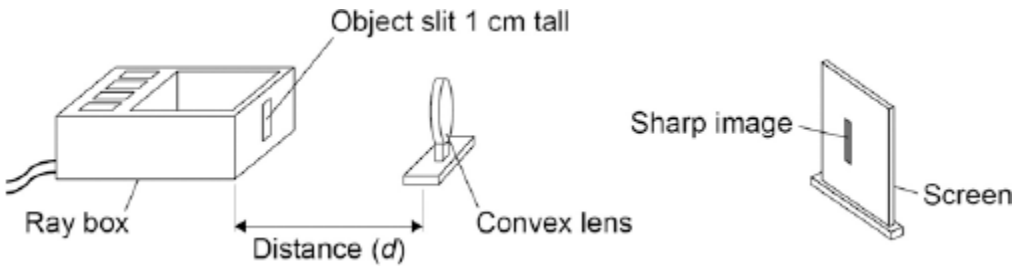
1 A student investigated how the magnification produced by a convex lens varies with the distance (*d*) between the object and the lens.

The student used the apparatus shown in **Figure 1**.

Figure 1



(a) The student measured the magnification produced by the lens by measuring the image height in centimetres.

Explain why the image height in centimetres was the same as the magnification.

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(2)

(b) The data recorded by the student is given in **Table 1**.

Table 1

Distance between the object and the lens in cm	**Magnification**
25	4.0
30	2.0
40	1.0
50	0.7
60	0.5

It would be difficult to obtain accurate magnification values for distances greater than 60 cm.

Suggest **one** change that could be made so that accurate magnification values could be obtained for distances greater than 60 cm.

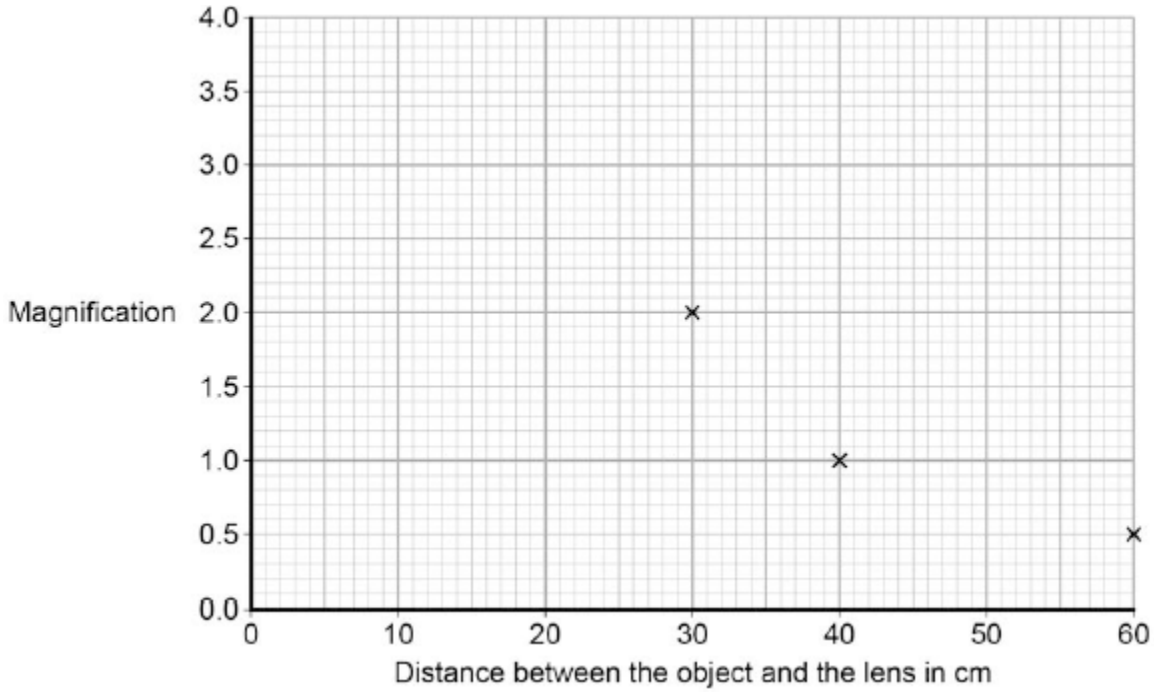
.....

.....

(1)

(c) The graph in **Figure 2** is incomplete.

Figure 2



Complete the graph in **Figure 2** by plotting the missing data and then drawing a line of best fit.

(2)

(d) How many times bigger is the image when the object is 35 cm from the lens compared to when the object is 55 cm from the lens?

.....

.....

.....

(2)

(e) During the investigation the student also measured the distance between the lens and the image.

Table 2 gives both of the distances measured and the magnification.

Table 2

Distance between the lens and the image in cm	Distance between the lens and the object in cm	Magnification
100	25	4.0
60	30	2.0
40	40	1.0
33	50	0.7
30	60	0.5

Consider the data in **Table 2**.

Give a second way that the student could have determined the magnification of the object.

Justify your answer with a calculation.

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(2)
(Total 9 marks)

2 The data given in the table below was obtained from an investigation into the refraction of light at an air to glass boundary.

Angle of incidence	Angle of refraction
20°	13°
30°	19°
40°	25°
50°	30°

Describe an investigation a student could complete in order to obtain similar data to that given in the table above.

Your answer should consider any cause of inaccuracy in the data.

A labelled diagram may be drawn as part of your answer.

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(Total 6 marks)

3 The data given in the table below was obtained from an investigation into the refraction of light at an air to glass boundary.

Angle of incidence	Angle of refraction
20°	13°
30°	19°
40°	25°
50°	30°

(a) Describe an investigation a student could complete in order to obtain similar data to that given in the table above.

Your answer should consider any cause of inaccuracy in the data.

A labelled diagram may be drawn as part of your answer.

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(6)

(b) State the reason why light is refracted as it crosses from air into glass.

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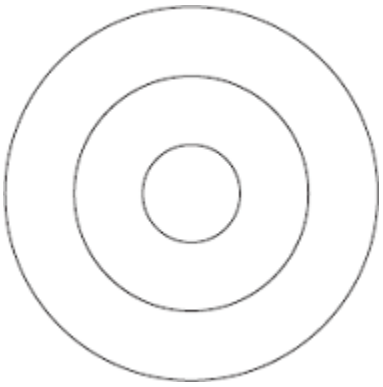
(1)

(Total 7 marks)

4 A teacher demonstrates the production of circular waves in a ripple tank.

Diagram 1 shows the waves at an instant in time.

Diagram 1



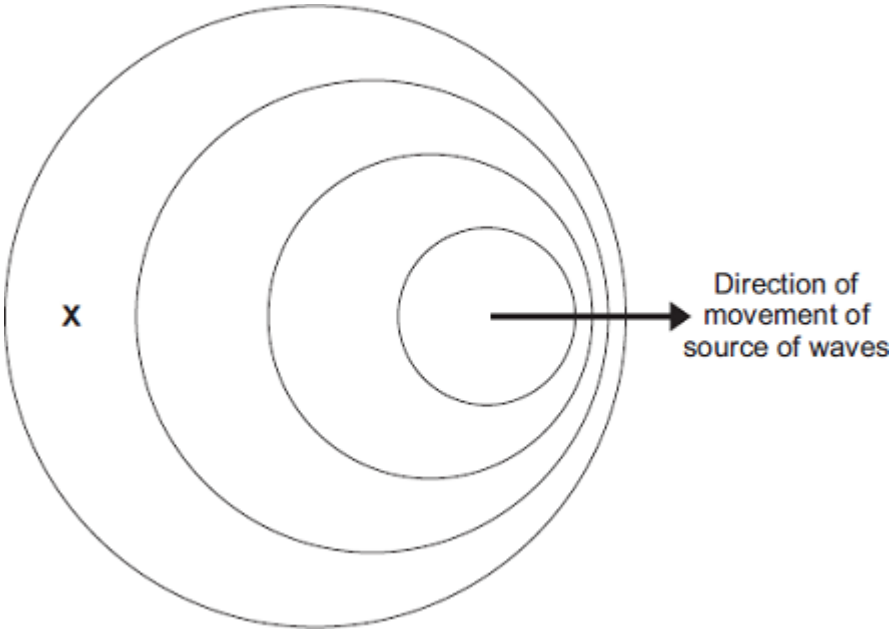
(a) Show on **Diagram 1** the wavelength of the waves.

(1)

(b) The teacher moves the source of the waves across the ripple tank.

Diagram 2 shows the waves at an instant in time.

Diagram 2
(Actual size)



(i) Use the correct answer from the box to complete each sentence.

decreased	**increased**	**stayed the same**

In **Diagram 2**, the observed wavelength of the waves at **X**

has ..... .

In **Diagram 2**, the frequency of the waves at **X**

has ..... .

(2)

(ii) Take measurements from **Diagram 2** to determine the wavelength of the waves received at **X**.

Give the unit.

.....

.....

Wavelength = ...

(3)

(c) The teacher uses the waves in the ripple tank to model the changes in the wavelengths of light observed from distant galaxies.

When observed from the Earth, there is an increase in the wavelength of light from distant galaxies.

(i) State the name of this effect.

.....

(1)

(ii) What does this increase in wavelength tell us about the movement of most galaxies?

.....

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(1)

(iii) Explain how this observation supports the Big Bang theory of the formation of the Universe.

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(4)

(iv) State **one** other piece of evidence that supports the Big Bang theory of the formation of the Universe.

.....

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(1)

(Total 13 marks)

5 (a) Radio waves, microwaves and visible light are all electromagnetic waves that are used for communication.

(i) Name another electromagnetic wave that is used for communication.

.....

(1)

(ii) Name an electromagnetic wave which is **not** used for communication.

State a use for this electromagnetic wave.

Electromagnetic wave .....

Use .....

.....

(2)

(b) The table below shows the wavelengths for some electromagnetic waves, **A**, **B**, **C** and **D**.

Wave	Wavelength
A	1000 m
B	100 m
C	10 m
D	3 cm

A teacher is going to demonstrate diffraction of waves through a gap. She will carry out the demonstration in a classroom.

The teacher is able to generate waves **A**, **B**, **C** and **D**.

Which wave, **A**, **B**, **C** or **D**, would she use? ☐

Explain your answer.

.....

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.....

.....

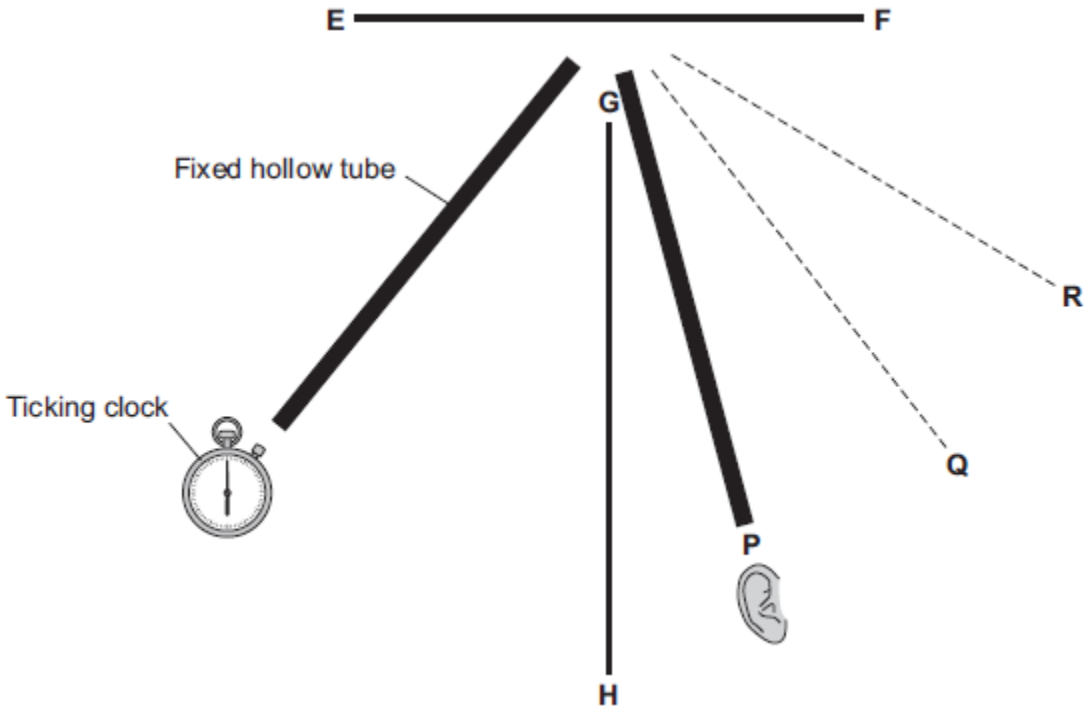
.....

.....

(3)

(c) In another demonstration, a teacher used a loud ticking clock as a source of sound, two hollow tubes and two smooth surfaces, **EF** and **GH**.

The figure below shows one of the hollow tubes fixed in position with a ticking clock at one end.



A student placed his ear at one end of the other hollow tube in position **P**. He moved this hollow tube, in turn, to positions **Q** and **R**.

(i) At which position, **P**, **Q** or **R**, did he hear the loudest sound? ☐

(1)

(ii) Explain your answer to part **(i)**.

.....

.....

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.....

.....

(3)

(iii) Suggest why smooth surface **GH** in the figure above was needed.

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(1)

(iv) The frequency of a sound wave is 15 Hz.

The speed of sound is 330 m / s.

Calculate the wavelength of the sound wave.

.....

.....

Wavelength = ... m

(2)

(v) Give a reason why it would **not** be possible to do the demonstration in the figure above using sound waves with a frequency of 15 Hz.

.....

.....

(1)
(Total 14 marks)

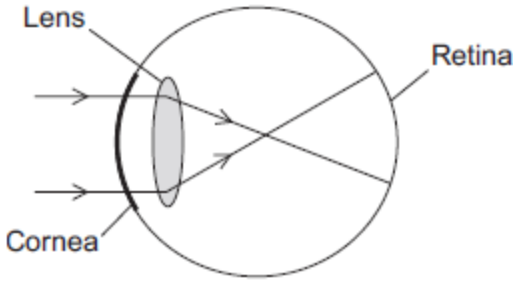
6 Lenses can be used to correct visual defects.

Figure 1 shows a child wearing glasses.
Wearing glasses allows a lens to correct a visual defect.

Figure 1

(a) **Figure 2** shows rays of light entering a child's eye and being focused at a point. This point is not on the retina so the child sees a blurred image.

Figure 2



(i) What is the visual defect of this eye?

.....

.....

