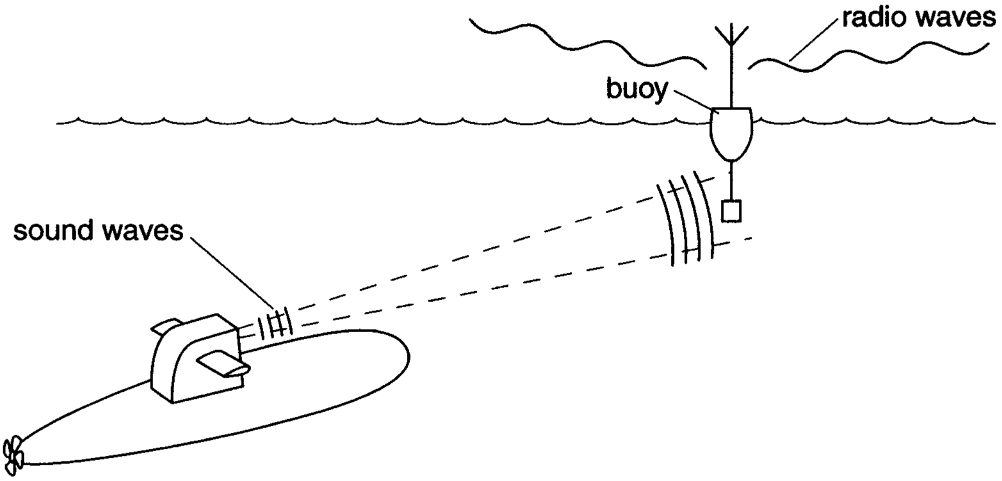
Calculate the maximum value of the power corresponding to the minimum value of the focal length 0.120 m. Consider sensible **significant figures**.

maximum power = ...D [1]

(c) Complete the equation below to indicate the range of values within which the power can be expected to lie.

P = 8.0 $\pm$ .... D [1]

9 Radio waves cannot be transmitted through water, but submarines can now transmit and receive e-mails, without having to surface.



An 'acoustic modem' on the submarine transmits sound waves through water, at a frequency of 8.0 kHz. The waves carry information at 2.4 kbit s^{-1} to a radio buoy. The information is relayed from the buoy to shore by radio waves. The buoy can also receive radio signals, and transmit the information as sound waves back to the submarine.

(a) Show that the wavelength of the 8.0 kHz sound waves in sea water is about 0.2 m.

speed of sound in sea water = 1500 m s^{-1}

[3]

(b) The sound waves travel 5.0 km from the submarine to the buoy.

Calculate the time taken for the sound waves to travel this distance.

time taken = ... s [2]

(c) A typical e-mail message contains 1500 bytes of information.

Calculate the time taken to transmit the e-mail at 2.4 kbit s^{-1}.

time to transmit = ...s [2]

(d) Suggest and explain reasons why a live two-way video picture link **cannot** be supported by this underwater signalling system, although still pictures **can** be transmitted.

[3]

[Total: 10]

6 In a cinema people watching a 3-D film wear spectacles containing polarizing filters. This is so that each eye sees only one of a pair of images projected onto the same area of the screen. Two projectors are used, each projecting an image in differently polarized light to achieve this.

State and explain how the polarizing filters must be arranged in spectacles to achieve this.

[2]

7 An overhead projector uses a converging lens to produce a magnified image of a transparency, as shown in Fig. 7.1.

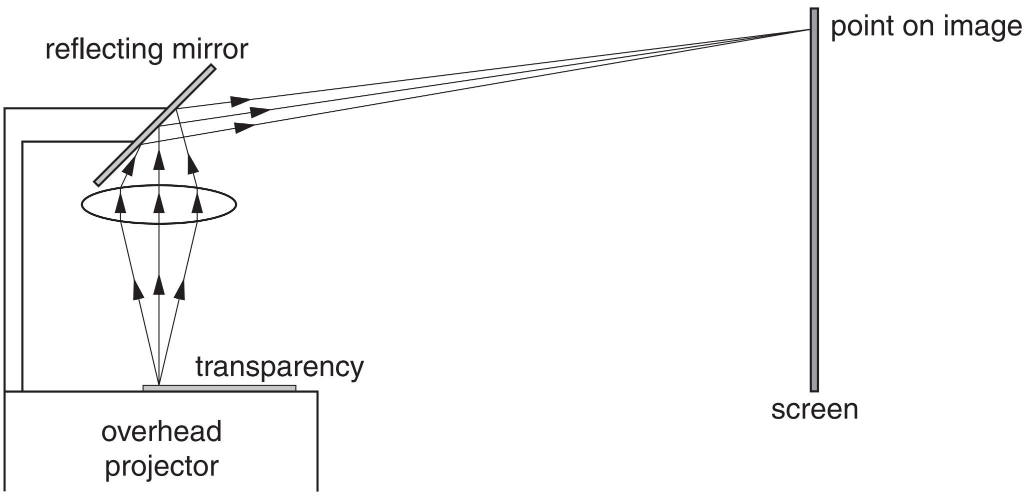


Fig. 7.1

The transparency is 0.15 m wide, and the image is 1.20 m wide.

