3 Simon needs glasses for reading. Without glasses the nearest he can comfortably focus is 1.0 m away. He would like a normal reading distance of 0.25 m. This is illustrated in Fig. 3 below.

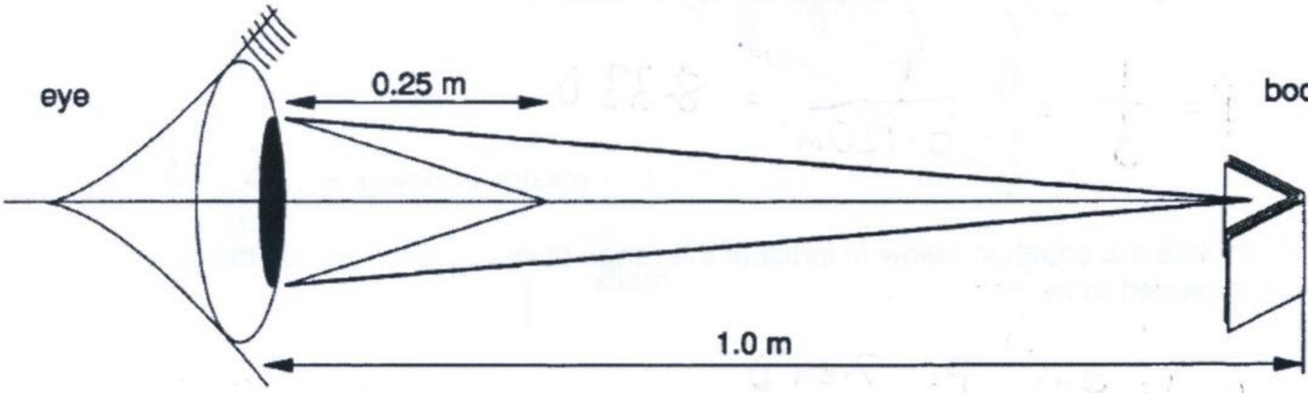


Fig. 3 (not to scale)

(a) What is the difference in curvature between the wavefronts arriving at his eye from these two distances?

$$\frac{1}{-0.25} - \frac{1}{-1} = -4 - -1 =$$

difference in curvature = ...3.......... dioptre [2]

(b) What power is needed for his reading lenses?

power of lenses = ...3.......... dioptre [1]

2860Jun01

JAN 04

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.

$0.125\text{m} + 0.005\text{m} =$ maximum value for f = ...0.130..........m [1]

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

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

For the mean value $f = 0.125\,\text{m}$ $P = 8.00\,\text{D}$.

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

$P = \frac{1}{f} = \frac{1}{0.120\text{m}} = 8.33\text{ D}$

maximum power = 8.33 D [1]

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

for $f = 0.13$ $P = 7.69\text{ D}$

P = 8.0 ± 0.3 D [1]

2860 Jan04

7 This question is about a beam of light emitted by an LED.
Light waves are emitted from a diode junction encapsulated in a curved plastic lens as shown in Fig. 7.1.

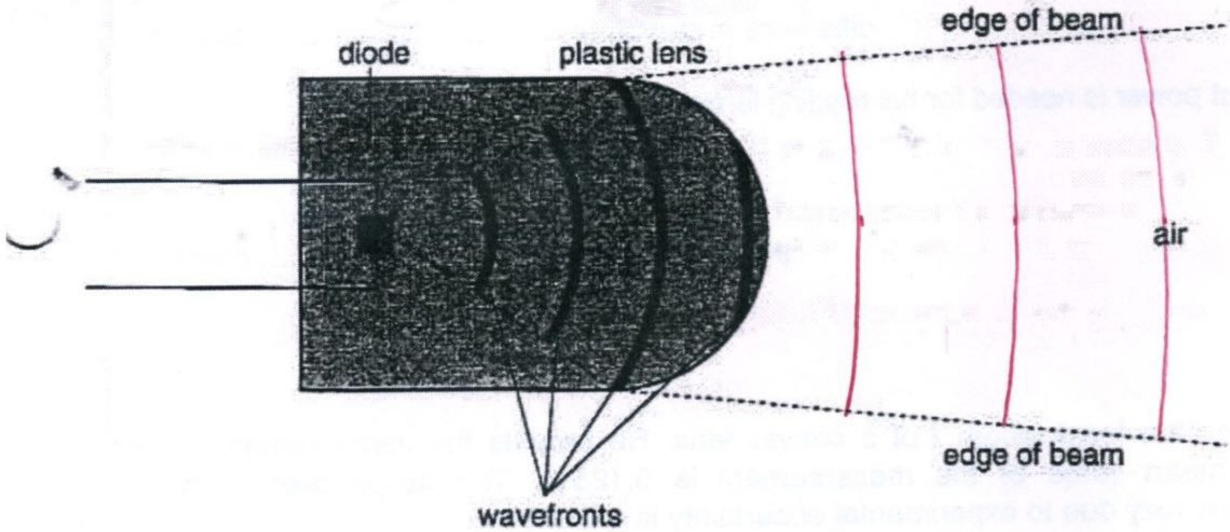


Fig. 7.1

Complete Fig. 7.1 to show **three** successive wavefronts in the beam after they have completely emerged from the plastic lens into air. [2]

9 A slide projector produces a magnified focused image of a slide as shown in Fig. 9.

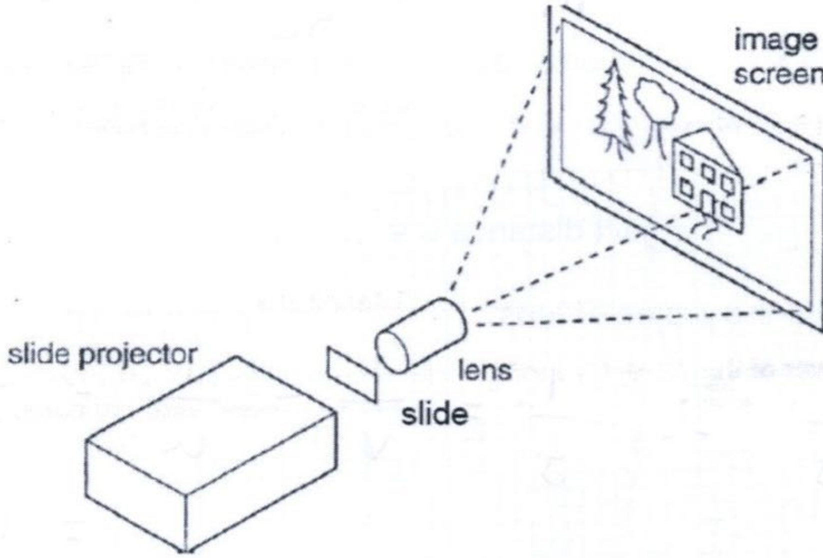


Fig. 9

(a) State the type of lens required for the projector.

converging / convex

[1]

(b) The image on the screen is projected the correct way up.
How must the slide be placed in the projector to achieve this?

slide upside down

[1]

(c) The width of the slide is 35 mm. If the image on the screen is to be 1.75 m wide, what is the magnification?

$m = \frac{\text{image size}}{\text{object size}} = 1.75\,m / 35 \times 10^{-3}\,m = 50$

magnification = ...[2]

(d) The image is 4.0 m from the projector lens.
Calculate the object distance u from the slide to the lens.

$m = \frac{v}{u} \quad \therefore \quad u = \frac{v}{m} = \frac{4.0\text{m}}{50} = \underline{\underline{0.080\text{m}}}$

object distance u = ...[2]

(e) Calculate the power of the projector lens.

$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} \quad \therefore \quad \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{1}{4} - \frac{1}{-0.080}$

$= \underline{\underline{12.8\text{ D}}}$

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

power of lens = ... D [3]

3 The equation describing image formation by a lens is:

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

(a) Complete the following explanation of this equation in words.

The curvature of the wavefronts leaving the lens is equal to

....the curvature of the wavefronts arriving....

plus the....curvature added by the lens....