(1)

(ii) Use the correct answer from the box to complete the sentence.

converging	convex	diverging

The type of lens used to correct this visual defect is a ..... lens.

(1)

(b) Visual defects may be corrected with eye surgery. A laser may be used in eye surgery.

Use the correct answer from the box to complete the sentence.

light	sound	X-rays

A laser is a concentrated source of ..... .

(1)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Lasers can be used to correct a visual defect by changing the shape of the cornea.

A knife is used to cut a flap in the cornea. The laser vaporises a portion of the cornea and permanently changes its shape. The flap is then replaced.

Most patients are back at work within a week. Driving may be unsafe for one to two weeks. Tinted glasses with ultraviolet protection are needed when out in the sun for the first three months.

Many people in their mid-40s need reading glasses. This is because the eye lens becomes less flexible with age. Laser surgery cannot cure this.

Laser surgery for both eyes costs £1000. A pair of glasses costs £250.

Describe the advantages and disadvantages of:

- having laser surgery to correct visual defects
- wearing glasses to correct visual defects.

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Extra space .....

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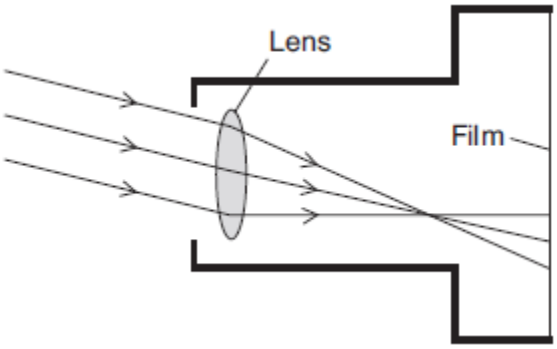
(6)

(d) **Figure 3** shows parallel rays of light, from a point on a distant object, entering a camera.

Figure 3



Describe the adjustment that has to be made to focus the image on the film.

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(2)
(Total 11 marks)

7 (a) What is ultrasound?

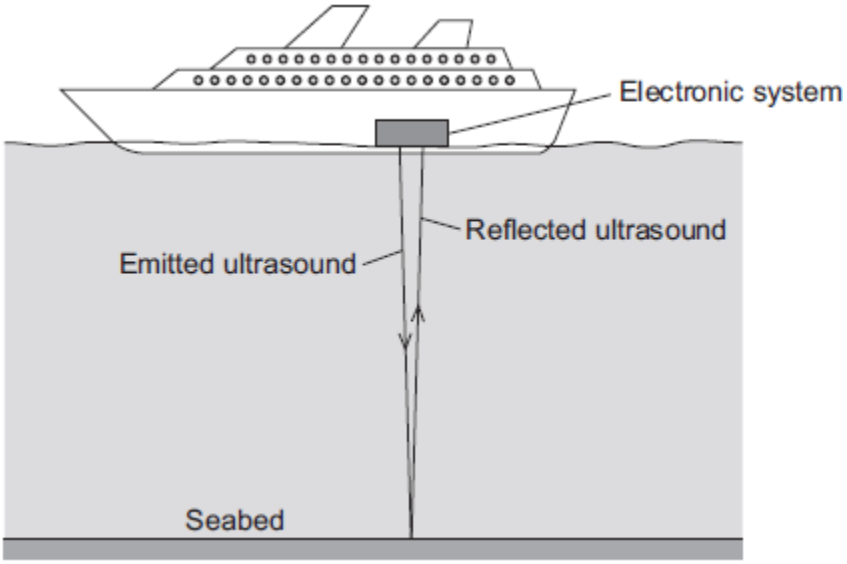
.....

.....

(1)

(b) **Figure 1** shows how ultrasound is used to measure the depth of water below a ship.

Figure 1



A pulse of ultrasound is sent out from an electronic system on-board the ship.

It takes 0.80 seconds for the emitted ultrasound to be received back at the ship.

Calculate the depth of the water.

Speed of ultrasound in water = 1600 m / s

.....

.....

.....

.....

Depth of water = ... metres

(3)

(c) Ultrasound can be used in medicine for scanning.

State **one** medical use of ultrasound scanning.

.....

(1)

(d) Images of the inside of the human body can be made using a Computerised Tomography (CT) scanner. The CT scanner in **Figure 2** uses X-rays to produce these images.

Figure 2

monkeybusinessimages/iStock/Thinkstock

State **one** advantage and **one** disadvantage of using a CT scanner, compared with ultrasound scanning, for forming images of the inside of the human body.

Advantage of CT scanning .....

.....

.....

Disadvantage of CT scanning .....

.....

.....

(2)
(Total 7 marks)

8 Waves may be longitudinal or transverse.

(a) Describe the differences between longitudinal waves and transverse waves.

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(3)

(b) Radio waves are electromagnetic waves.

Describe how radio waves are different from sound waves.

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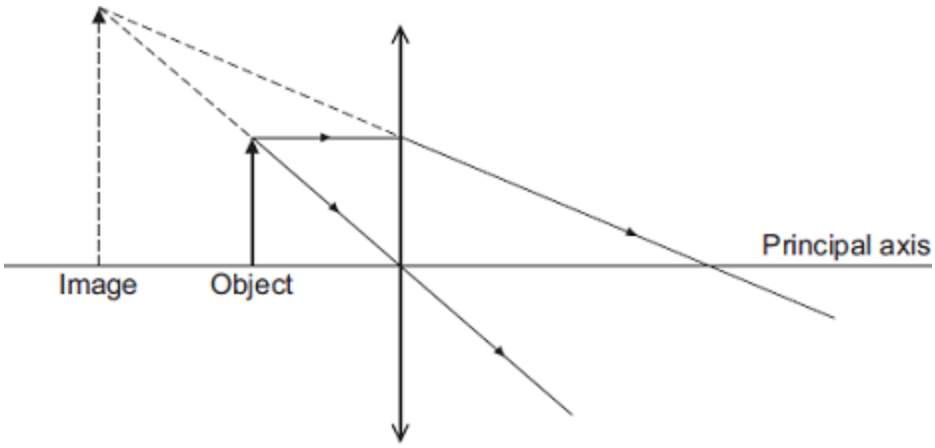
(4)
(Total 7 marks)

9 (a) The diagram shows how a convex lens forms an image of an object.

This diagram is **not** drawn to scale.



(i) Which **two** words describe the image?

Draw a ring around each correct answer.

diminished **inverted** **magnified** **real** **upright**

(2)

(ii) The object is 4 cm from the lens. The lens has a focal length of 12 cm.

Calculate the image distance.

.....

.....

.....

Image distance = ... cm

(3)

(b) What does a minus sign for an image distance tell us about the nature of the image?

.....

(1)

(Total 6 marks)

10 (a) Light waves transfer energy.

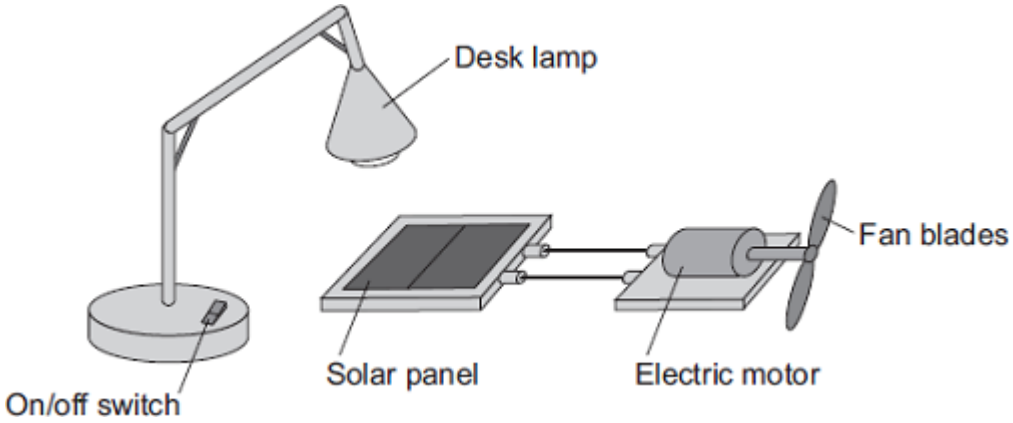
(i) Complete the following sentence.

The oscillations producing a light wave are .....

to the direction of the energy transfer by the light wave.

(1)

(ii) The apparatus in the diagram shows that light waves transfer energy.



Describe how switching the desk lamp on and off shows that light waves transfer energy.

You do **not** need to describe the energy transfers.

.....

.....

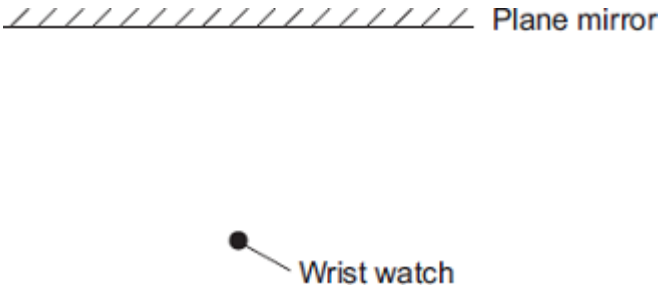
.....

.....

(2)

(b) A student holds a wrist watch in front of a plane mirror. The student can see an image of the wrist watch in the mirror.

The diagram shows the position of the wrist watch and the mirror.



Draw a ray diagram showing how the image of the wrist watch is formed.

Mark the position of the image.

(4)

(c) The image of the wrist watch seen by the student is virtual.

What is a virtual image?

.....

.....

(1)
(Total 8 marks)

11 Ultrasound and X-rays are waves used in hospitals to create images of the inside of the human body. To produce the images below, the waves must enter the human body.

Ultrasound scan of an unborn child

© Isabelle Limbach/Thinkstock

X-ray of a broken bone

© itsmejust/iStock

(a) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate*.

Describe the features of ultrasound and X-rays, and what happens to each type of wave after it has entered the human body.

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(6)

(b) It would **not** be safe to use X-rays to produce an image of an unborn child.

Explain why.

.....

.....

.....

.....

(2)

(c) Ultrasound can be used for medical treatments as well as for imaging.

Give **one** use of ultrasound for medical treatment.

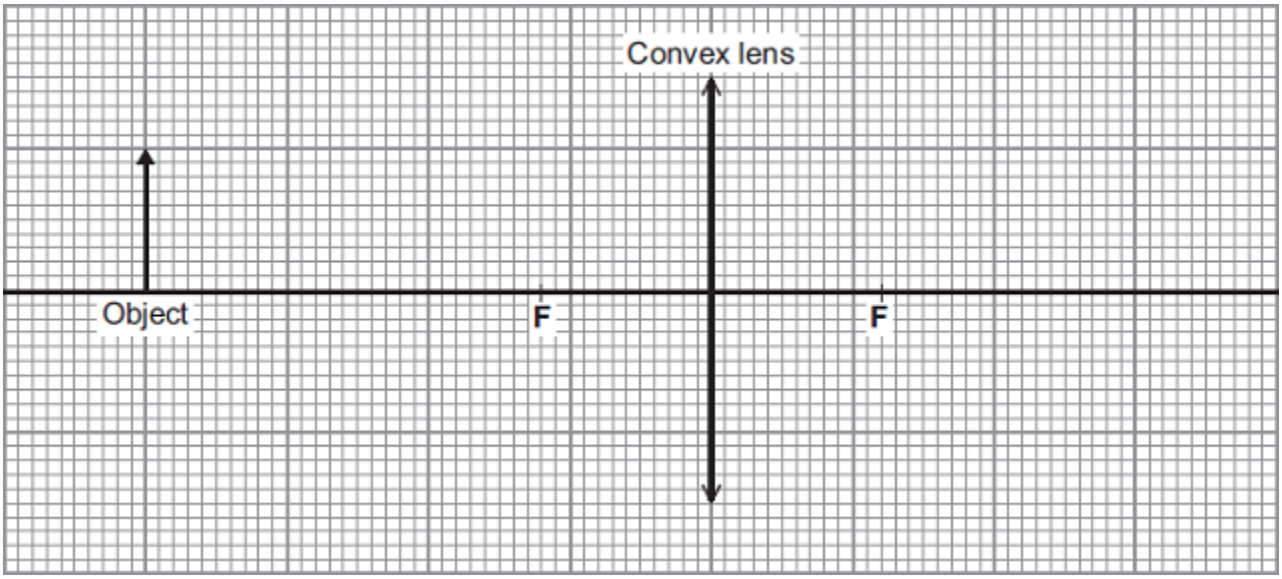
.....

.....

(1)
(Total 9 marks)

12 (a) A camera was used to take a photograph. The camera contains a convex (converging) lens.

Complete the ray diagram to show how the lens produces an image of the object.



F = Principal focus

(4)

(b) State **two** words to describe the nature of the image produced by the lens in the camera.

1 .....

2 .....

(2)
(Total 6 marks)

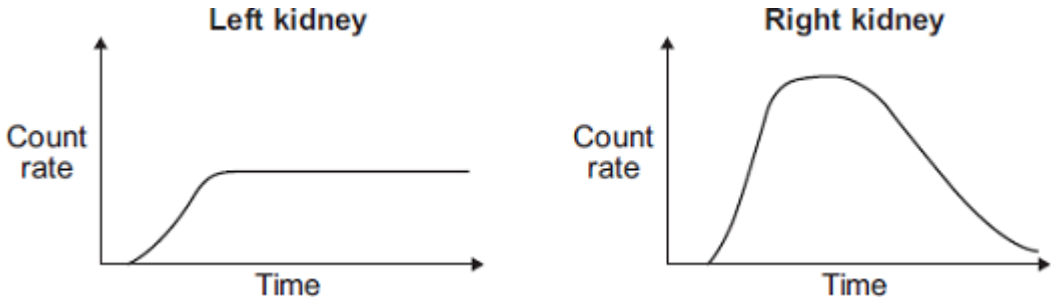
13 A doctor uses the radioactive isotope technetium-99 to find out if a patient's kidneys are working correctly.

The doctor injects a small amount of technetium-99 into the patient's bloodstream. Technetium-99 emits gamma radiation.

If the patient's kidneys are working correctly, the technetium-99 will pass from the bloodstream into the kidneys and then into the patient's urine.

Detectors are used to measure the radiation emitted from the kidneys.

The level of radiation emitted from each kidney is recorded on a graph.



(a) How do the graphs show that technetium-99 is passing from the bloodstream into each kidney?

.....

.....

(1)

(b) By looking at the graphs, the doctor is able to tell if there is a problem with the patient's kidneys.

Which **one** of the following statements is correct?

Put a tick (✓) in the box next to your answer.

