1 Different parts of the electromagnetic spectrum have different uses.

(a) The diagram shows the electromagnetic spectrum.

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

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

amplitude	**frequency**	**speed**	**wavelength**

The arrow in the diagram is in the direction of increasing .....

and decreasing ..... .

(2)

(ii) Draw a ring around the correct answer to complete the sentence.

The range of wavelengths for waves in the electromagnetic spectrum is approximately

- 10^{-15} to 10^{4}
- 10^{-4} to 10^{4}
- 10^{4} to 10^{15}

metres.

(1)

(b) The wavelength of a radio wave is 1500 m.
The speed of radio waves is 3.0×10^{8} m / s.

Calculate the frequency of the radio wave.

Give the unit.

.....

.....

.....

Frequency = ...

(3)

(c) (i) State **one** hazard of exposure to infrared radiation.

.....

(1)

(ii) State **one** hazard of exposure to ultraviolet radiation.

.....

(1)

(d) X-rays are used in hospitals for computed tomography (CT) scans.

(i) State **one** other medical use for X-rays.

.....

.....

(1)

(ii) State a property of X-rays that makes them suitable for your answer in part **(d)(i)**.

.....

.....

(1)

(iii) The scientific unit of measurement used to measure the dose received from radiations, such as X-rays or background radiation, is the millisievert (mSv).

The table shows the X-ray dose resulting from CT scans of various parts of the body.

The table also shows the time it would take to get the same dose from background radiation.

Part of the body	**X-ray dose in mSv**	**Time it would take to get the same dose from background radiation**
Abdomen	9.0	3 years
Sinuses	0.5	2 months
Spine	4.0	16 months

A student suggests that the X-ray dose and the time it would take to get the same dose from background radiation are directly proportional.

Use calculations to test this suggestion and state your conclusion.

.....

.....

.....

.....

.....

.....

.....

.....

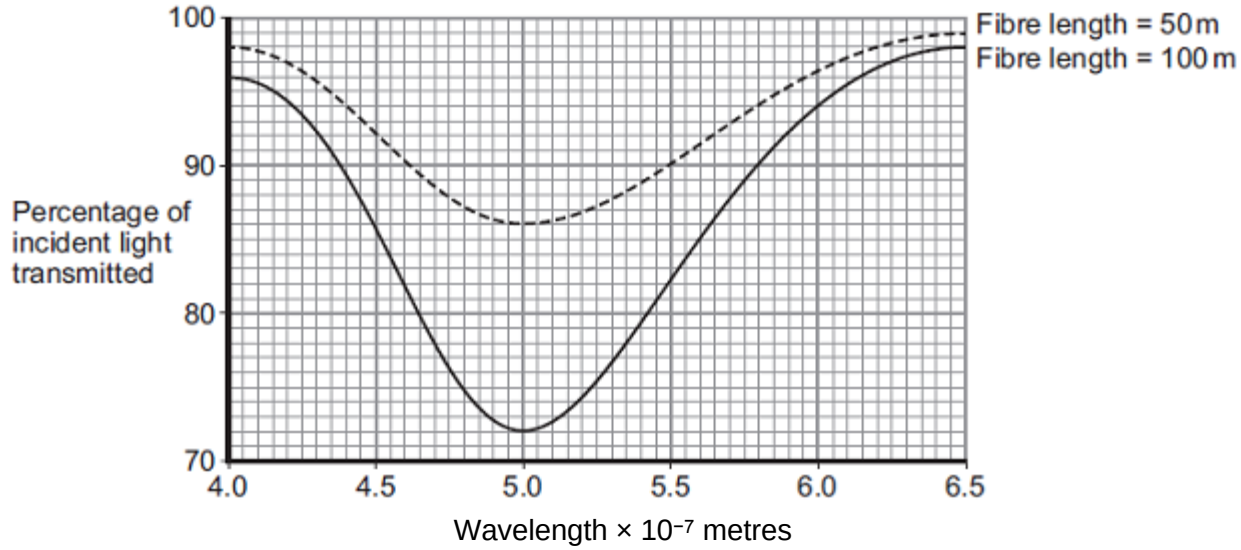
.....