[2]

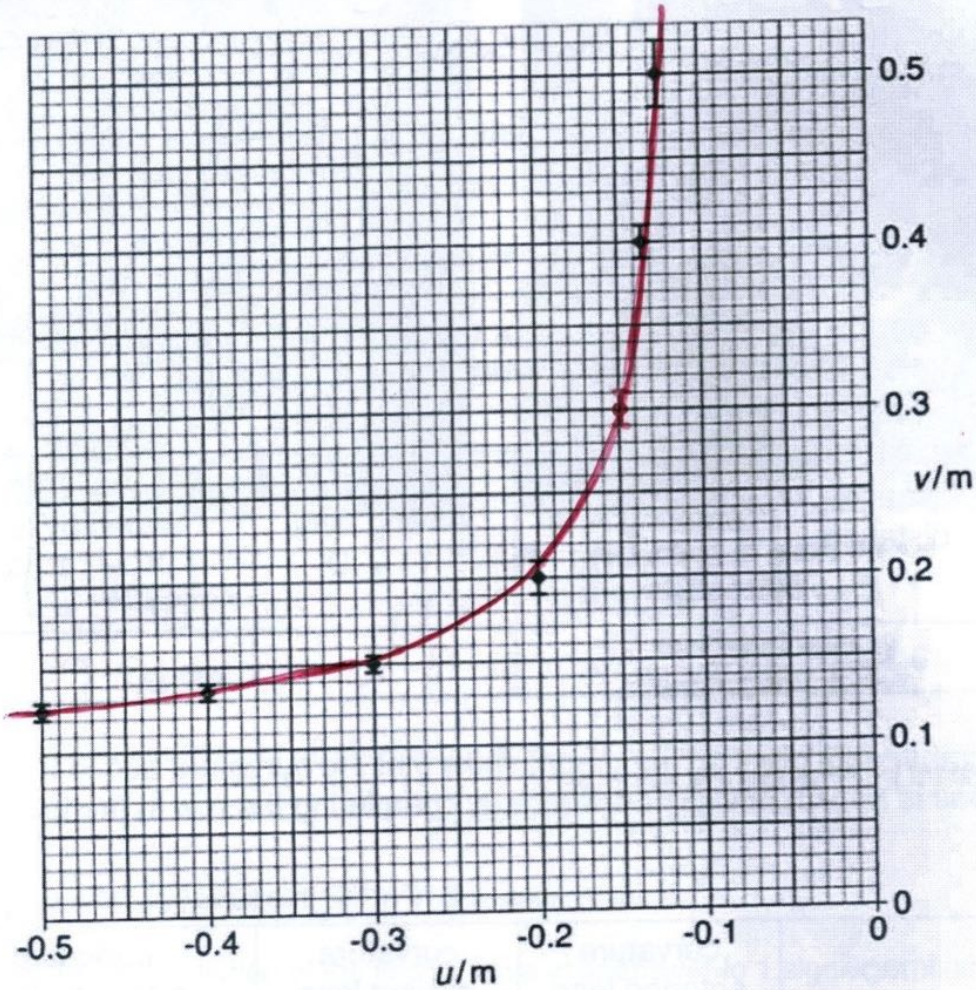
(b) State where an object should be placed so that the image distance is approximately equal to the focal length.

at large distance

[1]

11 A student uses a lens to form the image of a lamp filament on a screen.

(a) She obtains values of image distance *v* for different values of the object distance *u*. She plots a graph as shown below.



(i) The uncertainty (spread) in *v* values is indicated by the vertical error bars. The uncertainty in the *u* values is negligible.

Plot the point from the student's data given in the table below.
Include the error bar, to show the uncertainty.

object distance u / m	image distance v / m	uncertainty in v $\pm v$ / m
–0.150	0.300	0.010

[2]

(ii) Draw the curve of best fit for the data points on the graph above. [1]

(b) **(i)** Suggest a practical difficulty that could lead to the uncertainty in the measurement of *v*.

e.g. Judging if the object is in focus

(ii) Suggest how this difficulty might be overcome.

e.g. Use a green filter so only one wavelength range
Use an object with some detail eg. filament [2]

(c) **(i)** The student uses the data to calculate the focal length of the lens using the relationship

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}.$$

Complete the row in the table below for the curvatures of the wavefronts entering and leaving the lens, and for the curvature added by the lens. [1]

object distance u / m	image distance v / m	curvature entering lens $\frac{1}{u}$ / D	curvature leaving lens $\frac{1}{v}$ / D	curvature added by lens $\left\{\frac{1}{v} - \frac{1}{u}\right\}$ / D
–0.150	0.300	−6.67	3.33	10.0

(ii) For **one** other data point on the graph, show that the curvature added to wavefronts by the lens is **approximately constant** by completing the row in the table below. [1]

e.g.

object distance u / m	image distance v / m	curvature entering lens $\frac{1}{u}$ / D	curvature leaving lens $\frac{1}{v}$ / D	curvature added by lens $\left\{\frac{1}{v} - \frac{1}{u}\right\}$ / D
−0.3	0.150	−3.33	6.67	10.0

(iii) Calculate the focal length of the lens used in this experiment.

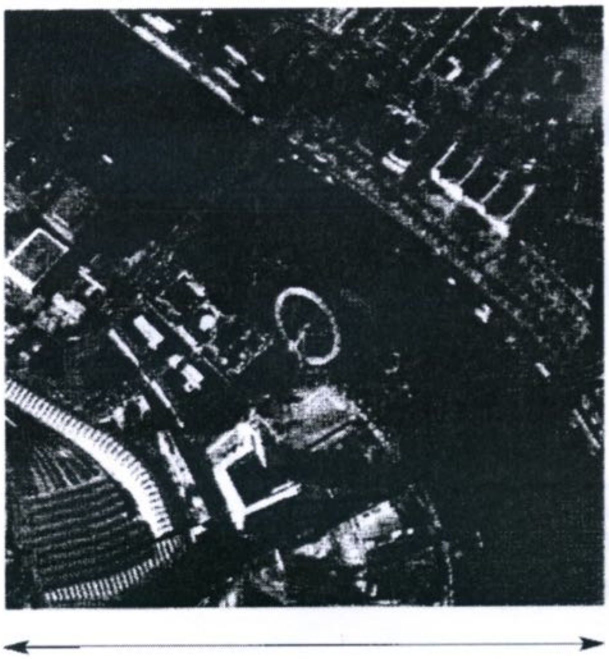
focal length = $\frac{1}{P} = \frac{1}{10} = 0.10$ m [1]

(iv) Suggest how you could use the student's data to estimate the uncertainty in the value of the focal length.

Use upper & lower limits for the measured values. Draw a dot plot of the results from all / a number of points and work out the spread ($\frac{1}{2}$ the range). [2]

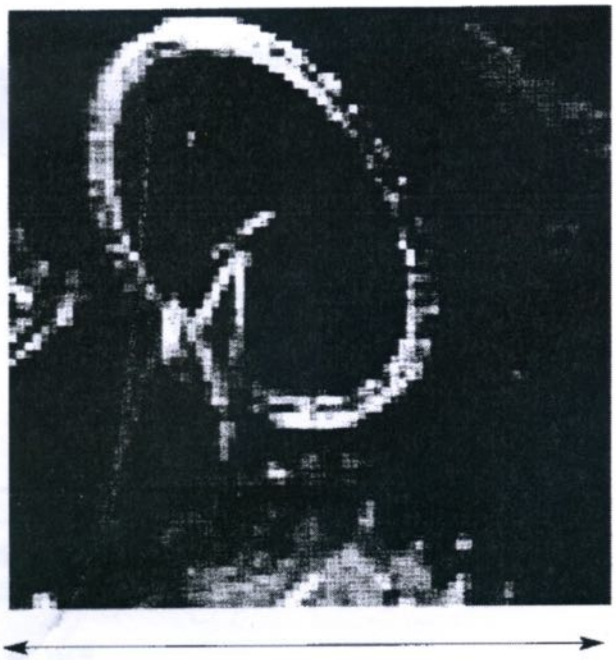
[Total: 10]

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.

$\frac{4 \rightarrow 5.5}{8} \times 75 = 38 \rightarrow 52$

pixels along diameter = 45 [1]

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

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

135m/45

resolution is about 3 m / pixel [1]

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

Each pixel represents the same distance in the image.
(They are both the same image - scaling does not change 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.

400 × 400 × 8 =

information = 1,280,000 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.

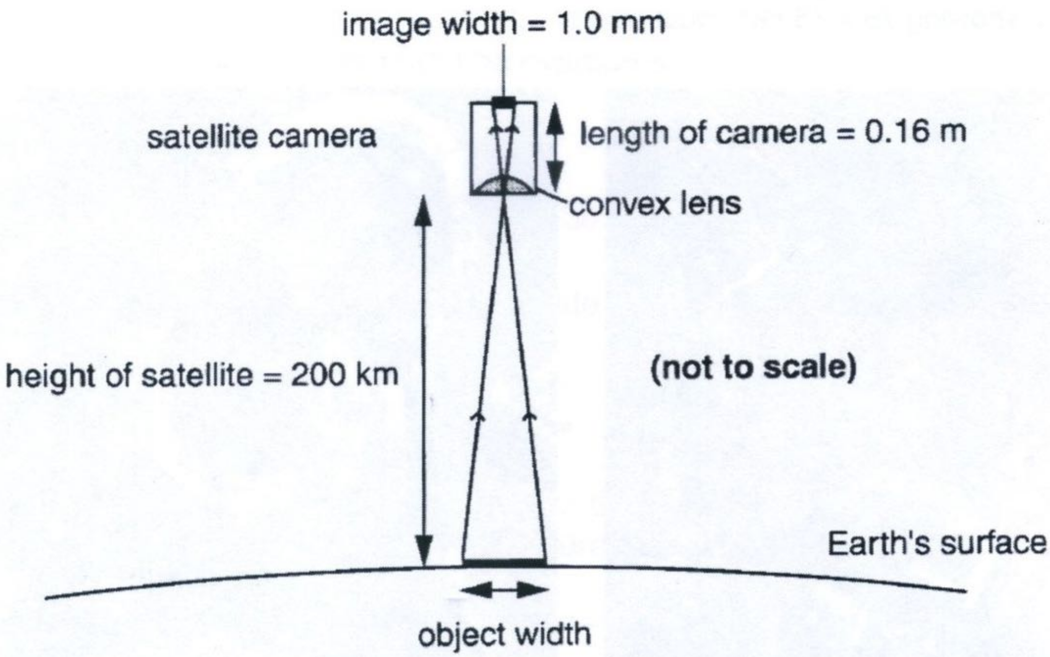


Fig. 9.3

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

$m = \frac{v}{u} = \frac{0.16\text{m}}{200 \times 10^3\text{m}} = 8.00 \times 10^{-7}$

[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.