Only the right kidney is working correctly. ☐

Only the left kidney is working correctly. ☐

Both kidneys are working correctly. ☐

Explain the reason for your answer.

.....

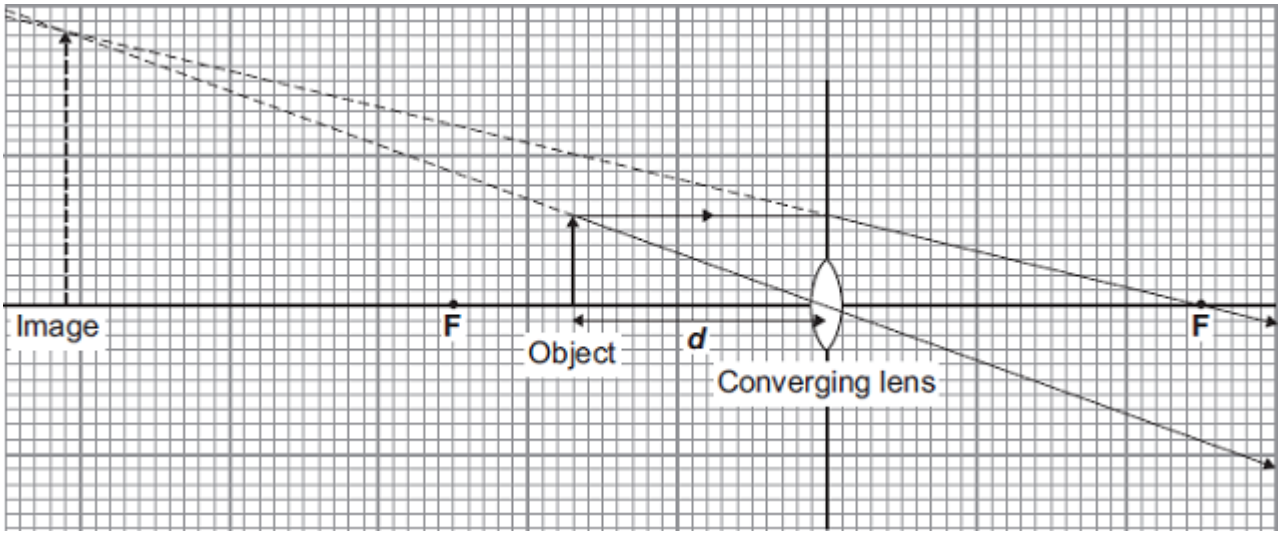
.....

.....

.....

(3)
(Total 4 marks)

14 A student investigates how the magnification of an object changes at different distances from a converging lens.
The diagram shows an object at distance ***d*** from a converging lens.



(a) (i) The height of the object and the height of its image are drawn to scale.

Use the equation in the box to calculate the magnification produced by the lens shown in the diagram.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Show clearly how you work out your answer.

.....

.....

.....

Magnification = ...

(2)

(ii) The points **F** are at equal distances on either side of the centre of the lens.

State the name of these points.

.....

(1)

(iii) Explain how you can tell, **from the diagram**, that the image is virtual.

.....

.....

(1)

(b) The student now uses a different converging lens. He places the object between the lens and the point **F** on the left.

The table shows the set of results that he gets for the distance ***d*** and for the magnification produced.

Distance *d* measured in cm	**Magnification**
5	1.2
10	1.5
15	2.0
20	3.0
25	6.0

His friend looks at the table and observes that when the distance doubles from 10 cm to 20 cm, the magnification doubles from 1.5 to 3.0.

His friend's conclusion is that:

> The magnification is directly proportional to the distance of the object from the lens.

His friend's observation is correct.

His friend's conclusion is wrong.

(i) Explain using data from the table why his friend's conclusion is wrong.

.....

.....

.....

.....

(2)

(ii) Write a correct conclusion.

.....

.....

(1)

(iii) The maximum range of measurements for ***d*** is from the centre of the lens to **F** on the left.

The student **cannot** make a correct conclusion outside this range.

Explain why.

.....

.....

(1)
(Total 8 marks)

15 Small sailing boats can be fitted with a passive radar device. The device increases the chance that the small boat will be seen on the radar screen of a large ship.
The radar transmitter on the large ship emits microwaves.

(a) Microwaves and radio waves are both part of the electromagnetic spectrum.

How are microwaves different from radio waves?

.....

.....

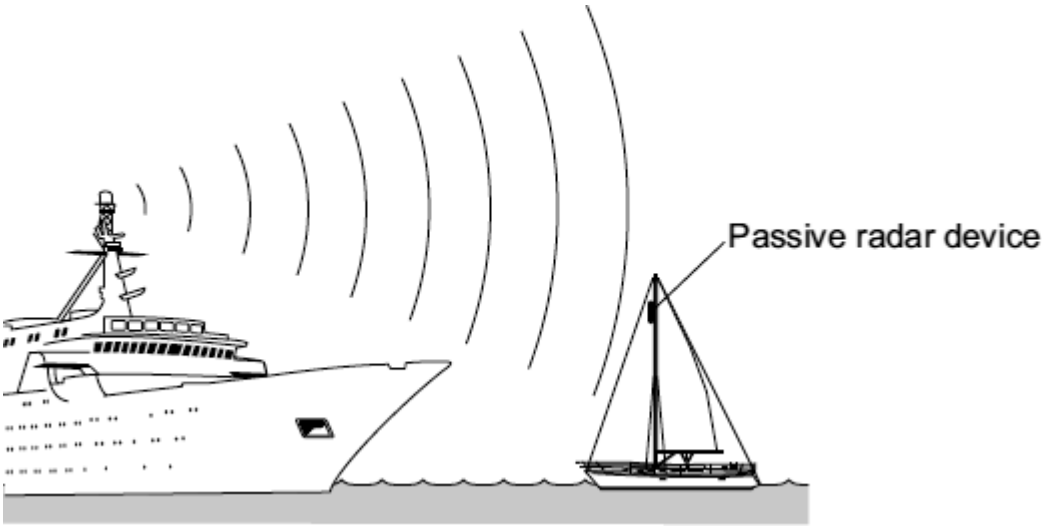
(1)

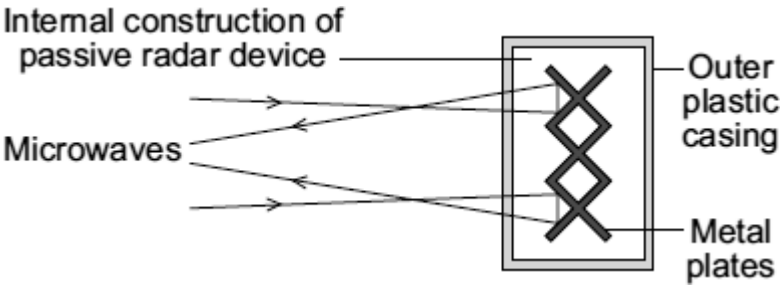
(b) How fast do microwaves travel through the air or a vacuum compared to radio waves?

.....

(1)

(c) The diagrams show the position of a passive radar device on a small boat and the internal construction of one type of passive radar device.





Microwaves can be absorbed, reflected or transmitted by different materials and types of surface.

Explain what happens to the microwaves from the ship's transmitter when they reach the passive radar device.

.....

.....

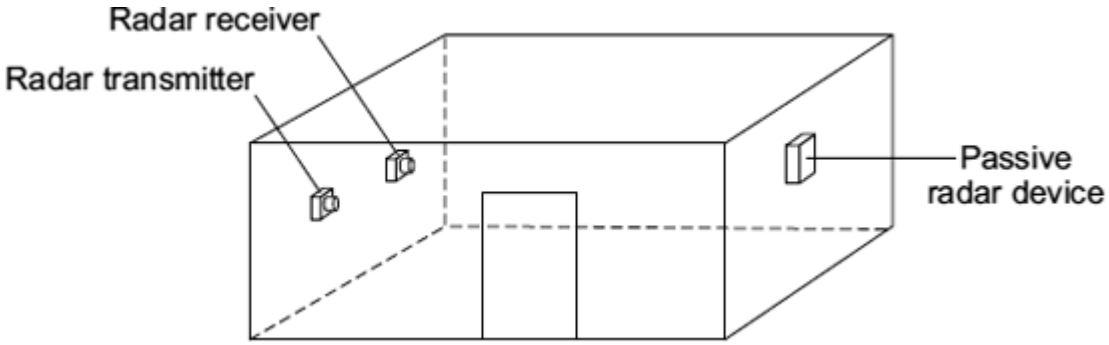
.....

.....

(2)

(d) Each type of passive radar device has an RCS value. The larger the RCS value, the easier it is for a small boat fitted with the device to be detected.

An independent group of scientists measured the RCS values of 4 different types of device. The RCS value for each device was measured in the same room using the same equipment.



(i) Why are the walls of the room covered in a material that absorbs the waves emitted by the radar transmitter?

.....

.....

(1)

(ii) Why is it important to use the same room and the same equipment?

.....

.....

(1)

(iii) Why is it important that the measurements are made by an independent group of scientists?

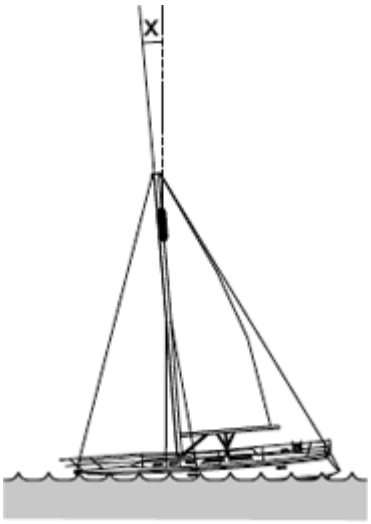
.....

.....

(1)

(e) The movement of a small boat causes the mast and device to lean over, therefore the RCS values were measured at different angles.

The table gives the RCS values obtained by the scientists.



Device	Angle X			
	0 °	**5 °**	**10 °**	**15 °**
A	1.4	1.6	1.7	1.8
B	4.7	2.6	2.3	1.9
C	9.3	3.3	1.9	1.1
D	4.5	4.8	5.0	4.6

(i) Describe how the RCS values for **device A** are different to the RCS values for **device B**.

.....

.....

.....

.....

(2)

(ii) The scientists recommended that a passive radar device fitted to a small boat should have:

- the largest possible RCS value
- an RCS value consistently above 2.0

Which **one** of the devices, **A**, **B**, **C** or **D**, would you recommend that someone fits to their boat?

.....

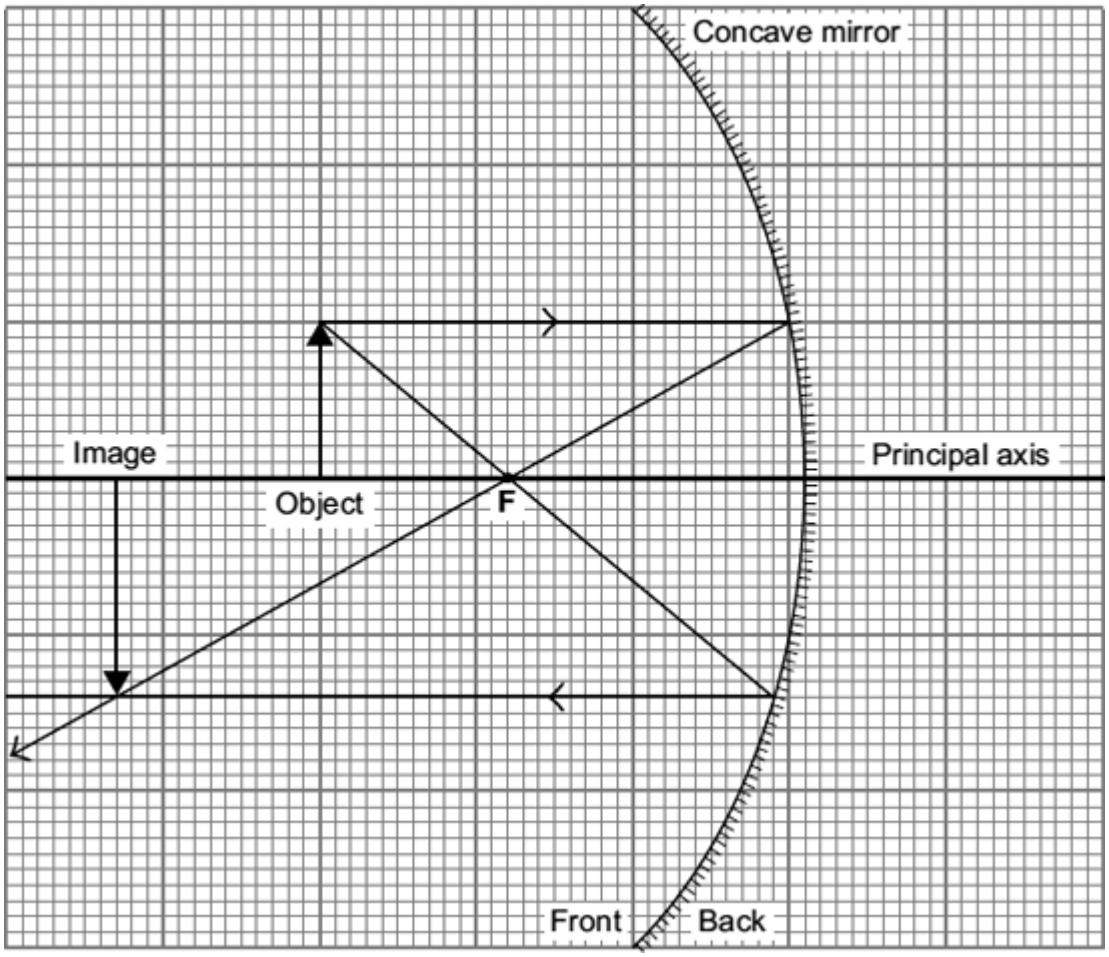
Give a reason for your answer.

.....

.....

(1)
(Total 10 marks)

16 The ray diagram shows the image formed by a concave mirror.



Use the equation in the box to calculate the magnification.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Show clearly how you work out your answer.