(a) Calculate the linear magnification of the system.

linear magnification = ... **[1]**

(b) The distance of the image $v = 2.40$ m from the projector lens.

Use your answer to **(a)** to calculate the object distance u of the transparency from the lens.

object distance u = ... m **[1]**

[Section A Total: 20]

(c) The rear surface of the mirror can be heated electrically to clear frost and demist the mirror. A current I is passed through the reflecting alloy at the back of the mirror, as shown in Fig. 8.4.

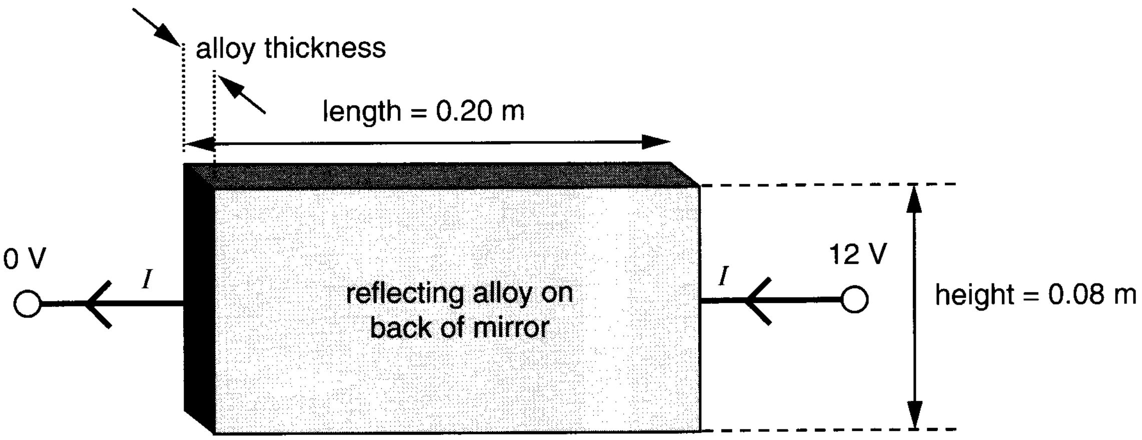


Fig. 8.4

(i) The heater dissipates 50 W from the 12 V car battery.

Show that the current I drawn by the heater is about 4 A.

[2]

(ii) Show that the conductance G of the heater is about 0.3 S.

[2]

(iii) The dimensions of the mirror are length = 0.20 m and height = 0.08 m as shown in Fig. 8.4.

Calculate the thickness of the reflecting alloy film used to heat the mirror.

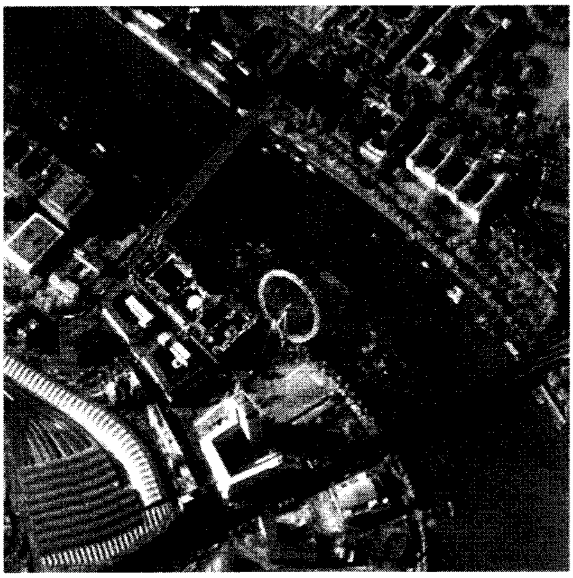
conductivity of reflecting alloy = $3.1 \times 10^5\,\mathrm{S\,m^{-1}}$

thickness = ... m [3]

[Total: 10]

For Examiner's Use

9 The London Eye was photographed from a satellite 200 km above the Earth.
Fig. 9.1 is the original image which is 400 × 400 pixels. Fig. 9.2 is a magnified view of part of the original showing 75 × 75 individual pixels.



400 pixels

Fig. 9.1

75 pixels

Fig. 9.2

(a) Estimate the number of pixels along a diameter of the image of the London Eye.

pixels along diameter = ... [1]

(b) The London Eye is about 135 m in diameter.