$\frac{i}{o} = 8 \times 10^{-7} \therefore \quad O = i / 8 \times 10^{-7} = \frac{1 \times 10^{-3}\text{ m}}{8 \times 10^{-7}}$

width of object = 1250 m [1]

i = image size
O = object size

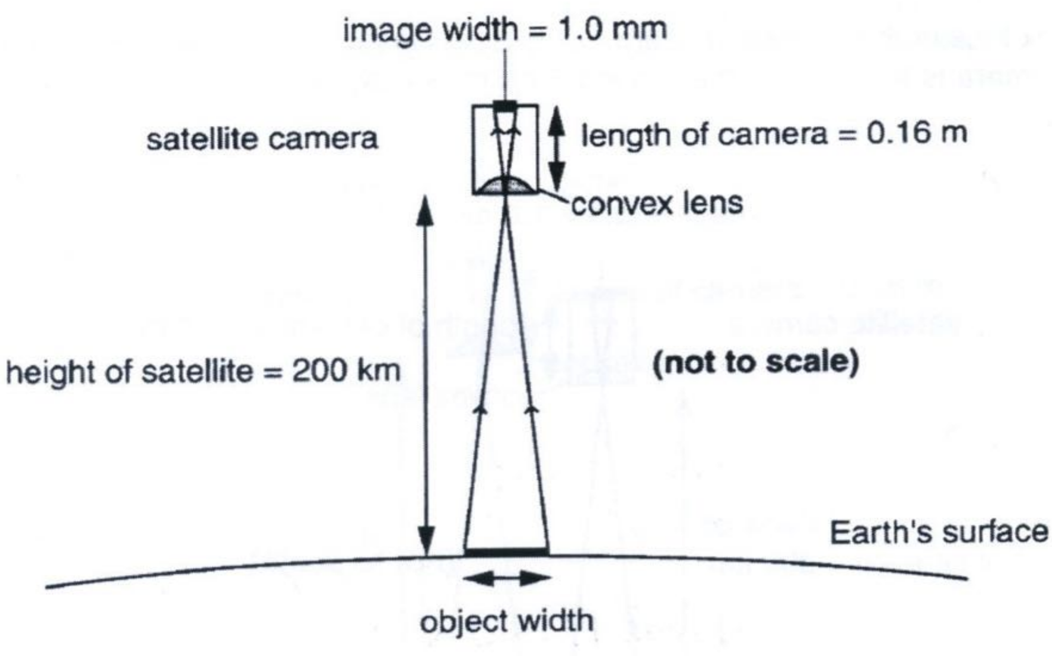


Fig. 9.3 (repeated)

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

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

similar triangles

i.e.

$$\frac{a}{b} = \frac{x}{y}$$

[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.

u is very large so $\frac{1}{u} \propto 0$

$\therefore \frac{1}{v} \approx \frac{1}{f} \quad \therefore v \approx f$

[2]

8 This question compares sending information by fax and by e-mail.

(a) A fax system converts an A4 page into an array of black (1) or white (0) pixels. There are 10 pixels per mm.
A letter **M** may occupy a square of side 2mm as shown magnified in Fig. 8.

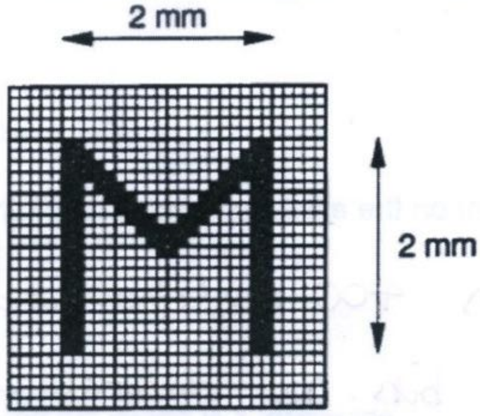


Fig. 8

(i) How many pixels are there in the 2 mm × 2 mm array?

20 × 20 =

number of pixels = ...400.......... [1]

(ii) How many bits are needed to code for each black or white pixel?

number of bits / pixel = ...1.......... [1]

(iii) How many bits are needed to code a letter (such as **M**) which occupies this area? (Assume no information compression is used).

number of bits = ...400.......... [1]

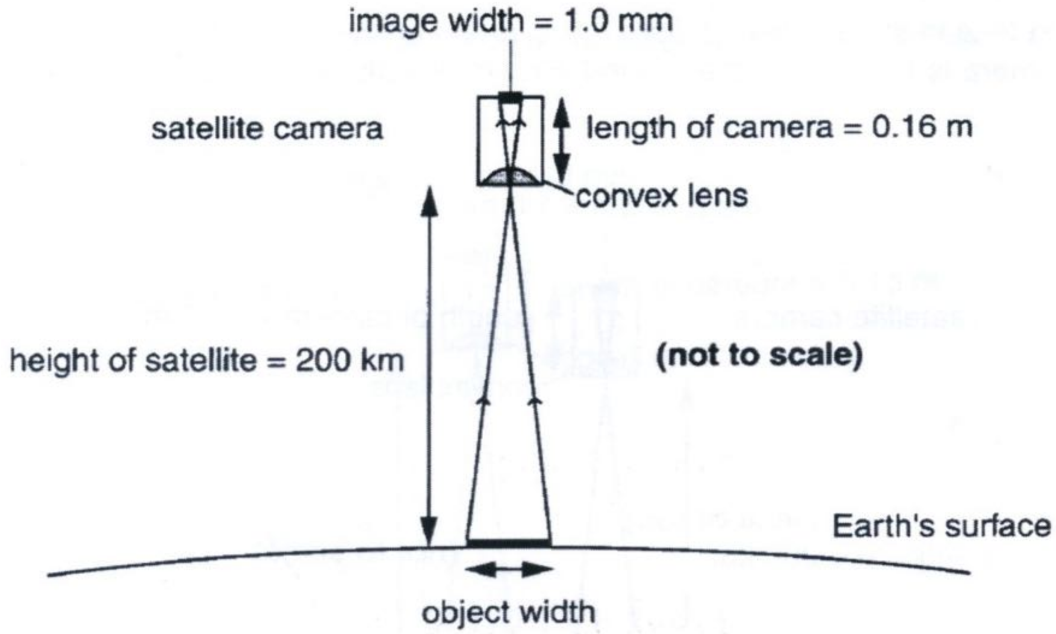


Fig. 9.3 (repeated)

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

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

similar triangles

i.e.

$$\frac{a}{b} = \frac{x}{y}$$

[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.

u is very large so $\frac{1}{u} \approx 0$

$\therefore \frac{1}{v} \approx \frac{1}{f}$ $\therefore v \approx f$

[2]

(b) (i) In e-mail, the letter **M** will be coded by a one byte international code. How many bits make a byte?

number of bits / byte = ...8.... [1]

(ii) Each keyboard character (letter, number, punctuation etc.), has its own one byte code. How many different characters can be coded in a one byte code?

number of characters = ...256.... [1]

(c) Compare and comment on the efficiency of coding information using fax and e-mail.

Fax requires 400 bit/character wheras e-mail requires 8 bits per characta. This is

$\frac{400}{8}$ = 50 times more efficient.

For 1 fax character you can send 50 e-mail characters.

[2]

2 The charge coupled device (CCD) sensor in a digital camera has an array of pixels 1536 wide by 1024 high. Each pixel value is stored as an eight-bit number. = 1 byte

Show that the information stored in one complete image recorded by the CCD is greater than 1 Mbyte.