.....

(3)
(Total 13 marks)

2 Different wavelengths of light can be used to transmit information along optical fibres.

The graph below shows how the percentage of incident light transmitted through a fibre varies with the wavelength of light and the length of the fibre.



Compare the percentages of incident light transmitted through the two different fibres over the range of wavelengths shown.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total 3 marks)

3 (a) Electromagnetic waves form a continuous spectrum with a range of wavelengths.

What is the approximate range of wavelengths of electromagnetic waves?

Tick (✓) **one** box.

10^{-15} metres to 10^{4} metres ☐

10^{-4} metres to 10^{15} metres ☐

10^{-6} metres to 10^{6} metres ☐

(1)

(b) Infrared waves and microwaves are used for communications.

(i) Give **one** example of infrared waves being used for communication.

.....

.....

(1)

(ii) A mobile phone network uses microwaves to transmit signals through the air. The microwaves have a frequency of 1.8×10^{9} Hz and travel at a speed of 3.0×10^{8} m/s.

Calculate the wavelength of the microwaves.

Give your answer to **two** significant figures.

.....

.....

.....

Wavelength = ... m

(3)

(c) Some scientists suggest there is a possible link between using a mobile phone and male fertility.

The results of their study are given in the table.

Mobile phone use in hours per day	Sperm count in millions of sperm cells per cm^3 of semen
0	86
less than 2	69
2 – 4	59
more than 4	50

The results show a negative correlation: the more hours a mobile phone is used each day, the lower the sperm count. However, the results do **not** necessarily mean using a mobile phone causes the reduced sperm count.

Suggest **one** reason why.

.....

.....

(1)

(Total 6 marks)

4 Galaxies emit all types of electromagnetic wave.

(a) (i) Which type of electromagnetic wave has the shortest wavelength?

.....

(1)

(ii) State **one** difference between an ultraviolet wave and a visible light wave.

.....

.....

(1)

(b) Electromagnetic waves travel through space at a speed of 3.0×10^8 m/s.

The radio waves emitted from a distant galaxy have a wavelength of 25 metres.

Calculate the frequency of the radio waves emitted from the galaxy and give the unit.

.....

.....

.....

Frequency = ...

(3)

(c) Scientists use a radio telescope to measure the wavelength of the radio waves emitted from the galaxy in part (b) as the waves reach the Earth. The scientists measure the wavelength as 25.2 metres. The effect causing this observed increase in wavelength is called red-shift.

(i) The waves emitted from most galaxies show red-shift.

What does red-shift tell scientists about the direction most galaxies are moving?

.....

.....

(1)

(ii) The size of the red-shift is **not** the same for all galaxies.

What information can scientists find out about a galaxy when they measure the size of the red-shift the galaxy produces?

.....

.....

.....

.....

(2)

(iii) What does the observation of red-shift suggest is happening to the Universe?

.....

.....

(1)

(Total 9 marks)

5 (a) The wavelengths of four different types of electromagnetic wave, including visible light waves, are given in the table.

Type of wave	Wavelength
Visible light	0.0005 mm
A	1.1 km
B	100 mm
C	0.18 mm

Which of the waves, **A**, **B**, or **C**, is an infra red wave?

.....

(1)

(b) A TV station broadcasts at 500 000 kHz. The waves travel through the air at 300 000 000 m/s.

Calculate the wavelength of the waves broadcast by this station.

Show clearly how you work out your answer.

.....

.....

Wavelength = ... m

(2)

(c) What happens when a metal aerial absorbs radio waves?

.....

.....

.....

.....

(2)

(d) Stars emit all types of electromagnetic waves. Telescopes that monitor X-rays are mounted on satellites in space.