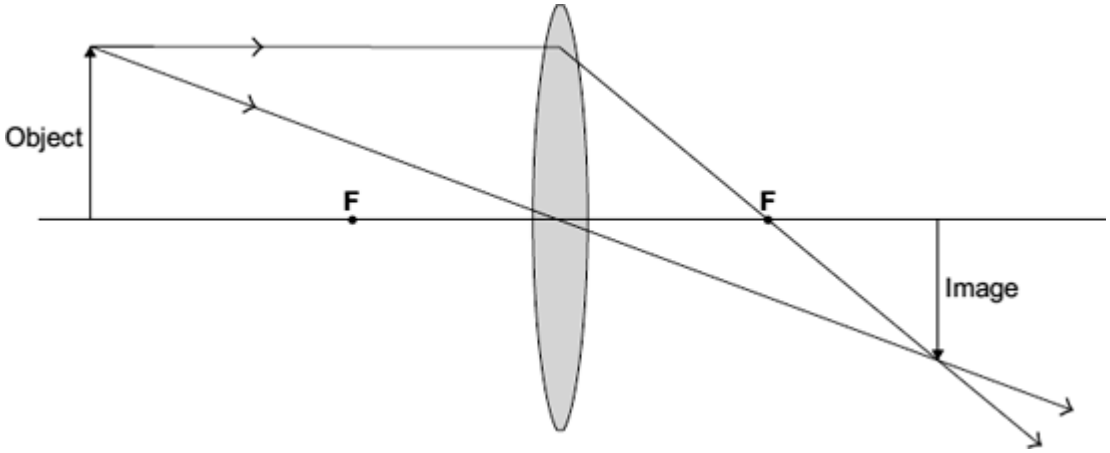
.....

.....

Magnification = ...

(Total 2 marks)

17 The diagram shows a lens, the position of an object and the position of the image of the object.



(a) What type of lens is shown?

.....

(1)

(b) What is the name of the points, **F**, shown each side of the lens?

.....

(1)

(c) (i) The image is real and can be put on a screen.

How can you tell **from the diagram** that the image is real?

.....

.....

(1)

(ii) Draw a ring around a word in the box which describes the image produced by the lens.

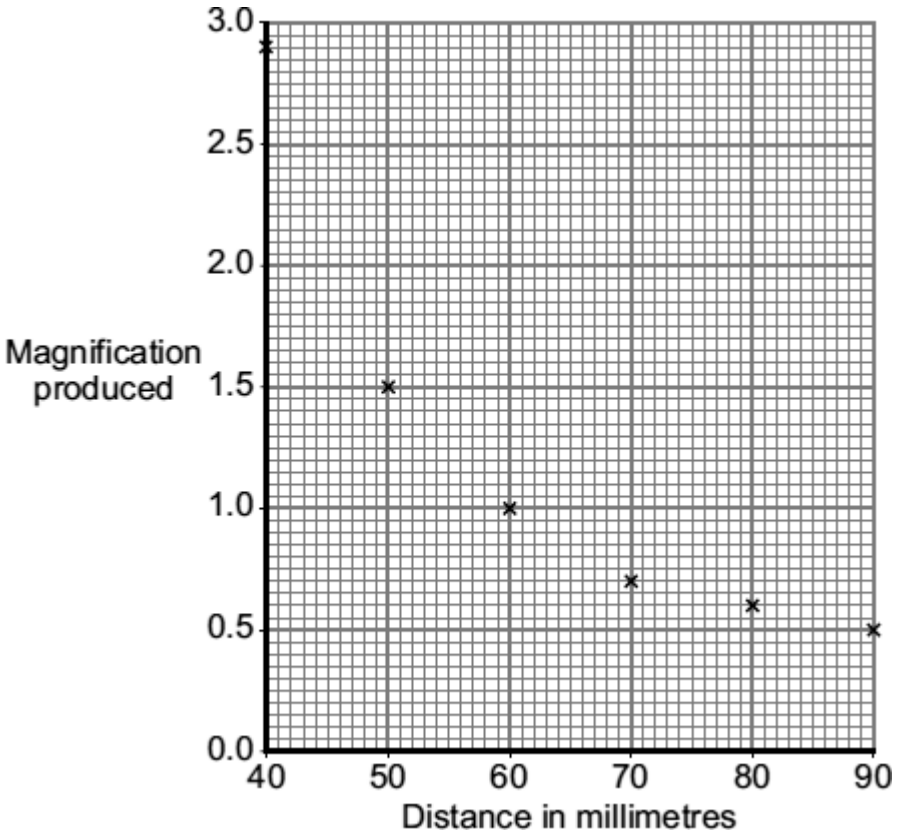
inverted	**larger**	**upright**

(1)

(d) A student investigates the relationship between the distance from the object to the lens and the magnification produced by the lens.
The student's results are given in the table.
The student did not repeat any measurements.

Distance in millimetres	Height of object in millimetres	Height of image in millimetres	Magnification produced
40	20	58	2.9
50	20	30	1.5
60	20	20	1.0
70	20	14	0.7
80	20	12	0.6
90	20	10	0.5

The student plots the points for a graph of *magnification produced* against *distance*.



(i) Draw a *line of best fit* for these points.

(1)

(ii) Complete the following sentence by drawing a ring around the correct word in the box.

A line graph has been drawn because both variables are

described as being

categoric.
continuous.
discrete.

(1)

(iii) Describe the relationship between *magnification produced* and *distance*.

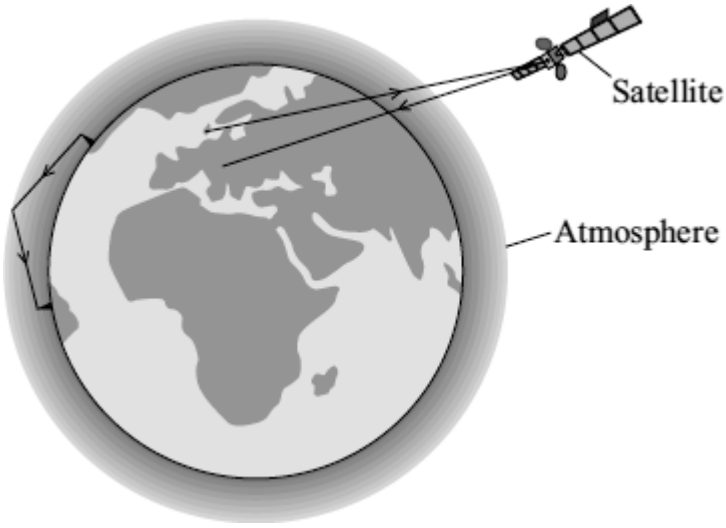
.....

.....

.....

(2)
(Total 8 marks)

18 (a) Electromagnetic waves have many uses. The diagram shows two ways of sending information using electromagnetic waves.



(i) What type of wave is used to send information to and from satellites?

.....

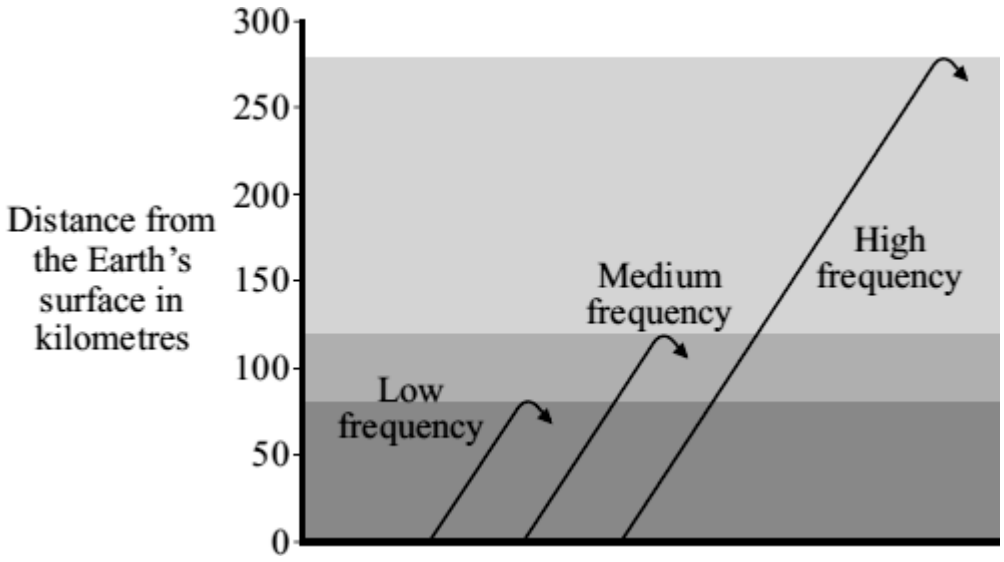
(1)

(ii) What property of this type of wave makes it suitable for satellite communications?

.....

(1)

(b) Different frequency radio waves travel different distances through the atmosphere before being reflected.



Use the information in the diagram to describe the connection between the frequency of a radio wave and the distance the radio wave travels through the atmosphere before it is reflected.

.....

.....

(1)

(c) Electromagnetic waves travel at a speed of 300 000 000 m/s.

A radio station transmits waves with a wavelength of 20 metres.

Calculate the frequency, in kilohertz (kHz), of these waves.

Show clearly how you work out your answer.

.....

.....

.....

.....

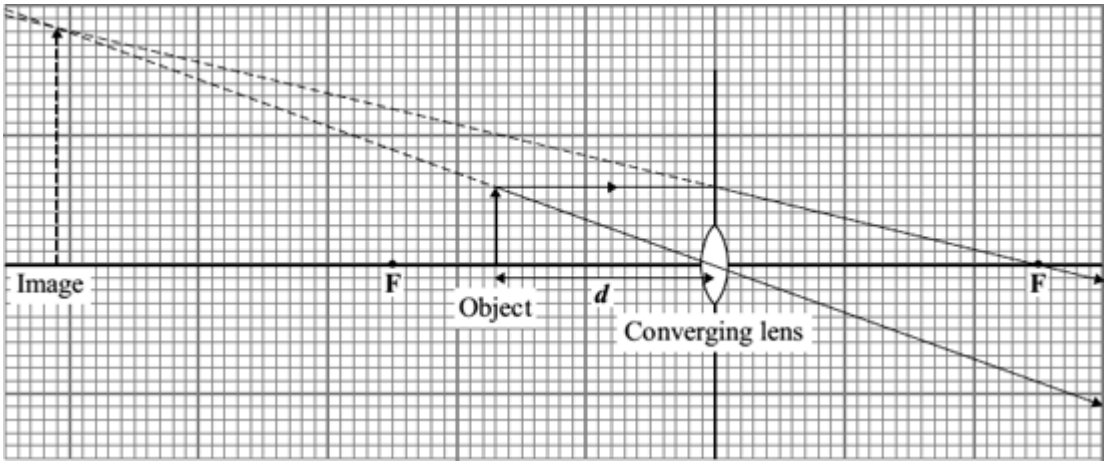
Frequency = ... kHz

(2)

(Total 5 marks)

19 A student investigates how the magnification of an object changes at different distances from a converging lens.

The diagram shows an object at distance ***d*** from a converging lens.



(a) (i) The height of the object and the height of its image are drawn to scale.

Use the equation in the box to calculate the magnification produced by the lens shown in the diagram.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Show clearly how you work out your answer.

.....

.....

.....

Magnification = ...

(2)

(ii) The points **F** are at equal distances on either side of the centre of the lens.

State the name of these points.

.....

(1)

(iii) Explain how you can tell, **from the diagram**, that the image is virtual.

.....

.....

(1)

(b) The student now uses a different converging lens. He places the object between the lens and point **F** on the left.

The table shows the set of results that he gets for the distance d and for the magnification produced.

Distance d measured in cm	**Magnification**
5	1.2
10	1.5
15	2.0
20	3.0
25	6.0

His friend looks at the table and observes that when the distance doubles from 10 cm to 20 cm, the magnification doubles from 1.5 to 3.0.

His friend's conclusion is that:

The magnification is directly proportional to the distance of the object from the lens.

His friend's observation is correct but his friend's conclusion is **not** correct.

(i) Explain, with an example, why his friend's conclusion is **not** correct.

.....

.....

.....

.....

(2)

(ii) Write a correct conclusion.

.....

.....

(1)

(iii) The maximum range of measurements for ***d*** is from the centre of the lens to **F** on the left.

The student **cannot** make a correct conclusion outside this range.

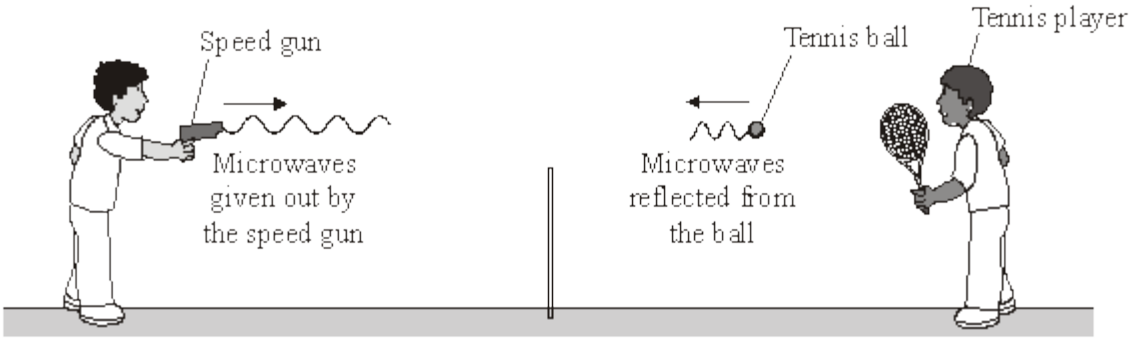
Explain why.

.....

.....

(1)
(Total 8 marks)

20 (a) The picture shows a speed gun being used to measure how fast a tennis player hits the ball.



Some of the microwaves from the speed gun are absorbed by the ball and some are reflected by the ball.

(i) Complete the following sentence by choosing **one** of the phrases from the box.

longer than	**the same as**	**shorter than**

The wavelength of the microwaves reflected from the ball are

..... the wavelength of the microwaves

from the speed gun.

(1)

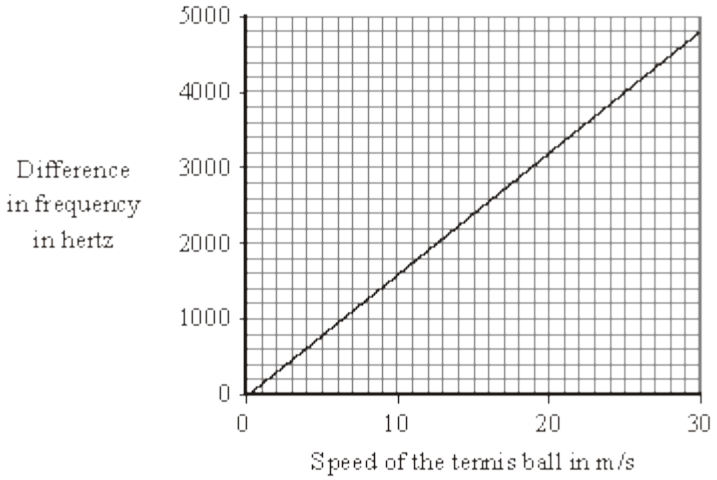
(ii) Complete the following sentence by drawing a ring around the correct line in the box.