1536 × 1024 × 1 byte = 1572864 bytes

= 1·6 Mbyte

[3]

5 An overhead projector uses a converging lens to produce a magnified image of a transparency, as shown below.

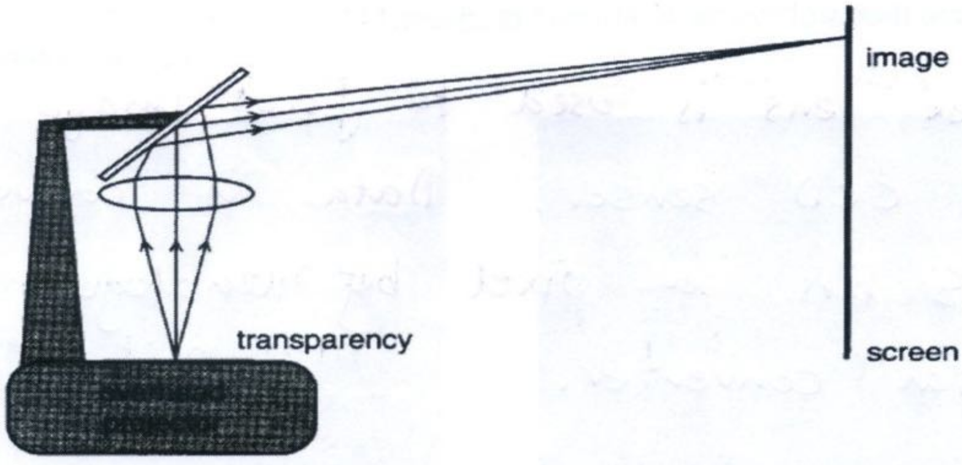


Fig. 5.1

The transparency is 0.20 m wide, and the image is 1.20 m wide.

(a) Calculate the linear magnification of the system.

$$m = \frac{\text{image size}}{\text{object size}} = \frac{1{\cdot}20\,m}{0{\cdot}2\,m} =$$

linear magnification = 6 **[1]**

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

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

$$m = \frac{v}{u} \quad \therefore \quad u = \frac{v}{m} = \frac{2{\cdot}40\,m}{6} = 0{\cdot}4\,m$$

[2]

14 This question is about an imaging system, producing data that can be stored and displayed by a computer.

(a) State your own example of such an imaging system.

Describe **three** pieces of information that could be obtained from the image.

e.g. example weather satellite image

information

1. cloud cover
2. sea surface temperature
3. land use

[4]

(b) (i) State the kind of waves or radiation used in the imaging system.

visible and Infra - Red

[1]

(ii) Describe how the data for the image are obtained.
You may find it useful to use a labelled diagram.

Convex lens is used to focus image onto CCD sensor. is converted to 8 bits per pixel by analogue to digital converter.

[3]

(c) (i) Explain the meaning of the term *image resolution* using your example.

Estimate a typical resolution for the image you have chosen.

Size that pixel represents in the image or the smallest detail that can be distinguished.

~ 10 km fa satellite image

(ii) Discuss **two** factors that might limit the resolution in your imaging system.

pixel density of sensor

distance to object

diffraction of light

[5]

11 Fig. 11.1 and 11.2 show images captured by cameras aboard the Mars Global Surveyor satellite.
Fig. 11.1 shows the 140 km-wide Holden Crater.
Fig. 11.2 shows the region indicated inside Holden Crater photographed using a much higher resolution camera.

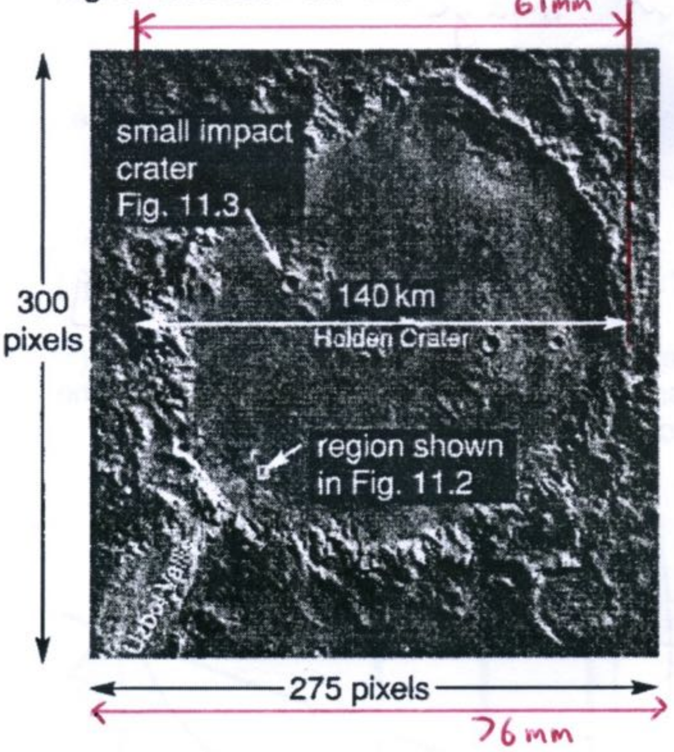


Fig. 11.1 (low resolution)

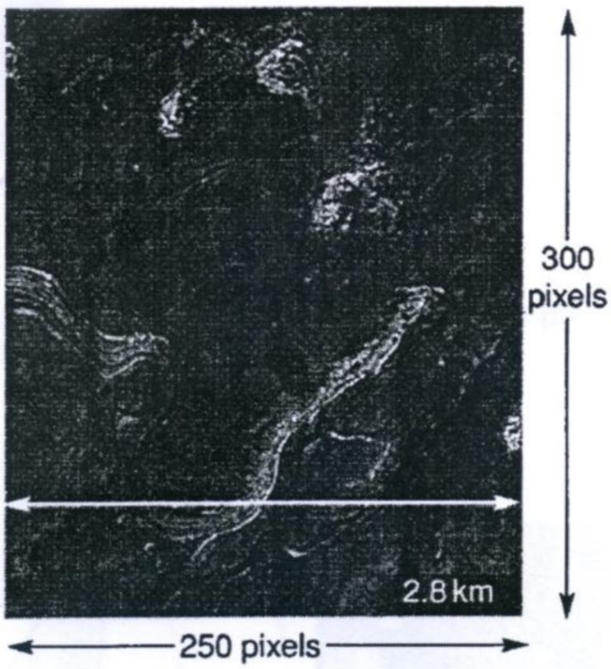


Fig. 11.2 (high resolution)

(a) **(i)** Estimate the resolution of the image shown in Fig. 11.1.

$\frac{76}{61}$ $\quad \frac{61}{76} \times 275 = 221$ pixel for crater

res $= \frac{140\text{km}}{221}$

resolution = ...630........ m pixel^{-1} [2]

(ii) Estimate the ratio

$$\frac{\text{resolution of Fig. 11.1}}{\text{resolution of Fig. 11.2}}.$$

res $= \frac{2.8 \times 10^3}{250} = 11$ m pixel^{-1}

$\frac{630}{11} =$

ratio = ...57........[1]

(iii) Suggest and explain **one** way in which the resolution of this imaging system could be improved.

greater pixel density / smaller pixels on CCD

[2]

(b) The images shown in Fig. 11.1 and 11.2 have been processed to reduce noise.

(i) State what is meant by *noise* in an image.

random data in image

[1]

(ii) Explain how some of the pixel values could have been altered to reduce the noise.

median filter replace values by median of neighboring values

[1]

(c) Physicists analysing the image are trying to find the shape of an impact crater. Fig. 11.3 shows a magnified image of the small impact crater indicated in Fig. 11.1. The crater wall casts a shadow inside the impact crater.

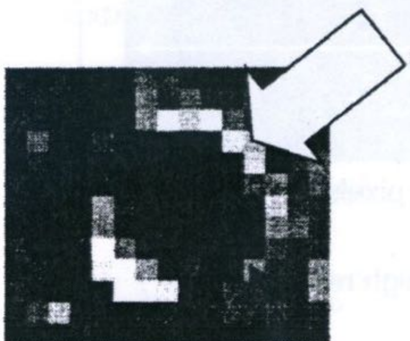


Fig. 11.3

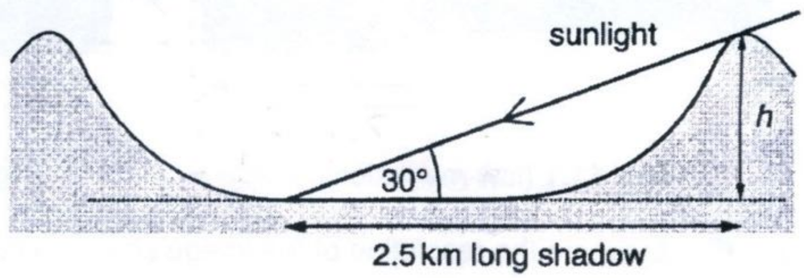


Fig. 11.4

The Sun is at an angle 30° above the horizontal causing the shadow about 2.5 km long, as shown in Fig. 11.4.

Estimate the height h of the crater rim above the crater floor, making your method clear.