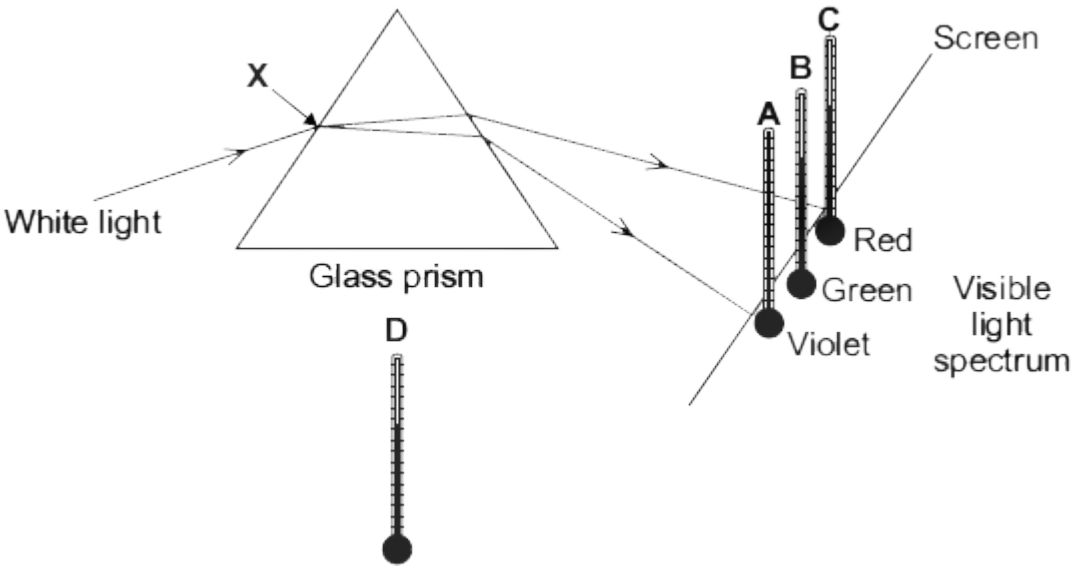
Why would an X-ray telescope based on Earth **not** be able to detect X-rays emitted from distant stars?

.....

.....

(1)
(Total 6 marks)

6 The diagram shows the apparatus that a student used to investigate the heating effect of different wavelengths of light.



(a) (i) The student put thermometer **D** outside of the light spectrum.

Suggest why.

.....

.....

(1)

(ii) The table gives the position and reading of each thermometer 10 minutes after the investigation started.

Thermometer	Position of thermometer	Temperature in °C
A	in violet light	21
B	in green light	22
C	in red light	24
D	outside the spectrum	20

What should the student conclude from the data in the table?

.....

.....

.....

.....

(2)

(b) A similar investigation completed in 1800 by the scientist Sir William Herschel led to the discovery of infrared radiation.

Suggest how the student could show that the spectrum produced by the glass prism has an infrared region.

.....

.....

.....

.....

(2)

(c) A person emits infrared radiation at a frequency of 3.2×10^{13} Hz.

Calculate the wavelength of the infrared radiation that a person emits.

Take the speed of infrared radiation to be 3.0×10^{8} m/s.

Show clearly how you work out your answer.

.....

.....

.....

.....

Wavelength = ... m

(2)

(d) A thermal imaging camera detects infrared radiation. Electronic circuits inside the camera produce a visible image of the object emitting the infrared radiation.

At night, police officers use thermal imaging cameras to track criminals running away from crime scenes.

Thermal imaging cameras work better at night than during the day.

Explain why.

.....

.....

.....