When the ball absorbs microwaves, its temperature will

decrease slightly
not change
increase slightly

(1)

(b) The microwaves reflected from the ball have a higher frequency than the microwaves from the speed gun.
The graph shows how the difference between the two frequencies depends on the speed of the ball.



(i) Describe the pattern that links the difference between the two frequencies and the speed of the ball.

.....

.....

(1)

(ii) The speed gun measures the difference between the two frequencies as 3200 Hz.

Use the graph to find the speed of the tennis ball.
Show clearly on the graph how you obtain your answer.

Speed of the tennis ball = ... m/s

(2)

(iii) Which **one** of the following gives the reason why the data has been shown as a line graph and **not** as a bar chart?

Put a tick (✓) in the box next to your choice.

Frequency and speed are both categoric variables. ☐

Frequency and speed are both continuous variables. ☐

Speed is a continuous variable and frequency is a categoric variable. ☐

(1)

(Total 6 marks)

21 (a) Some scientists think that there is a link between using a mobile phone and some types of illness. Other scientists disagree. They say that the evidence is limited and unreliable.

(i) Suggest what scientists could do to show a link between using a mobile phone and illness.

.....

.....

(1)

(ii) How could scientists improve the reliability of the evidence?

.....

.....

(1)

(iii) Complete the following passage by drawing a ring around the word in the box that is correct.

There has been little or no experimental research into the health of children who use mobile phones.

This is partly because of the | economic / environmental / ethical | issues involved in using children in scientific research.

(1)

(b) Before being sold, new mobile phones must be tested and given a SAR value.
The SAR value is a measure of the energy absorbed by the head while a mobile phone is being used.

The table gives the SAR value for three mobile phones made by different companies.
To be sold in the UK, a mobile phone must have a SAR value lower than 2.0 W/kg.

Mobile phone	SAR value in W/kg
J	0.18
K	0.86
L	1.40

(i) All companies use the same test to measure a SAR value.

Why is using the same test important?

.....

.....

(1)

(ii) Would the companies that make the mobile phones, **J**, **K** and **L**, be correct to claim that these three phones are totally safe to use?

Answer yes or no. .....

Give a reason for your answer.

.....

.....

(1)

(c) Devices designed to protect a mobile phone user from microwave radiation are now available.

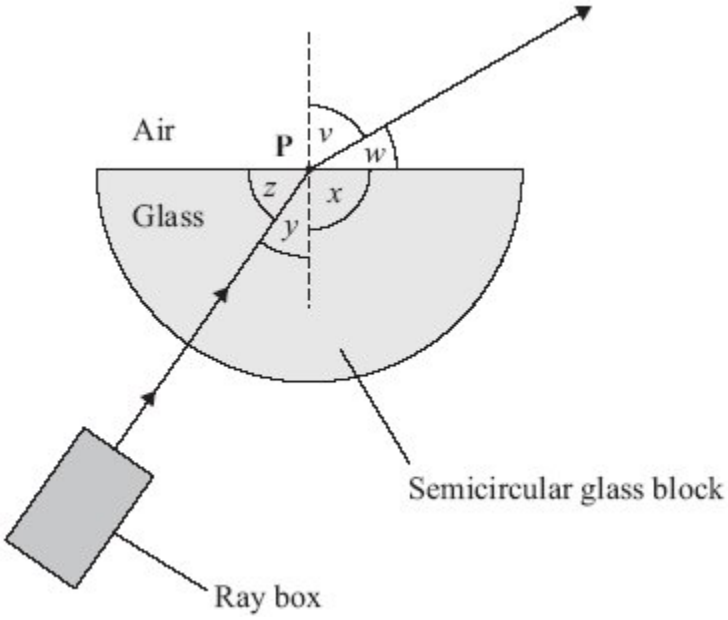
Why is it important that these devices are tested by scientists who are **not** working for the company that makes the devices?

.....

.....

(1)
(Total 6 marks)

22 A student uses a ray box and a semicircular glass block to investigate refraction.



(a) What is the vertical dashed line called?

.....

(1)

(b) Which angle, *v*, *w*, *x*, *y* or *z*, is the angle of refraction?

.....

(1)

(c) Why has refraction taken place?

.....

.....

(1)

(d) In an investigation, a student always aims the light from the ray box at point **P**.
She moves the ray box to give different values of angle *v*.
She records angle *y* for each of these values. The table shows her results.

Angle *v* measured in degrees	**Angle *y* measured in degrees**
30	19
40	25
50	31
60	35
70	39
80	41

The student studies the data and comes to the following conclusion.

Angle *y* is directly proportional to angle *v*.

Her friend says that this conclusion is **not** correct.

(i) Use data from the table to explain why the conclusion is **not** correct.

.....

.....

(2)

(ii) Write a correct conclusion for the experiment.

.....

.....

(1)

(iii) Why is your conclusion only valid when angle *v* is between 30° and 80°?

.....

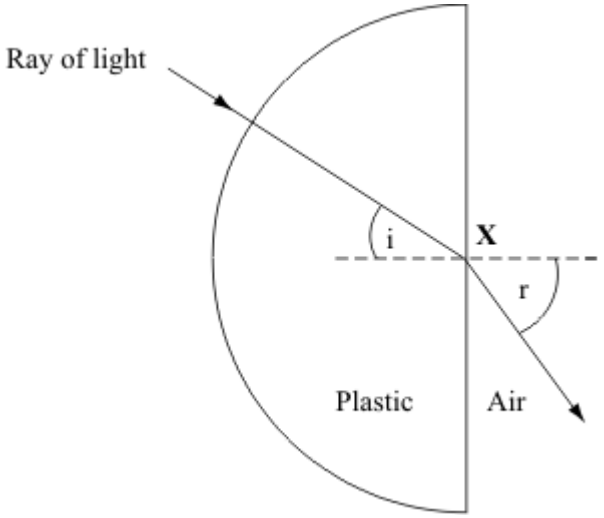
.....

(1)
(Total 7 marks)

23 (a) A student investigated the refraction of light as it passes out of a transparent plastic block.

She aimed a ray of light at point **X**. She marked the position of the ray as it passed through the transparent plastic block and into the air.

The angle *i* is the angle of incidence.



(i) What is the name of angle **r**?

.....

(1)

(ii) What is the name of the dashed line?

.....

(1)

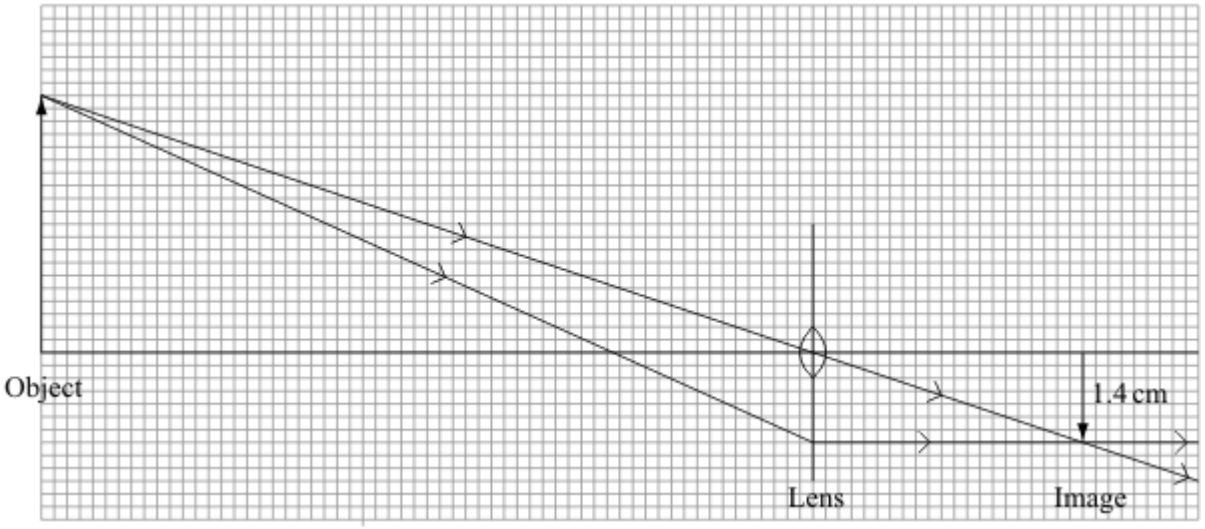
(b) A camera uses a lens to produce an image which falls on a light detector.

Name a light detecting device which may be used in a camera.

.....

(1)

(c) The diagram shows the position of an image formed in a camera.



(i) What type of lens is shown in the diagram?

.....

(1)

(ii) Use the equation in the box to calculate the magnification.

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Show clearly how you work out your answer.

.....

.....

Magnification = ...

(2)

(d) Why does the image formed in a camera have to be a real image?

.....

.....

(1)

(Total 7 marks)

24 The drawing shows someone ironing a shirt. The top of the ironing board is covered in a shiny silver-coloured material.

Explain why the shiny silver-coloured material helps to make ironing easier.

.....

.....

.....

.....

(Total 2 marks)

25 After a person is injured a doctor will sometimes ask for a photograph to be taken of the patient's bone structure, e.g. in the case of a suspected broken arm.

(i) Which type of electromagnetic radiation would be used to take the photograph?

.....

(1)

(ii) Describe the properties of this radiation which enable it to be used to photograph bone structure.

.....

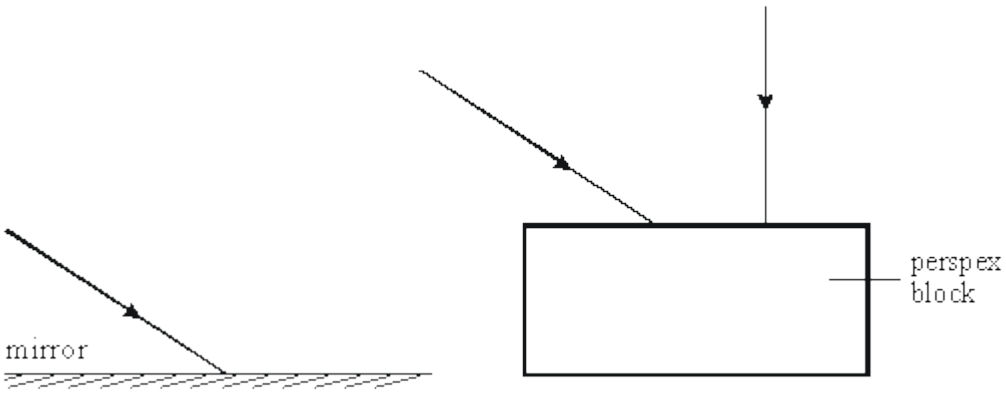
.....

.....

.....

(2)
(Total 3 marks)

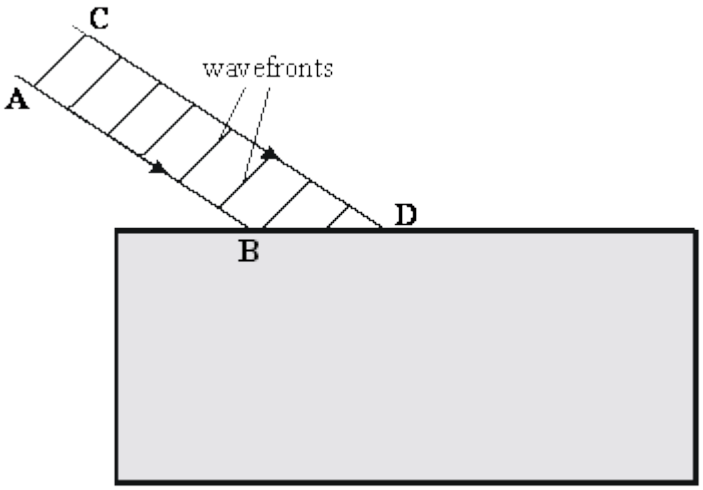
26 (a) The diagrams below show rays of light striking a mirror and a perspex block.



Complete the paths of the three rays of light on the diagrams to show the rays leaving the mirror and the perspex block.

(4)

(b) The diagram below shows a beam of light striking a perspex block.



(i) Continue the paths of the rays AB and CD inside the perspex block.

(ii) Draw the wavefronts of the beam of light in the perspex.

(iii) Explain why the beam behaves in the way you have shown.

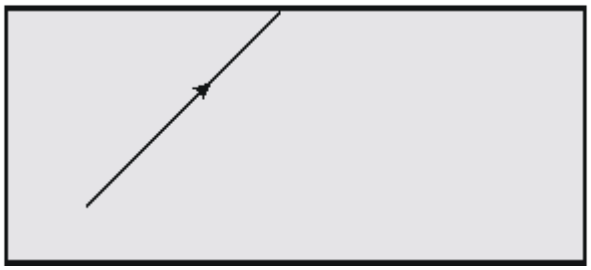
.....

.....

.....

(7)

(c) The diagram below shows a ray of light striking a perspex-air surface from inside the perspex. The critical angle is 45º.

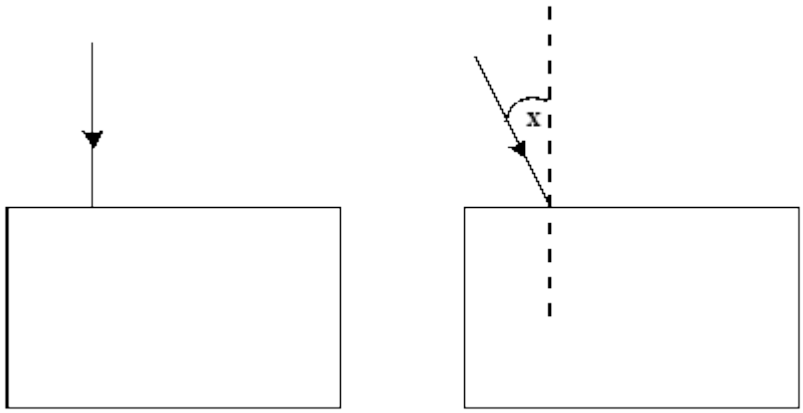


Draw the path of the ray after it reaches the perspex-air boundary.

(2)

(Total 13 marks)

27 (a) The diagrams show rays of light. Each ray strikes a surface of a glass block.