$\tan\theta = \frac{opp}{adj}$ $\therefore$ $opp = adj \tan\theta$

$= 2.5\text{km} \tan 30°$

h = 1.4 m [2]

[Total: 9]

7 This question is about the fixed focus disposable camera, shown in Fig. 7.1.

Fig. 7.1

(a) Fig. 7.2 shows three wavefronts of light moving towards a lens from a very distant object.

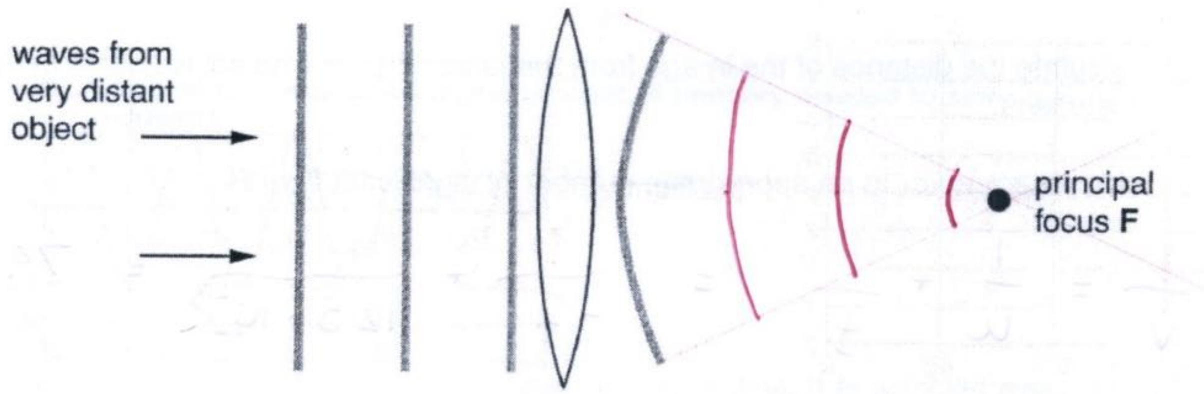


Fig. 7.2

On Fig. 7.2, draw the wavefronts of light after passing through the lens, as they move towards **F** the principal focus of the lens.
One wavefront has been drawn for you. [1]

(b) The focal length *f* of the camera lens is 12.5 mm.

Calculate the power of the lens, in dioptres.

$$P = \frac{1}{f} = \frac{1}{12.5 \times 10^{-3}\,\text{m}} =$$

power = ...80...... D [2]

(c) **(i)** The camera is used to photograph a very distant object.

The film is 12.5 mm behind the lens.

Using the equation $\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$

explain why the image is in focus on the film.

u Is very large $\therefore \frac{1}{u} \approx 0$

so $\frac{1}{v} = \frac{1}{f} \therefore v = f$ and $f = 12.5$ mm

so v will be $\simeq 12.5$ mm

[3]

(ii) Calculate the distance of the image from the lens, when the object is 2.00 m in front of the lens.

Give your answer to an appropriate number of significant figures.

$\frac{1}{v} = \frac{1}{u} + \frac{1}{f} = \frac{1}{-2} + \frac{1}{12.5 \times 10^{-3}} = 79.5$ D

$\therefore v = \frac{1}{79.5} = 0.0126$ m

image distance = 12.6 mm [3]

(d) An advertisement for the camera states that the depth of field is from 2.0 m to infinity(∞). The depth of field is the range of object distances which give a reasonable focus on the film.

Suggest how your answer to **(c)(ii)** supports this statement.

At 2.0 m infront of camera film is only 0.1 mm from focal plane – the image will be almost in focus.

[1]

[Total: 10]

2 A portable MP3 player has a memory of 64 Mbytes.
A song requires about 2 Mbytes of memory for storage in the MP3 player.

(a) Estimate the number of songs that the MP3 memory can store.

$64/2$

number of songs = ...32.... [1]

(b) The same song on a CD is sampled at 44.1 kHz using 4 bytes per sample.
The song lasts for 150 s.

(i) Show that the information stored on the music CD is about 26 Mbytes.

$$\underbrace{44.1 \times 10^3}_{\text{samples in 1 second}} \times \underbrace{4}_{\text{bytes per sample}} \times \underbrace{150}_{\text{no of seconds}} = 26.5 \text{ Mbytes}$$

[2]

(ii) Suggest **one** way in which the amount of memory needed to store a song can be reduced.

Use lower sampling rate / bit depth

[1]

5 Fig. 5.1 shows an analogue voltage signal varying in time. It is sampled every 1.0 ms for conversion into a digital signal.

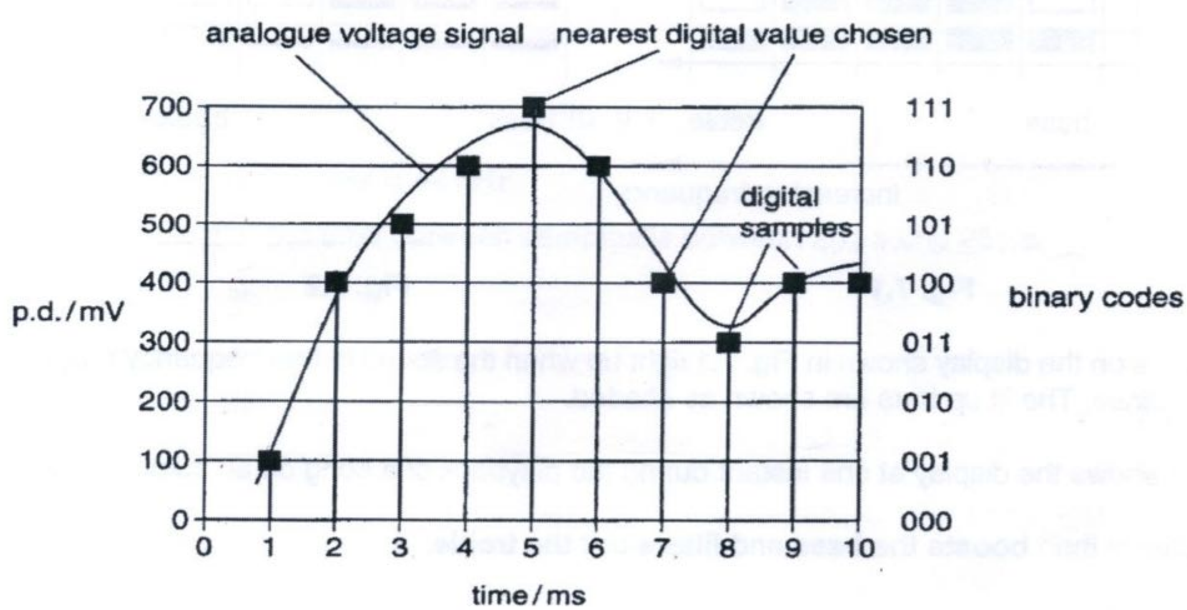


Fig. 5.1

(a) (i) State the number of bits used for the binary code of each sample in Fig. 5.1.

8 alternatives

number of bits per sample = ...3.... [1]

$\log_2 8 =$

(ii) State the number of different signal levels defined by this number of bits.

number of signal levels = ...8...... [1]

(b) Fig. 5.1 illustrates that the digital signals, introduced during digital sampling, can differ from the analogue signal.

(i) State the largest difference (measured in mV) that could be introduced in this example.

largest difference = ...50... mV [1]

(ii) Suggest **one** way in which these differences could be reduced to make the sampling more accurate.

Use more bits per sample.

[1]

7 A spectrum analyser displays the intensity of sound in five ranges from low (bass) to high (treble). Fig. 7.1 shows the display.

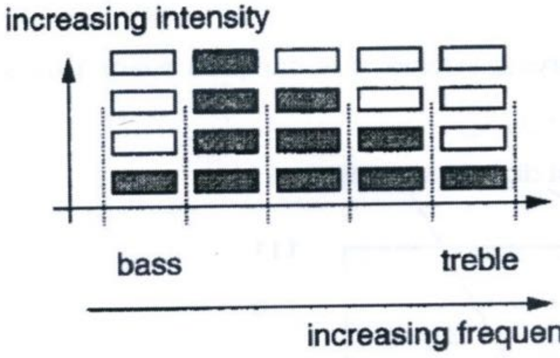


Fig. 7.1

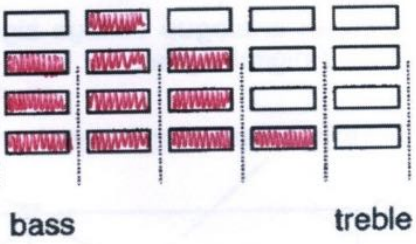


Fig. 7.2

More bars on the display shown in Fig. 7.1 light up when the sound in that frequency range is more intense. The lit up bars are shown as shaded.

Fig. 7.1 shows the display at one instant during the playback of a song on an audio system.

The listener then **boosts the bass** and **filters out the treble**.