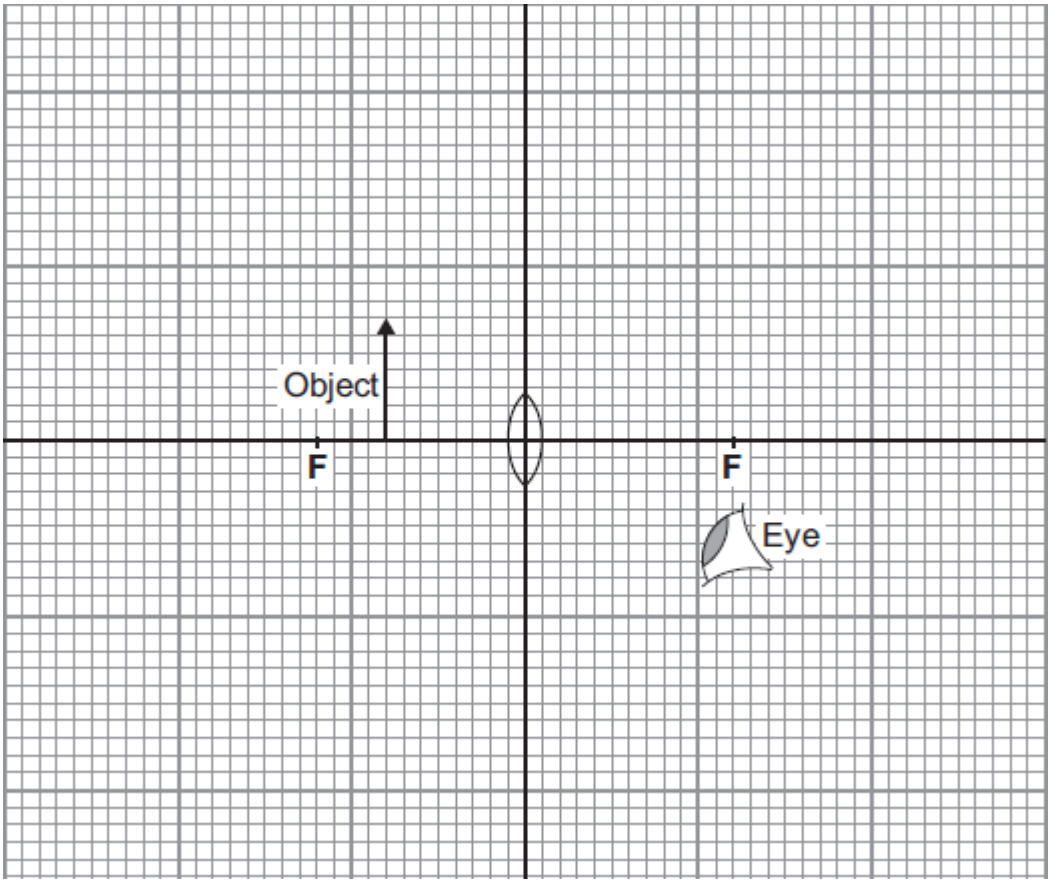
.....

(2)

(Total 9 marks)

7 (a) The diagram shows a converging lens being used as a magnifying glass.

(i) On the diagram, use a ruler to draw two rays from the top of the object which show how and where the image is formed. Represent the image by an arrow drawn at the correct position.



(3)

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

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

Show clearly how you work out your answer.

.....

.....

Magnification = ...

(2)

(b) A camera also uses a converging lens to form an image.

Describe how the image formed by the lens in a camera is different from the image formed by a lens used as a magnifying glass.

.....

.....

.....

.....

(2)
(Total 7 marks)

8 Radio waves and microwaves are two types of electromagnetic wave.

Both waves:

- can be used for communications
- travel at the same speed through air.

(a) Give **two** more properties that are the same for both radio waves and microwaves.

1 .....

.....

2 .....

.....

(2)

(b) Some satellites are used to transmit television programmes. Signals are sent to, and transmitted from, the satellites using microwaves.

What is the property of microwaves that allows them to be used for satellite communications?

.....

.....

(1)

(c) Electromagnetic waves travel at a speed of 3.0×10^8 m/s.

A radio station transmits waves with a wavelength of 2.5×10^2 m.

Calculate the frequency of the radio waves.

Show clearly how you work out your answer and give the unit.

.....

.....

.....