Estimate the resolution of the image. Give your answer to 1 significant figure.

resolution is about .... m / pixel [1]

(c) Explain why both images in Fig. 9.1 and Fig. 9.2 have the **same** resolution.

[1]

(d) The original image Fig. 9.1 has 400 × 400 pixels and a greyscale of 8 bits per pixel.

Calculate the amount of information stored in the original image Fig. 9.1.

information = ... bits [1]

(e) The convex lens in the satellite camera forms a real image 0.16 m behind the lens. The satellite camera is focused on the ground 200 km directly below the satellite, as shown in Fig. 9.3.

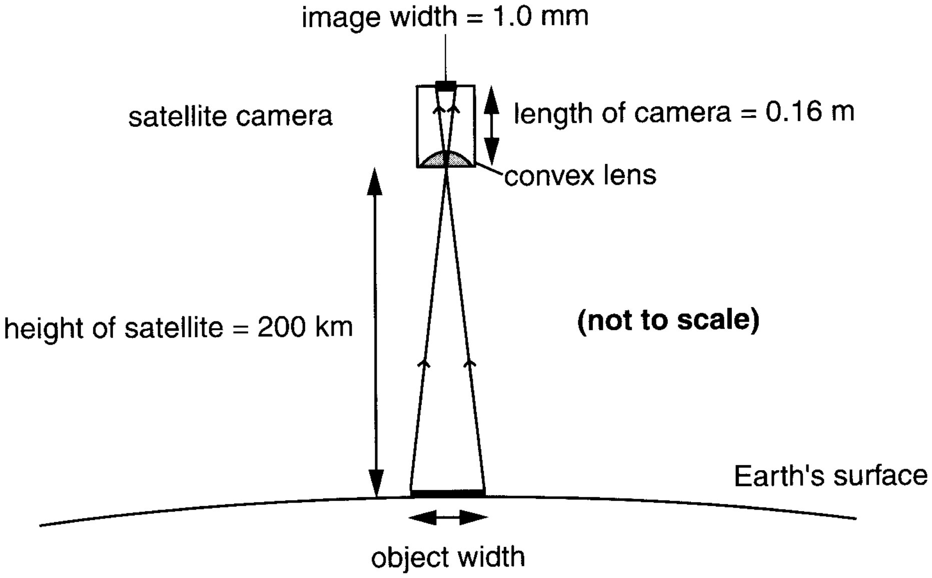


Fig. 9.3

(i) Show that the magnification is 8×10^{-7}.

[1]

(ii) Calculate the width of object on the Earth's surface that would produce an image that is 1.0 mm wide in the camera.

width of object = ... m [1]

[Turn over

For Examiner's Use

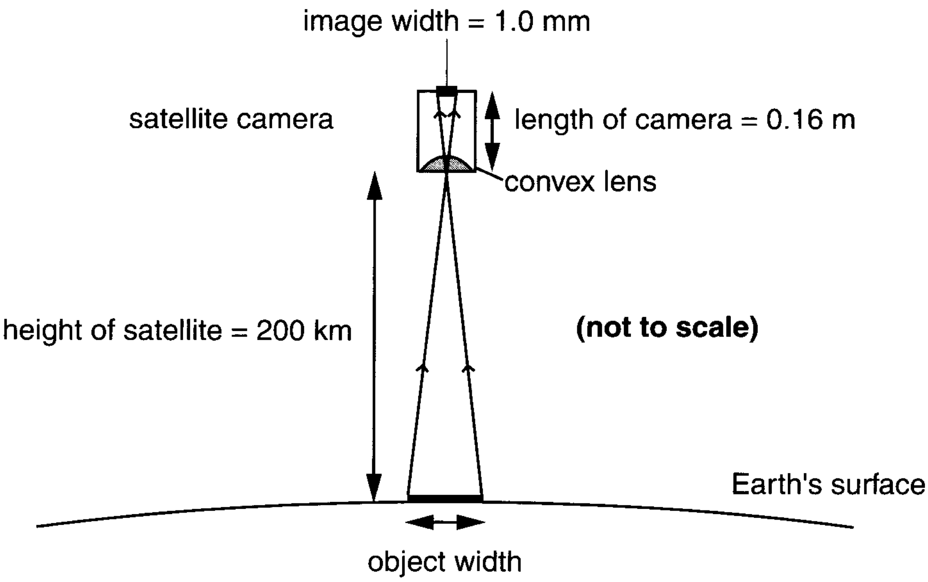


Fig. 9.3 (repeated)

(iii) Using the geometry of Fig. 9.3, explain why the ratios

$$\frac{\text{image distance}}{\text{object distance}} \text{ and } \frac{\text{image width}}{\text{object width}} \text{ are equal.}$$

[1]

(f) Using the lens equation

$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$$

explain why, for this camera, the image distance v is very nearly equal to the focal length f of the lens.

[2]

[Total: 9]