Sketch on Fig. 7.2 a possible appearance of the spectrum analyser after this change, at the same instant of the new playback of the song.

[2]

8 This question is about converting an analogue musical sound signal into a digital signal so that it may be written to a CD.

This is for high fidelity (good quality) sound reproduction.

The graph Fig. 8.1 shows part of the analogue waveform and the digital sampling points.

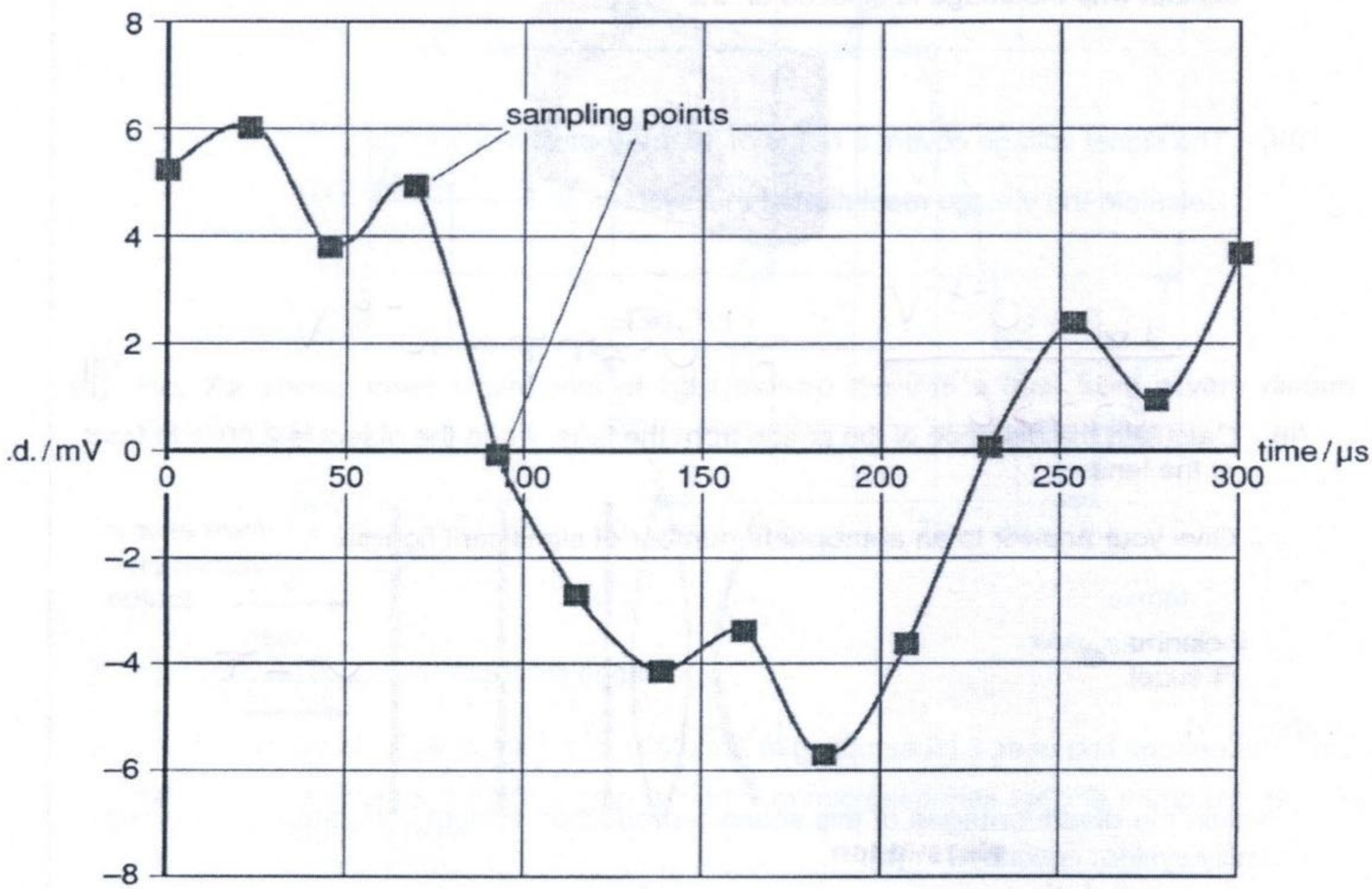


Fig. 8.1

(a) (i) The sampling rate is 44 kHz.

Show that the time between samples is between 20 μs and 25 μs.

$$\frac{1}{44 \times 10^3 \text{ Hz}} = 22.7 \mu s$$

[2]

(ii) The system uses 16 bit sampling.

Show that the number of voltage levels coded by 16 bits is about 66 000.

$N = 2^b = 2^{16} = 65536$

[1]

(iii) The signal voltage covers a range of 16 mV (between ± 8 mV).

Calculate the voltage resolution of this system.

$$\frac{16 \times 10^{-3}\ \text{V}}{65536} = 0.244 \times 10^{-6}\ \text{V}$$

voltage resolution = 0.24 μV [2]

(b) A telephone line uses 8 bit sampling at an information rate of 64 kbits per second.

Explain the **disadvantages** of this sound reproduction system compared with the high quality system described in **(a)**.

Highest frequency that can be coded is 2× sampling rate $= 2 \times \frac{64 \times 10^3}{8} = 16\ \text{kHz}$

With 8 bits per sample there are only $2^8 = 256$ alternatives so the voltage resolution will be much poorer.

i.e. $\frac{16\ \text{mV}}{256} = 62.5\ \mu\text{V}$

[3]

[Total: 8]

7 Fig. 7.1 shows two waveforms displayed on an oscilloscope screen.
One is the original analogue signal from a recording of a dolphin whistling.
The other is the result of digitising it to the nearest of 8 binary coded levels.

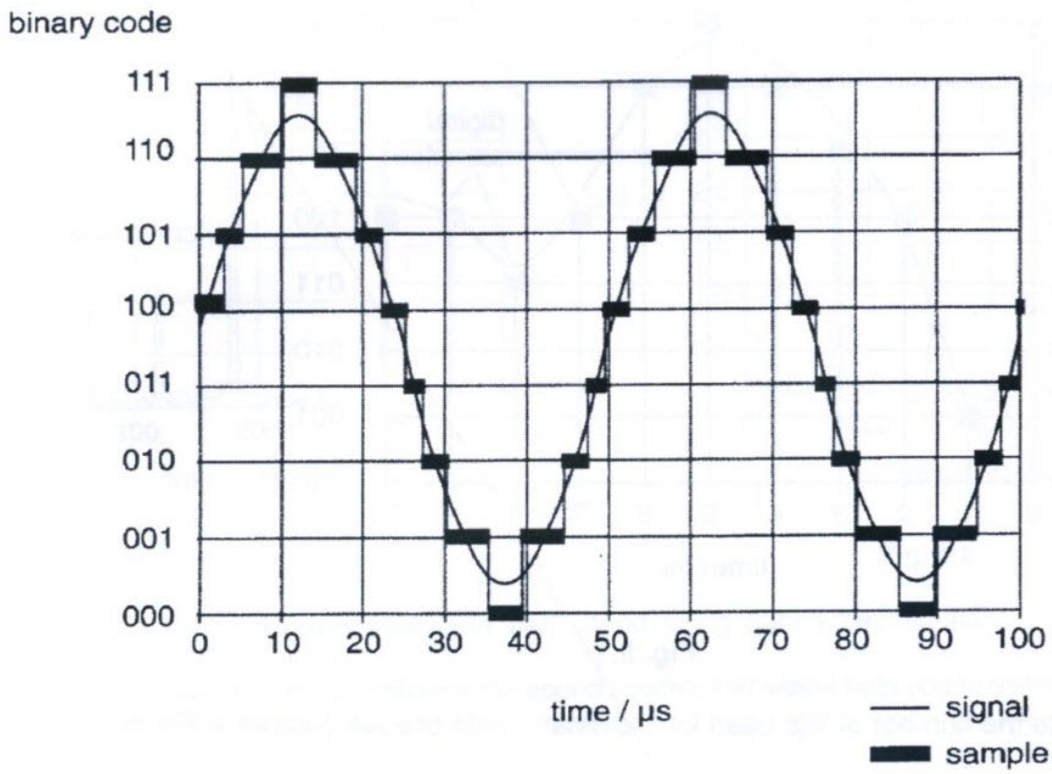


Fig. 7.1

(a) **(i)** Read from the graph the time period T in microseconds for one complete cycle of the dolphin whistle.

$T =$ 50 μs [1]

(ii) Calculate the frequency f corresponding to this time period T.

$f = \frac{1}{T} = \frac{1}{50 \times 10^{-6}}$

$f =$ 20,000 Hz [1]

(b) **(i)** State the number of bits per sample needed to code for the 8 binary levels.

$b = \log_2 N = \log_2 8 =$ number of bits = 3 [1]

(ii) The waveform is sampled every 1.0 μs. $= 1 \times 10^{-6}$ s

Calculate the rate at which information is digitised in this sampled waveform.