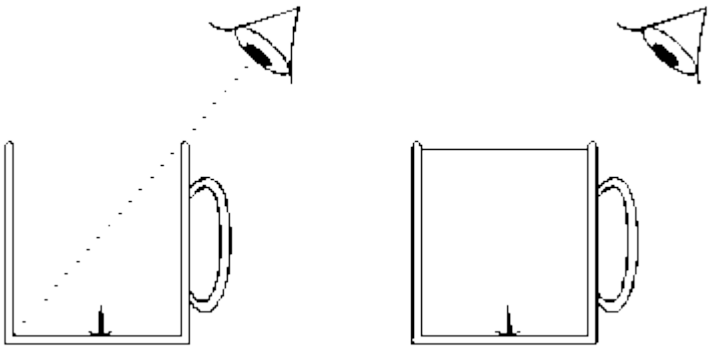


(i) On the diagram draw the path of each ray through the glass block and out into the air again.

(ii) Label another angle on the diagram which is equal to the angle marked **X**. Label this angle **Y**.

(4)

(b) The diagrams show two beakers. Both beakers have a drawing pin inside as shown.



The first beaker is empty. The eye cannot see the drawing pin.
The second beaker is full of water and the eye can see the drawing pin.

Explain how the eye is able to see the drawing pin in the second beaker. You may add to the diagram if it helps your answer.

.....

.....

.....

(3)
(Total 7 marks)

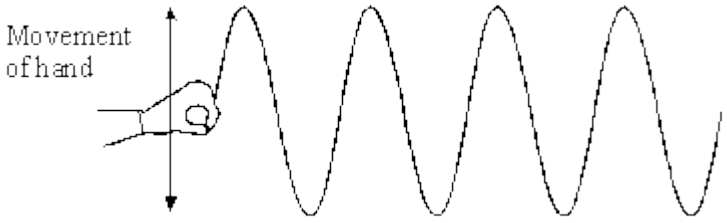
28 Lenses are used in many optical devices.

Complete the table below about the images formed by some optical devices.

OPTICAL DEVICE	NATURE OF IMAGE	SIZE OF IMAGE	POSITION OF IMAGE
Eye	real		
Projector		Magnified	
camera			Closer to lens than the object

(Total 6 marks)

29 The diagram shows a wave travelling along a rope.



(a) On the diagram:

(i) show the wavelength and label it **W**;

(ii) show the amplitude and label it **A**.

(2)

(b) The wavelength of the wave is 0. I m. Its frequency is 2 Hz.

Calculate the speed of the wave. Show clearly how you work out your answer and give the unit.

.....

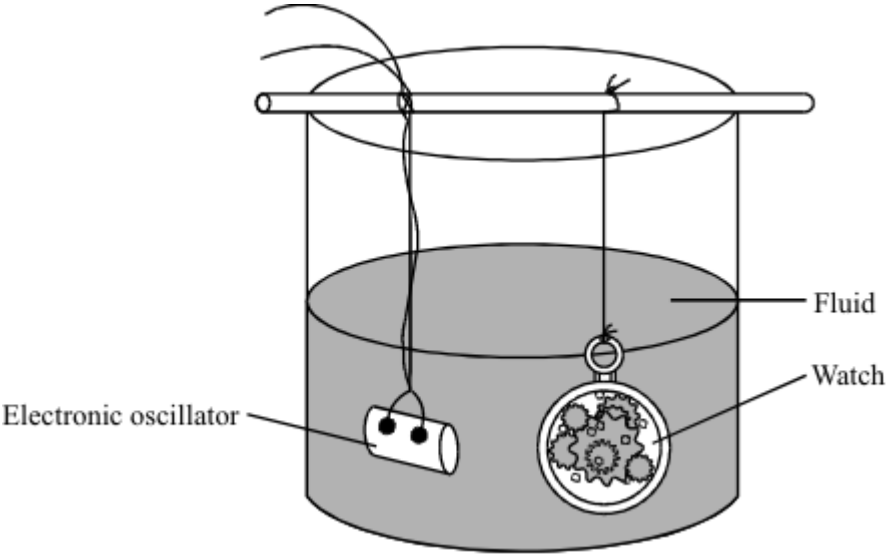
.....

.....

Speed of wave .....

(3)
(Total 5 marks)

30 The diagram shows how ultrasonic waves can be used to clean a watch.



Suggest how this method cleans the watch.

.....

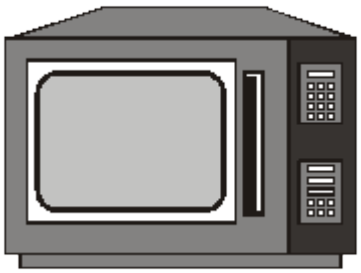
.....

.....

.....

(Total 2 marks)

31 Microwave ovens can be used to heat many types of food.



(i) Describe, in as much detail as you can, how microwaves heat food.

.....

.....

.....

.....

(2)

(ii) Microwaves have a frequency of 10 000 million Hz. Their wavelength is 0.03 m.

Calculate the speed of microwaves.

Show clearly how you work out your answer.

.....

.....

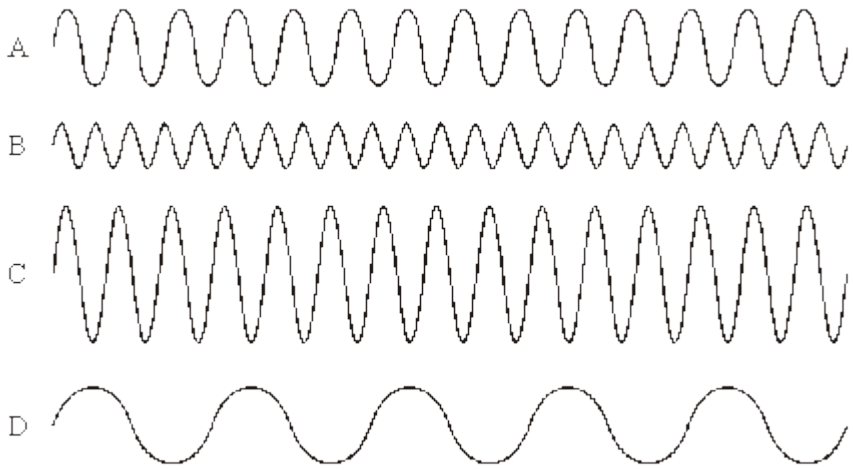
.....

Speed of microwaves..... m/s

(2)

(Total 4 marks)

32 The diagram shows oscilloscope traces of four waves, **A**, **B**, **C** and **D**. All four waves are drawn to the same scale.



Which wave has:

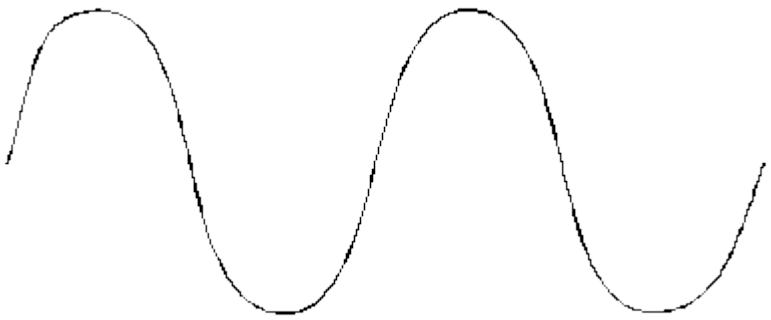
(a) the longest wavelength; .....

(b) the greatest amplitude; .....

(c) the highest frequency? .....

(Total 3 marks)

33 (a) On the wave drawn below, mark the amplitude and wavelength.



(2)

(b) A wave is said to have a frequency of 25 Hz.

Explain what the term *frequency* means.

.....

.....

.....

(1)

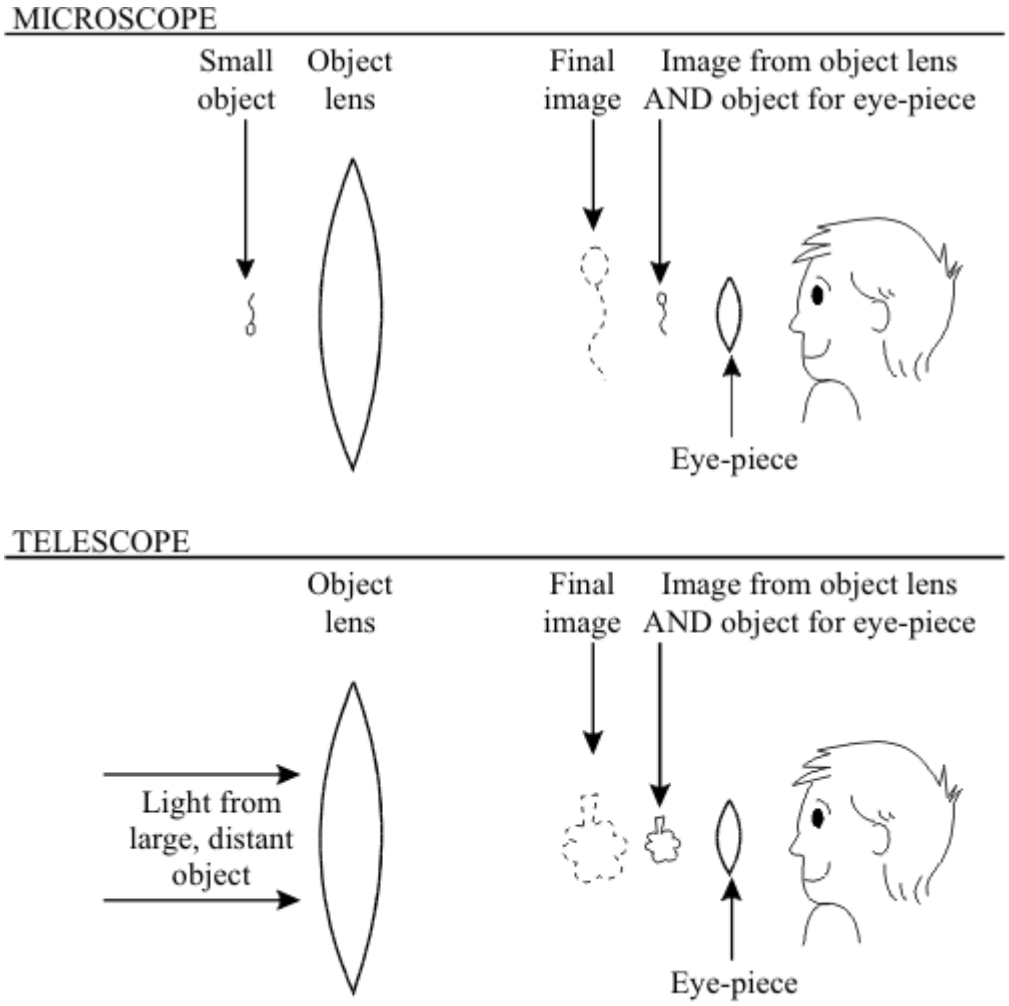
(c) From the electromagnetic spectrum, give the name and use of a radiation of lower frequency than light.

Name .....

Use .....

(2)
(Total 5 marks)

34 The diagrams show how the same two lenses can be used to make a microscope **or** a telescope.



The microscope and the telescope made from the two lenses are similar in some ways but different in others.

Complete the table to show these **similarities** and **differences**.

	Similarities	**Differences**
What the micro-scope and telescope are used for		
The job done by the eye-piece		
How the final image compares with the **original** object		

(Total 7 marks)

35 Explain fully why pregnant women should not normally have X-rays of the lower body.

.....

.....

.....

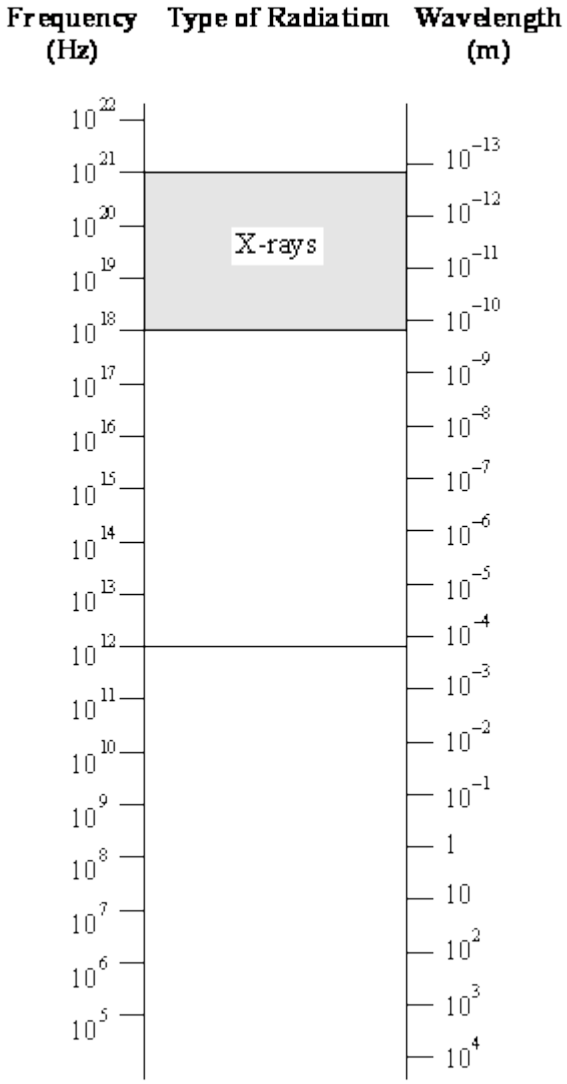
.....

.....

(Total 4 marks)

36 The diagram below shows the range of wavelengths and frequencies for all the types of radiation in the electromagnetic spectrum.

X–rays, which have frequencies in the range 10^{18}–10^{21} Hz are already marked on the diagram.



Complete the diagram by adding the following:

(a) *gamma* radiation, which has shorter wavelengths than X–rays;

(b) *radio* waves which have wavelengths longer than 0.1m;

(c) the *visible* spectrum which has wavelengths from 400 nm (violet) to 700 nm (red);

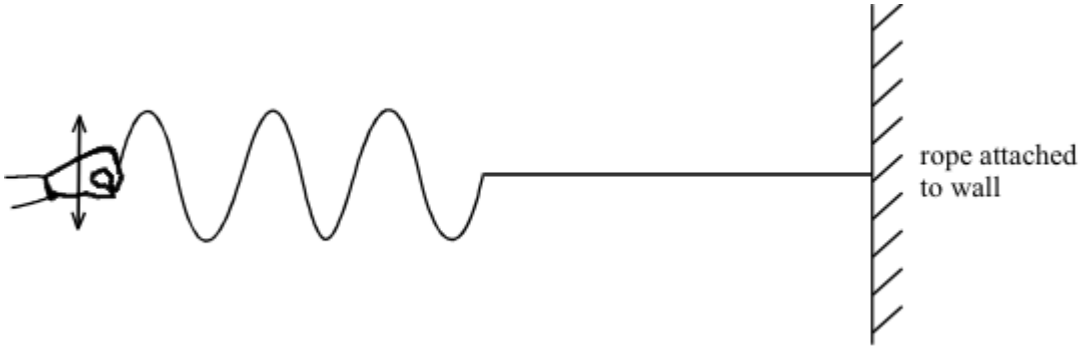
(d) *ultraviolet* radiation (i.e. radiation with a higher frequency than violet light);

(e) *microwaves* which have a shorter wavelength than radio waves and *infrared* radiation which has a higher frequency than microwaves;

(f) an *FM* radio programme on 92MHz. (Show this with an arrow ®)

(Total 7 marks)

37 The diagram shows some waves travelling along a rope.



(a) Show on the diagram

(i) the wavelength of one of the waves

(2)

(ii) the amplitude of one of the waves

(2)

(b) The waves shown on the diagram were produced in two seconds.