1×10^6 samples per second $\times 3$

information rate = 3×10^6 bits s^{-1} [1]

5 Figs. 5.1 and 5.2 show the frequency components (spectra) of two sounds from a voice recognition system.

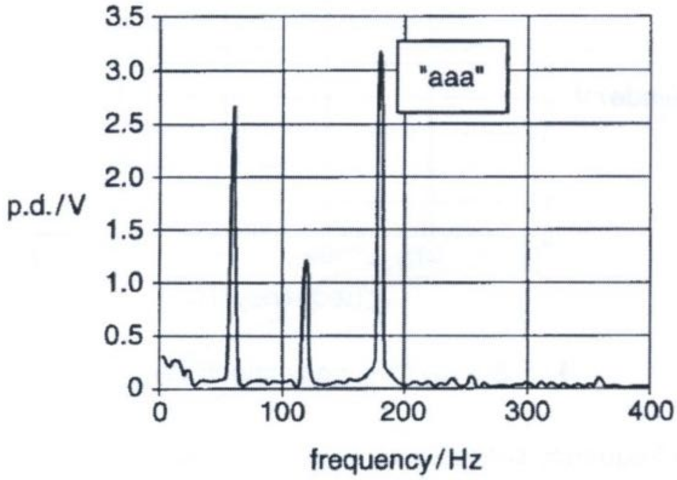


Fig. 5.1

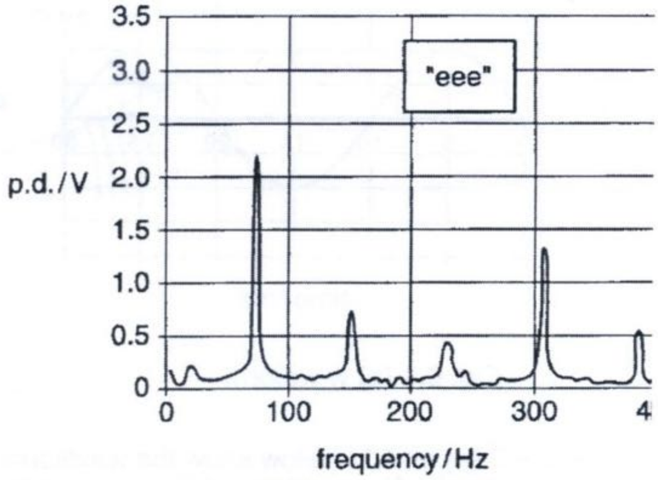


Fig. 5.2

(a) In Fig. 5.1, the voice was making an "aaa" sound, in Fig. 5.2 an "eee" sound.

Describe **two** differences between the sound spectra that would help you to distinguish between the sounds, by inspecting the spectra.

① presence of peak at ~180 Hz = "aaa"

② presence of peak at ~310 Hz = "eee"

[2]

(b) The fundamental frequency component waveform of the "eee" spectrum at 77 Hz is shown in Fig. 5.3.

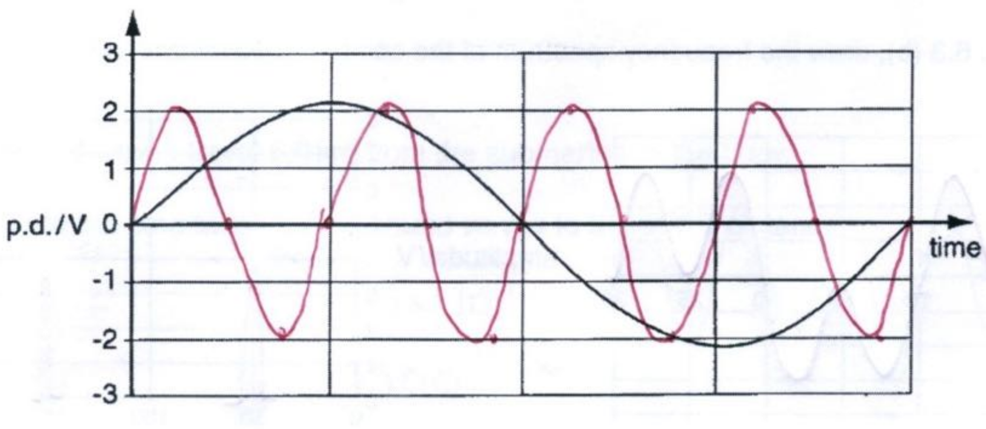


Fig. 5.3

Using information from Fig. 5.2, draw on Fig. 5.3 a waveform for the fourth harmonic component at 308 Hz at **four times** the fundamental frequency. [2]

Use

6 This question is about the relationship between analogue waveforms and their frequency spectra.

Fig. 6.1 (a) shows the waveform of a pure sound and Fig. 6.1 (b) its frequency spectrum.

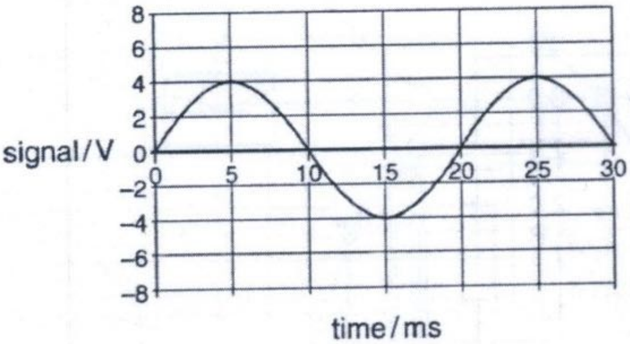


Fig. 6.1 (a) waveform

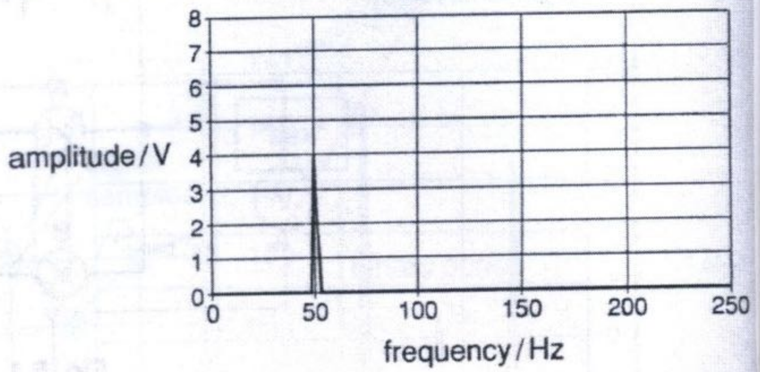


Fig. 6.1 (b) frequency spectrum

Fig. 6.2 (a) and (b) below show the waveform and frequency spectrum of a higher frequency sound.

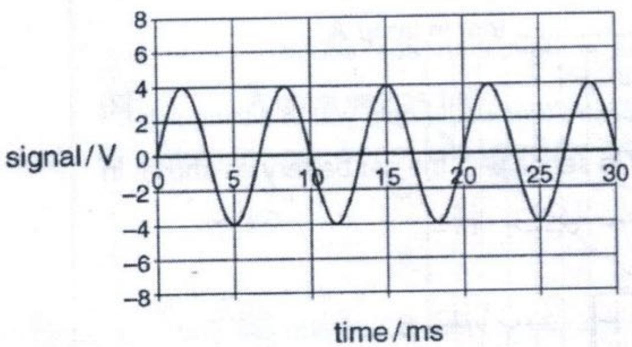


Fig. 6.2 (a) waveform

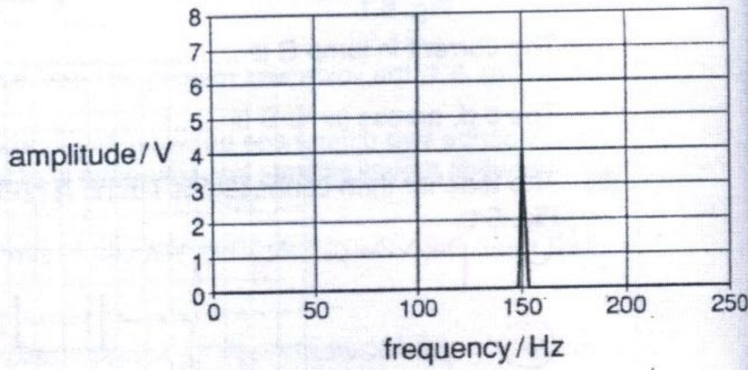


Fig. 6.2 (b) frequency spectrum

The waveforms of Fig. 6.1(a) and 6.2(a) are to be added to produce a combined waveform.