What is the frequency of the waves?

.....

(2)

(Total 6 marks)

Mark schemes

1 (a) magnification = $\frac{\text{image height}}{\text{object height}}$

1

dividing by an object height of 1 cm gives the same (numerical) value

1

(b) accept anything practical that would work eg:

use a taller object

use a (travelling) microscope

attach a scale to the screen and use a magnifying glass

1

(c) both points plotted correctly

1

correct line of best fit drawn

a curve passing through all points (within ½ square), judge by eye

1

(d) values of 1.4 and 0.6 extracted from the graph

1

2.33 times bigger

accept any number between 2.3 and 2.5 inclusive

1

(e) by dividing the distance between the lens and the image by the distance between the lens and the object

1

at least one correct calculation and comparison eg 100÷25 = 4 which is the same as the measured magnification

1

[9]

2

Level 3 (5–6 marks):
A detailed and coherent plan covering all the major steps is provided. The steps in the method are logically ordered. The method would lead to the production of valid results.

A source of inaccuracy is provided.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

place a glass block on a piece of paper

draw around the glass block and then remove from the paper

draw a line at 90° to one side of the block (the normal)

use a protractor to measure and then draw a line at an angle of 20° to the normal

replace the glass block

using a ray box and slit point the ray of light down the drawn line

mark the ray of light emerging from the block

remove the block and draw in the refracted ray

measure the angle of refraction with a protractor

repeat the procedure for a range of values of the angle of incidence

possible source of inaccuracy

the width of the light ray

which makes it difficult to judge where the centre of the ray is

[6]

3 (a) **Level 3 (5–6 marks):**
A detailed and coherent plan covering all the major steps is provided. The steps in the method are logically ordered. The method would lead to the production of valid results.

A source of inaccuracy is provided.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

place a glass block on a piece of paper

draw around the glass block and then remove from the paper

draw a line at 90° to one side of the block (the normal)

use a protractor to measure and then draw a line at an angle of 20° to the normal

replace the glass block

using a ray box and slit point the ray of light down the drawn line

mark the ray of light emerging from the block

remove the block and draw in the refracted ray

measure the angle of refraction with a protractor

repeat the procedure for a range of values of the angle of incidence

possible source of inaccuracy

the width of the light ray

which makes it difficult to judge where the centre of the ray is

6

(b) velocity / speed of the light decreases

allow velocity / speed of the light changes

1

[7]

4 (a) wavelength correctly shown

1

(b) (i) increased

1

decreased

1

(ii) 17-18 inclusive

1

evidence of measurement divided by 3 or mean of 3 separate measurements

1

mm

accept cm if consistent with answer

1

(c) (i) red shift

1

(ii) moving away

1

(iii) the furthest galaxies show the biggest red shift

1

(meaning that) the furthest galaxies are moving fastest

1

(so the) Universe is expanding

1

(extrapolating backwards this suggests that) the Universe started from an initial point

1

(iv) cosmic microwave background radiation

allow CMBR

1

[13]

5 (a) (i) infrared / *IR*

1

(ii) *UV / X-rays / gamma rays*

1

appropriate use corresponding with given wave:

dependent on first marking point

- UV: security marking ***or*** *tanning*
- X-rays: medical imaging ***or*** *checking baggage*
- gamma rays: sterilising surgical instruments ***or*** killing harmful bacteria in food

accept any sensible alternative uses

1

(b) D

1

gap must be comparable to wavelength

accept converse

1

can create gap of that size in classroom

dependent on first marking point

1

(c) (i) Q

1

(ii) sound waves reflected

accept 'it' for sound waves

ignore bounce

1

at EF

1

angle of incidence equal to angle of reflection

1

(iii) stop sound going direct from clock to ear

1

(iv) 22 (m)

*allow **1** mark for correct substitution, ie*

*330 = 15 × λ scores **1** mark*

2

(v) outside audible range

1

[14]

6 (a) (i) short sight

accept myopia

1

(ii) diverging

1

(b) light

1

(c) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1–2 marks)
There is a basic description of one advantage ***or*** disadvantage of using **either** of the methods

Level 2 (3–4 marks)
There is a *description* of some advantages **and / or** disadvantages of using **both** methods
or
a full, detailed description of the advantages and disadvantages of using **either** of the methods.

Level 3 (5–6 marks)
There is a *clear description* of the advantages and disadvantages of using **both** methods.

examples of the points made in the response
extra information

laser surgery

advantages:

- *appearance*
- *permanent effect*
- no glasses which need changing

disadvantages:

- risks associated with surgery
- large cost
- not able to drive etc straightaway
- (still) might need glasses for reading

wearing glasses

advantages:

- able to function straightaway
- any problems easy to sort out

disadvantages:

- *easily broken*
- *easily lost*
- need changing
- overall cost might be greater if several changes in vision
- might eventually need two pairs of glasses

6

(d) move lens

1

closer to film

1

[11]

7

(a) (sound waves) which have a frequency higher than the upper limit of hearing for humans
or
a (sound) wave (of frequency) above 20 000 Hz

sound waves that cannot be heard is insufficient

a wave of frequency 20 000 Hz is insufficient

1

(b) 640

*an answer of 1280 gains **2** marks*

*allow **2** marks for the correct substitution*

ie 1600 × 0.40 provided no subsequent step

*allow **2** marks for the substitution* $\frac{1600 \times 0.80}{2}$

provided no subsequent step

*allow **1** mark for the substitution 1600 × 0.80 provided no subsequent step*

*allow **1** mark for the identification that time (boat to bed) is 0.4*

3

(c) any **one** from:

- pre-natal scanning / imaging
- imaging of a named organ (that is not surrounded by bone), eg stomach, bladder, testicles

  accept heart

  *do **not** allow brain **or** lungs (either of these negates a correct answer)*
- Doppler scanning blood flow

1

(d) advantage

any **one** from:

- (images are) high quality or detailed or high resolution

  clearer / better image is sufficient
- (scan) produces a slice through the body
- image can be viewed from any direction

  allow images are (always) 3D / 360°
- an image can be made of <u>any</u> part (inside the body)

  allow whole body can be scanned
- easier to diagnose **or** see a problem (on the image)

1

disadvantage

any **one** from:

- (the X-rays used **or** scans) are <u>ionising</u>

  allow a description of what ionising is
- mutate cells **or** cause mutations **or** increase chances of mutations

  allow for cells:

  DNA / genes / chromosomes / nucleus / tissue

- turn cells cancerous **or** produce abnormal growths **or** produce rapidly growing cells
- kill cells

  damage cells is insufficient
- shielding is needed

  can be dangerous (to human health) unqualified, is insufficient

1

[7]

8 (a) the oscillation / vibration (causing the wave)

a movement causes the wave is insufficient

1

for a transverse wave is perpendicular to the direction of energy transfer

accept direction of wave travel

1

and for a longitudinal wave is parallel to the direction of energy transfer

accept direction of wave travel

*if no marks awarded allow **1** mark for correctly linking perpendicular with transverse and parallel with longitudinal*

the marks may be scored by the drawing of two correctly labelled diagrams

1

(b) for radio waves:

accept converse for each mark

are transverse

1

travel at speed of light / higher speed

1

have greater frequencies

1

can travel through vacuum

*accept sound waves are not electromagnetic for **1** mark*

1

[7]

9 (a) (i) magnified

1

upright

1

(ii) v = −6(cm)

*max **2** marks if no minus sign*

*6(cm) gains **2** marks*

1/v = 1/12 − 1/4 = −1/6
*gains **2** marks*

1/12 = 1/4 + 1/v
*gains **1** mark*

−5.99(cm)
*using decimals gains **3** marks*

3

(b) it is <u>virtual</u>

1

[6]

10 (a) (i) perpendicular

accept correct description 1

1

(ii) light off – no / slow rotation

1

light on – fast(er) rotation

accept starts rotating

ignore references to energy transfers

1

(b) one ray drawn from wrist watch and reflected by mirror

accept solid or dashed lines

1

two rays drawn from wrist watch and reflected by mirror with i = r for both rays

judge angles by eye

1

one ray traced back behind mirror

accept solid or dashed lines

1

image in correct position

judged by eye

accept image marked where two reflected rays traced back cross behind the mirror

1

(c) cannot be formed on a screen

accept image formed behind the mirror

or

rays of light seem to come from it but do not pass through it

1

[8]

11 (a) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a 'best-fit' approach to the marking.

0 marks
No relevant / correct content.

Level 1 (1-2 marks)
There is a basic description of either wave
OR
What happens to either wave when they enter the body. However there is little other detail.

Level 2 (3-4 marks)
There is either:
A clear description of BOTH waves
OR
A clear description as to what happens to BOTH waves inside the body
OR
A clear description of ONE of the waves with clear detail as to what happens to either wave inside the body.

Level 3 (5-6 marks)
There is a detailed description of BOTH of the waves
AND
A detailed description as to what happens to EITHER wave inside the body.

Examples of the points made in the response:

Description of an X-ray

- X-rays are electromagnetic waves / part of the electromagnetic spectrum
  *do **not** allow a description of a property – eg X-rays travel*
- X-rays are (very) high frequency (waves)
  through a vacuum / at the speed of light
- X-rays are (very) high energy (waves)
- X-rays have a (very) short wavelength
- Wavelength (of X-rays) is of a similar size to (the diameter of) an atom
- X-rays are a transverse wave
  correct description acceptable – oscillations / vibrations are perpendicular (at 90°) to direction of energy transfer
- X-rays are ionising radiation

Description of ultrasound

- ultrasound has a frequency above 20 000 (hertz)

  or

  ultra sound is above 20 000 hertz
- ultrasound is above / beyond the human (upper) limit (of hearing)
  accept ultrasound cannot be heard by humans
- ultrasound is a longitudinal wave
  correct description acceptable – oscillations / vibrations (of particles) are parallel (in same direction) to direction of energy transfer

Statement(s) as to what happens to X-rays inside the human body:

- X-rays are absorbed by bone
- X-rays travel through / are transmitted by tissue / skin

Statement as to what happens to ultrasound inside body:

- ultrasound is (partially) reflected at / when it meets a boundary between two different media
- travel at different speeds through different media

(b) (because the X-rays) are ionising

accept a description of what ionising is

1

(they will) damage cells

instead of cell, any of these words can be used:

DNA / genes / chromosomes / nucleus

or

mutate cells / cause mutations / increase chances of mutations

or

turn cells cancerous / produce abnormal growths / produce rapidly growing cells

*do **not** accept they can be dangerous (to human health)*

*do **not** accept damage to soft tissue*

or

kill cells

1

(c) any **one** from:

- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  *accept curing prostate cancer **or** killing prostate cancer cells*
- removing plaque from teeth

  cleaning teeth is insufficient

1

[9]

12 (a) any **two** correct construction lines:

if more than 2 construction lines treat as a list

2

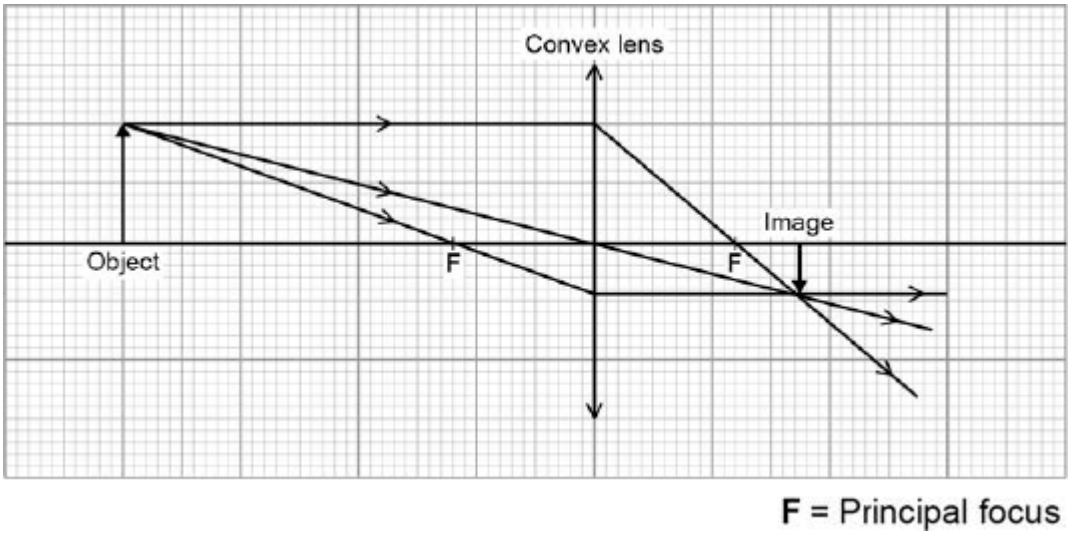
- line passing straight through centre of lens (& out other side)
- line travelling parallel to principal axis & then being refracted through principal focus (on RHS)
- line travelling through principal focus (on LHS) & then being refracted to be parallel to principal axis (on RHS)

inverted image drawn (with arrow) in correct location

1

one arrowhead from object to image on any construction ray

conflicting arrowheads negate this mark



1

(b) any **two** from:

- inverted

  accept upside down

- real

- diminished / smaller

  *allow ecf if ray diagram wrongly drawn but descriptions must relate to **their image***

  a converse negates mark, eg real and virtual scores zero

2

[6]

13 (a) (both graphs show an initial) increase in count rate

accept both show an increase

1

(b) only the right kidney is working correctly

1

any **two** from:

*if incorrect box chosen maximum of **1** mark can be awarded*

reference to named kidney can be inferred from the tick box

- count-rate / level / line for right kidney decreases (rapidly)

  it decreases is insufficient

- count-rate / level / line for left kidney does not change

  it does not change is insufficient

- radiation is being passed out into urine – if referring to right kidney
- radiation is not being passed out – if referring to the left kidney
- left kidney does not initially absorb as much technetium-99