(a) On Fig. 6.3 (a), sketch this combined waveform. [3]

(b) On Fig. 6.3 (b), draw the frequency spectrum of the combined waveform. [1]

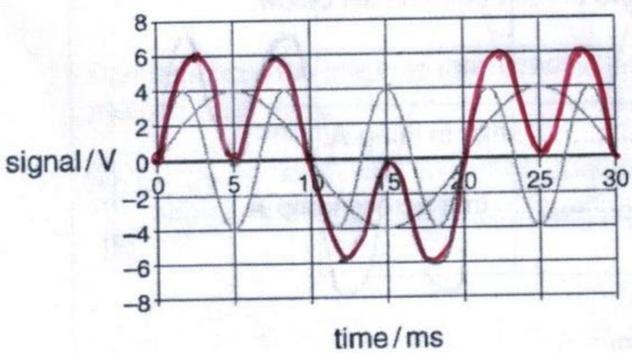


Fig. 6.3 (a) waveform

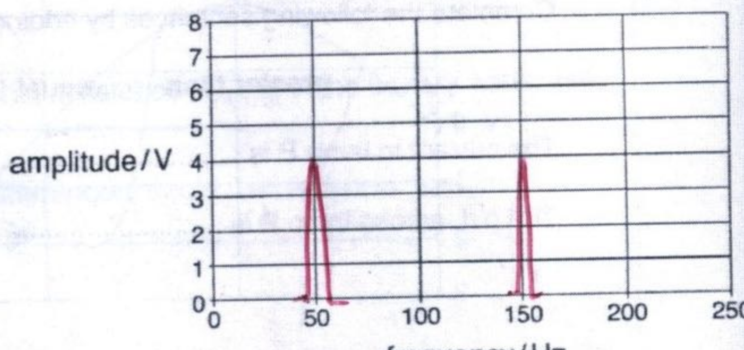
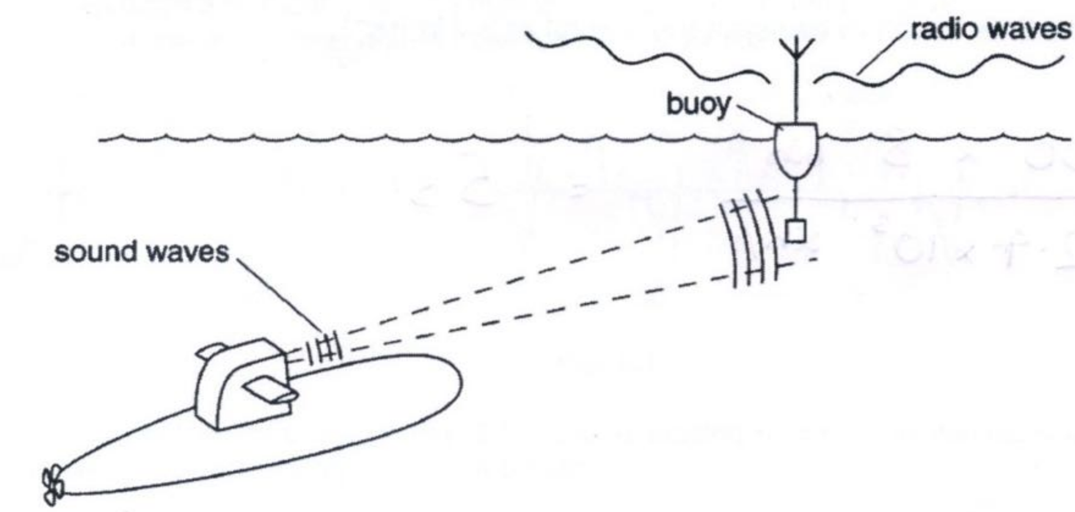


Fig. 6.3 (b) frequency spectrum

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}

$$s = f\lambda \quad \therefore \quad \lambda = \frac{\text{speed}}{f} = \frac{1500\ \text{ms}^{-1}}{8.0\times10^{3}\ \text{Hz}}$$

$$= 0.19\ \text{m}$$

[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.

$$t = \frac{\text{dist}}{\text{speed}} = \frac{5.0\times10^{3}\ \text{m}}{1500\ \text{ms}^{-1}} = 3.3\ \text{s}$$

time taken = 3.3 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}.

$$\frac{1500 \times 8 \text{ bits}}{2.4 \times 10^3 \text{ bits/s}} = 5 \text{ s}$$

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.

For video you need say 10 frames per second

this would mean $\frac{2.4 \times 10^3}{10} = 240$ bits $= 30$ byt

Assuming 1 byte per pixel (256 shads of grey)

that only gives you 30 pixels. The image

could only be 5 × pixels in size

A still image could be built up over

a few mins if necessary

[3]

[Total: 10]

2 A clarinet plays a musical note. The note is recorded, as shown in Fig. 2.1. It shows the waveform over a time interval of about 40 ms.

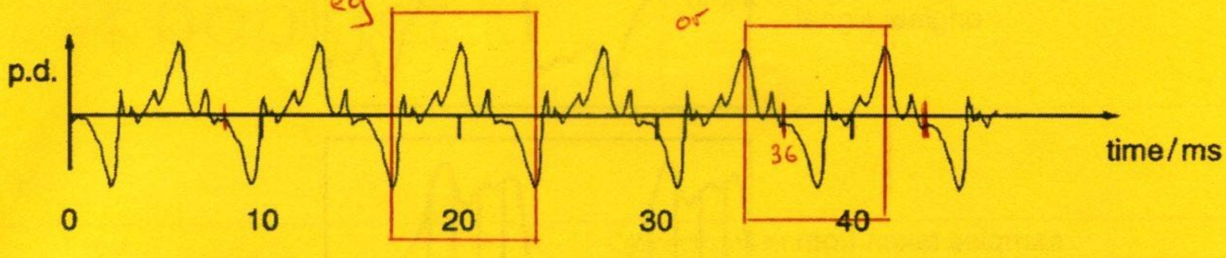


Fig. 2.1

(a) Draw on the waveform of Fig. 2.1 a box enclosing exactly **one** complete oscillation of the lowest frequency component of the note. [1]

(b) Use Fig. 2.1 to estimate the time period of this lowest frequency component of the note.

104 mm = 40 ms

19 mm = $\frac{19}{104} \times 40$ =

time period = 7.3 ms [1]

(c) Calculate the frequency of the lowest frequency component of the note using your value for the time period from **(b)**.

$f = \frac{1}{T} = \frac{1}{7.3 \times 10^{-3}\ m}$

frequency = 140 Hz [1]

7 Fig. 7.1 shows an analogue signal from which digital samples are taken for transmission. The reconstructed analogue signal at the receiver is also shown.

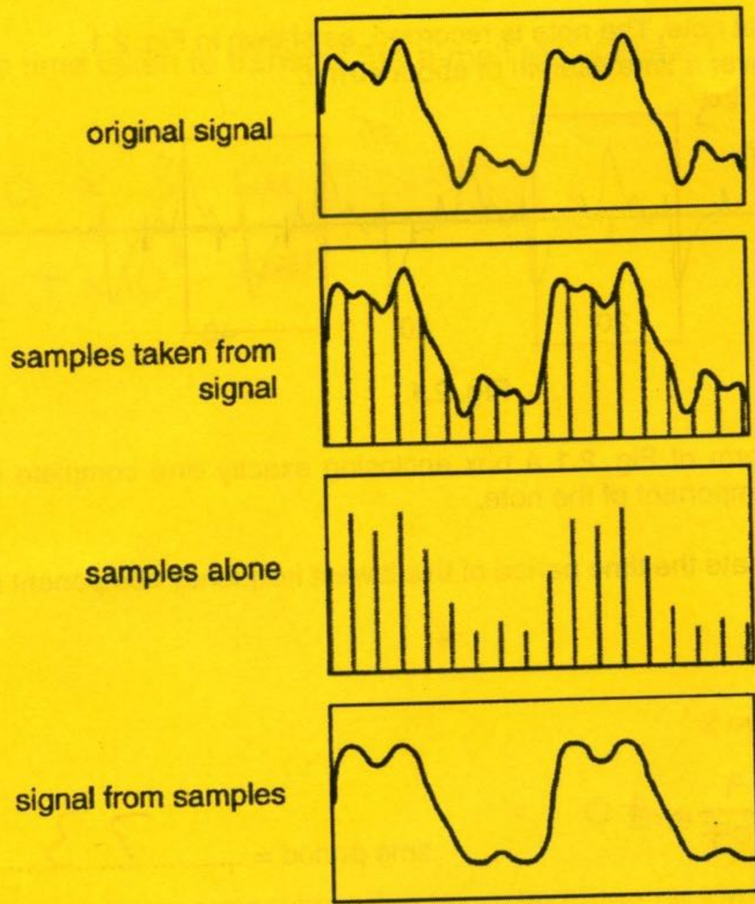


Fig. 7.1

(a) The diagrams show that the reconstructed signal is not exactly the same as the original signal.

State a difference between the signals.

High frequency components are missing

[1]

(b) Suggest how to improve the quality of the reconstructed signal.

Sample the original signal more frequently

[1]