2

[4]

14 (a) (i) answer in the range 3.0 ↔ 3.1 inclusive

*accept for **1** mark*

3.6 ÷ 1.2 or 3.7 ÷ 1.2

***or** 36 ÷ 12 or 37 ÷ 12*

***or** 18 ÷ 6 or 18.5 ÷ 6*

***or** 10.2 ÷ 3.4 or 102 ÷ 34*

***or** answer in the range but with a unit eg 3 cm*

2

(ii) (principal) focus / focal (point(s)) / foci / focus

accept 'focusses'

accept focals

*do **not** accept focal length*

1

(iii) at the intersection of virtual / imaginary rays

***or** 'where virtual / imaginary rays cross'*

***or** the rays of (real) light do not cross*

***or** the image on the same side (of the lens) as the object*

***or** the image is drawn as a dotted line*

***or** the image is upright*

*do **not** accept 'cannot be put on a screen'*

*do **not** accept any response which refers to reflected rays*

1

(b) (i) another correct observation about relationship between values of **d**

example

15 is three times bigger than 5 but

1

(but) not the relationship between corresponding values for magnification

2.0 is not three times bigger than 1.2

1

(ii) when the distance / **d** increases the magnification increases

or *the converse*

accept 'there is a positive correlation'

*do **not** accept any response in terms of proportion / inverse proportion*

1

(iii) (student has) no evidence (outside this range)

accept data / results / facts for 'evidence'

1

[8]

15 (a) higher frequency

general properties / uses are neutral

or

shorter wavelength

*do **not** accept different frequency / wavelength / energy*

or

greater energy

1

(b) the same (speed)

accept they travel at the speed of light

1

(c) pass through / transmitted by the plastic / casing

1

reflected by the metal / plates

*do **not** accept bounce / deflected etc for reflected*

*if neither marking point scores an answer reflected (back to boat / from the device) scores **1** mark*

1

(d) (i) waves are not reflected from the walls

accept microwaves / radar for waves

*do **not** accept bounce / deflected etc for reflected*

or

only waves (reflected) from the device are detected

accept to stop reflected waves affecting results

1

(ii) different types (of device) can be compared

fair test is insufficient

accept idea that only one variable is then changed

1

(iii) so (measurements / results / scientists) are not biased towards one type / manufacturer of device/s

accept to avoid bias

accept so they are not biased

1

(e) (i) any **two** from:

*if temperature is mentioned rather than angle a maximum of **1** mark can be scored*

- (for any angle) **A** values < **B** values

  ***or** converse eg **B** values are higher / better / stronger*

- **A** values increase with (increasing) angle

  accept weakest at 0° strongest at 15°

  values go up is insufficient

- **B** values decrease with (increasing) angle

  accept strongest at 0° weakest at 15°

  values go down is insufficient

- **A** values do not vary as much (as **B** values)

2

(ii) **D**

mark is for the reason

*reason cannot score if **D** is not chosen*

values are always over 2(.0)

1

[10]

16 1.4

*allow **1** mark for correct substitution*

ie 14 ÷ 10

or

28 ÷ 20

[2]

17 (a) converging (lens)

accept 'con vex (lens)'

accept biconvex

1

(b) (principal) foci

accept 'focus' / 'focuses' / 'focis'

focal point(s)

1

(c) (i) formed where (real) rays (of light) intersect / meet / cross

accept rays (of light) pass through the image

accept 'image is on the opposite side (of the lens to the object)'

accept (construction) lines cross over

a response relating to a screen or similar is neutral

lines are solid and not dotted is neutral

1

(ii) inverted

accept any unambiguous correct indication

1

(d) (i) smooth curve which matches the points

*judge by eye but do **not** accept point to point by ruler or otherwise*

1

(ii) continuous

1

(iii) as distance increases, magnification decreases

accept negative correlation

*a statement 'inversely proportional' is incorrect and limits maximum mark for this part question to **1***

1

further detail eg magnification falls steeply between 40 and 50 cm
or
magnification begins to level out after / at 70 cm

1

[8]

18 (a) (i) microwaves

1

(ii) can pass through the ionosphere

accept travels in a straight line

accept atmosphere for ionosphere

*do **not** accept air for ionosphere*

1

(b) higher the frequency, further the wave travels
(into the atmosphere before reflection)

1

(c) 15 000

*allow **1** mark for correct transformation and substitution*

ie $\frac{300\,000\,000}{20}$

*an answer of 15 000 000 only gains **1** mark*

allow both marks for an answer of 15 MHz (unit must be changed)

an answer of 15 gains no credit

2

[5]

19 (a) (i) answer in the range 3.0 ↔ 3.1 inclusive

accept for 1

3.6 ÷ 1.2 or 3.7 ÷ 1.2

or 36 ÷ 12 or 37 ÷ 12

or 18 ÷ 6 or 18.5 ÷ 6

or 10.2 ÷ 3.4 or 102 ÷ 34

or answer in the range but with a unit eg 3 cm

2

(ii) (principal) focus / focal (point(s)) / foci / focus

accept 'focusses'

accept focals

*do **not** accept focal length*

1

(iii) at the intersection of virtual / imaginary rays

***or** 'where virtual / imaginary rays cross'*

***or** the rays of (real) light do not cross*

***or** the image on the same side (of the lens) as the object*

***or** the image is drawn as a dotted line*

***or** the image is upright*

*do **not** accept 'cannot be put on a screen'*

*do **not** accept any response which refers to reflected rays*

1

(b) (i) another correct observation about relationship between values of **d** (1)

(but) not the same relationship between corresponding values for magnification (1)

example

15 is three times bigger than 5 but

2.0 is not three times bigger than 1.2

2

(ii) when the distance / **d** increases the magnification increases

or *the converse*

accept 'there is a (strong) positive correlation'

*do **not** accept any response in terms of proportion / inverse proportion*

1

(iii) (student has) no evidence (outside this range)

accept data / results / facts for 'evidence'

1

[8]

20 (a) (i) shorter than

1

(ii) increase slightly

1

(b) (i) go up in the same ratio
or (directly) proportional **or** as speed (of the tennis ball) increases so does the (difference in) frequency

accept as one goes up, so does the other

accept positive correlation

1

(ii) 20 (m/s)

*allow **1** mark for showing correct method on graph*
(ie horizontal or vertical line anywhere on graph)

if indicated by a cross, must be ± half square of correct value)

2

(iii) frequency and speed are both continuous variables

1

[6]

21 (a) (i) compare (the health of) mobile phone users with non-mobile phone users

must be an implied comparison between users and non-users

any idea of doing an experiment negates the mark

1

(ii) increase the sample size

accept use more people
accept have a large sample size
repeat the research / test is neutral

1

(iii) ethical

1

(b) (i) so the phones can be compared (fairly)

a fair test is insufficient
accept different tests (may) give different results

*do **not** accept to make the results reliable, unless qualified*
eg all variables are controlled
*do **not** accept bias unless qualified*

1

(ii) yes all are below the legal limit / 2 (W/kg)

or no and any **one** from:

- even absorbing a small amount of energy may be harmful
  accept microwaves for energy
  accept emits energy absorbed by head / other parts of body

- no proof that small amounts of energy are not harmful
  accept because the SAR value is not 0 (W/kg)

1

(c) any **one** from:

- to get an independent opinion

- company scientists may be biased
  accept company scientists may manipulate results

1

[6]

22 (a) the <u>normal</u>

1

(b) v

1

(c) any **one** from:

- light has moved from glass to air / from air to glass

  accept light has changed medium

- speed of light has changed

  beware of contradictions for this marking point eg light has moved from glass to air and slowed down gets zero

- angle of incidence is less than the critical angle

  ***or** (angle) i < (angle) c **or** (angle) y is less than the critical angle*

- change in density (of medium)

  eg glass is more (optically) dense than air

1

(d) (i) ratio of v to y does not give the same answer (in every case)

or value of v doubles value of y does not double

1

or increments for v are the same but increments for y are not the same

*allow for **1** mark a calculation but no conclusion*
eg 30 → 60 19 → 35 (38)

1

(ii) as (angle) v increases, angle y increases

accept as the angle of incidence increases, the angle of refraction increases

***or** there is a (strong) positive(non-linear) relationship between the variables*

***or** ratio of sines is constant*

*do **not** accept angle y is not directly proportional to angle v*

1

(iii) no evidence outside this range

OWTTE

or when angle y is greater than the critical angle total internal reflection occurs

1

[7]

23 (a) (i) (angle of) refraction

*take care **not** to credit 'angle of reflection'*

1

(ii) normal

*do **not** credit 'horizontal'*

1

(b) **either**

(photographic) film

or CCD(s) (charge-coupled device(s)) / CMOS(s) (sensor(s)) / (active) pixel sensor(s)

accept 'LDR(s)' / 'light dependent resistor(s)'

***not** lux meter*

*do **not** accept light sensor(s)*

1

(c) (i) converging

***or** 'convex'*

1

(ii) **either**

(0).35

or (0).4(1...)

*do **not** give any credit for an answer greater than 1*

or

*7 ÷ 20 for **1** mark*

or

*clear evidence that appropriate measuring / counting, has been made for **1** mark*

2

(d) otherwise it will have no effect on the light detector

or otherwise no (real) light will fall on the light detector

***or** 'a virtual / imaginary image will have no effect on the light detector'*

allow error carried forwards for 'light detector'

allow so it can be formed on the film

1

[7]

24 silver is a (good) reflector of heat (radiation) **or**
silver reflects the heat (radiation)

fact
heat = infra red
ignore references to light
accept shiny for silver
good radiator negates the mark
ignore references to good conductor
*do **not** accept bounce back*

1

less heat is lost through the board **or** more heat is retained by the shirt

explanation
accept both sides of shirt heated
*reflects heat back up gets **1** mark only*
ignore mention of friction

1

[2]

25 (i) X-rays or gamma rays

for 1 mark

1

(ii) passes through flesh;
stopped by bone/absorbed

for 1 mark each

2

[3]

26 (a) Reflection correct
Normal incidence correct in and out
Correct refraction in
Parallel ray out

each for 1 mark

4

(b) (i) Each ray correctly refracted in

1 + 1 = 2

7

(ii) Wavefronts perp sides
Wavefronts closer

(Cannot score wavefront marks if refracted rays clearly wrong)

(iii) Speed reduces
Starting at B
Then D

each for 1 mark

(c) TIR correct

gets 2 marks

Else rough reflection

gets 1 mark

2

[13]

27 (a) (i) Ignore arrows on rays
perpendicular rays goes straight in and out
other ray refracts towards normal (not along)
emerges parallel incident ray (by sight) if refraction correct (ignore reflections)

for 1 mark each

3

(ii) emergent angle marked Y if emerges parallel to right of normal

for 1 mark

1

(b) straight ray to water surface refracts/bends
straight to eye/towards surface on right image correctly shown
or states the same mark prose only of diagram incomplete

any 3 for 1 mark each

3

[7]

28 **Eye –** Diminished/smaller than object
Nearer the lens than object or on the retina

for 1 mark each

2

Projector – real
Further from lens than object

for 1 mark each

2

Camera – real
Smaller (than object)

for 1 mark each

2

[6]

29 (a) any two successive peaks labelled **W**

accept any 2 points on same part of adjacent waves
correct by eye

1

half 'height' of wave labelled **A**

correct by eye
N.B. at least one of the answers must be labelled

1

(b) 0.2

correct answer with no working = 2
allow 1 mark for s = f x w or correct working i.e., 2 × 0.1
N.B. correct answer from incorrectly recalled relationship = 0

2

m/s (unit)

*independent mark do **not** allow mps **or** mHz*

1

[5]

30 (ultrasonic) waves **or** vibrations **or** oscillations in fluid

*N.B. must mention fluid **or** liquid **or** water*

1

idea of shaking dirt particles off watch

allow cavitation / implosion of small bubbles

1

[2]

31 (i) absorbed by water / water heated

1

hot water heats (rest of) food / idea of particle vibration

1

(ii) 300 000 000 / 3×10^8

correct answer with no working = 2
*allow 1 mark for s = f x w **or** correct working i.e., 10000 (000000) × 0.03*
N.B. correct answer from incorrectly recalled relationship / substitution = 0

2

[4]

32 (a) **D**

1

(b) **C**

1

(c) **B**

1

[3]

33 (a) amplitude marked as approximately half a wave height

great precision is not required

1

wavelength marked as a trough to trough distance **or** a peak to peak distance

accept an equivalent repeat distance anywhere on the wave

1

(b) the number of waves each second

accept cycles per second accept 25 waves pass each second

1

(c) any **pair** from

microwave	cooking **or** communication **or** mobile phone
radio	communication **or** entertainment
infra-red	cooking **or** heating **or** remote control **or** security **or** night sights **or** thermal imaging

accept sensible specific uses

2

[5]

34 makes things look bigger/clearer/nearer M used for small objects;
or to see things better T used for distant objects

magnifies **or** makes it bigger

'it' = image of object; bigger for M;
inverted/upsidedown/ other way up smaller for T

any seven for 1 mark each

[7]

35 *idea that* X-rays cause mutations

gains 1 mark

but X-rays can cause/increase chance of mutations

gains 2 marks

mutations usually harmful/produce abnormal growth
serious effect on growing foetus/rapidly growing cells

each for 1 mark

[4]

36 (a) gamma rays above x-rays

for 1 mark

(b) upper radio wave boundary correct (10^{-1}m) (± 1mm)

for 1 mark

(c) visible radiation/light

- within the middle third of a wavelength band
- in the correct wavelength range (10^{-6} – 10^{-7}m)

each for 1 mark

(d) ultraviolet between *visible radiation and X-rays

for 1 mark

(e) microwaves above *radio waves and below *infra red
(*not necessarily immediately)

for 1 mark

(f) between 10^{8}Hz + 10^{7}Hz and nearer to 10^{8}Hz than to 10^{7}Hz

gains 1 mark

[7]

37 (a) (i) a horizontal distance indicated and labelled

gains 1 mark

but
horizontal distance indicated between identical points on adjacent waves (to within 3-4mm) and labelled

gains 2 marks

2

(ii) peak ↔ trough indicated*

gains 1 mark

but
peak / trough ↔ mean indicated*

(to within 1-2mm either end)*

gains 2 marks
(allow 1 mark if both lines unlabelled or 2 marks if both lines accurately drawn and unlabelled)

2

(b) • 1.5

• hertz / Hz **or** (waves / cycles) per second

for 1 mark each
(do not allow wavelength / hertz per second)

2

[6]