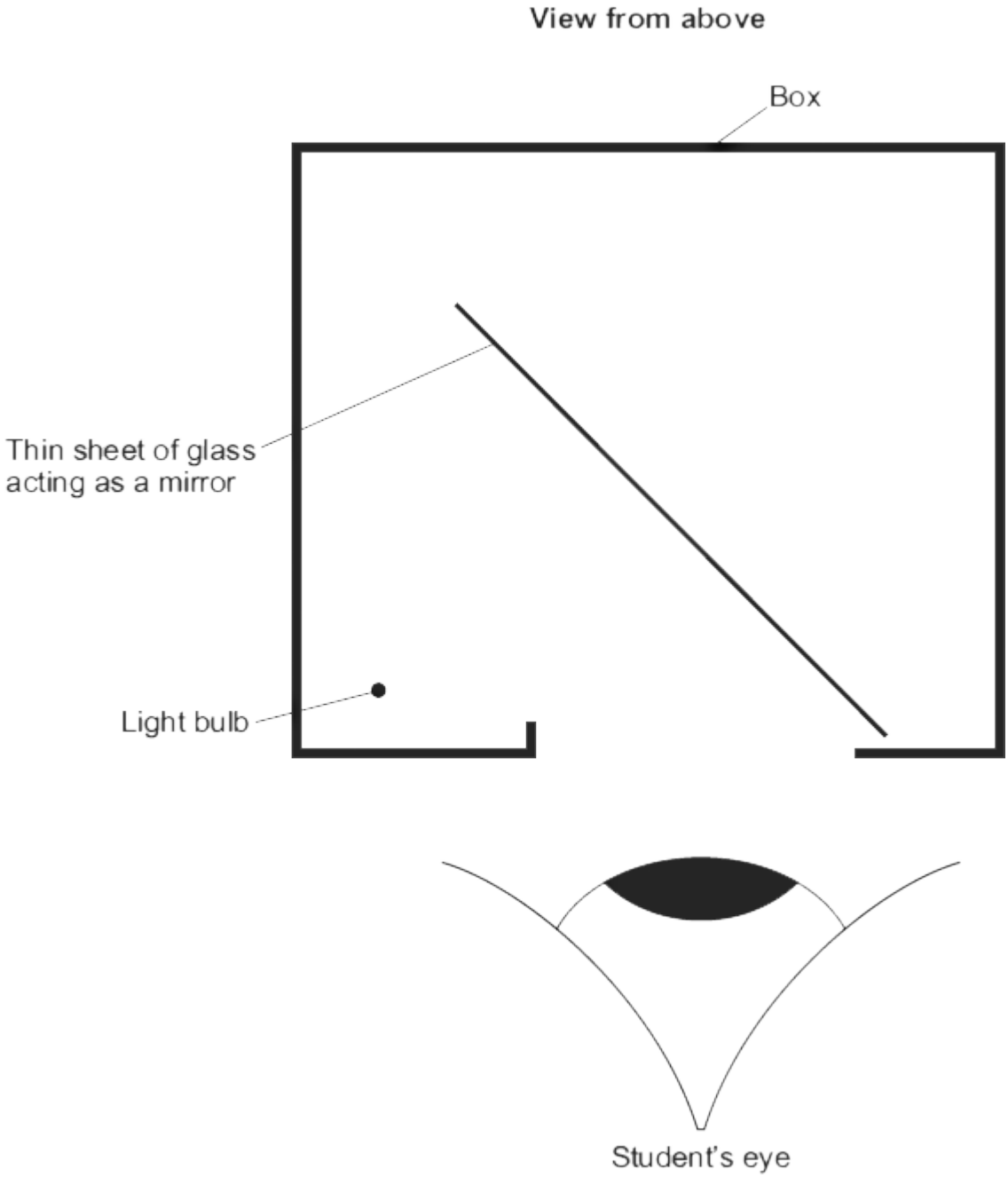
Frequency = ...

(3)

(Total 6 marks)

9 The diagram shows a model used to demonstrate an illusion known as ‘Pepper’s Ghost’.

A small light bulb and thin sheet of glass are put inside a box. The thin sheet of glass acts as a mirror. Although the light bulb is switched on, a student looking into the box cannot see the bulb. What the student does see is a virtual image of the bulb.



(a) Use a ruler to complete a ray diagram to show how the image of the light bulb is formed. Mark and label the position of the image.

(4)

(b) The image seen by the student is virtual.

Why?

.....

.....

(1)
(Total 5 marks)

10 (a) Microwaves and visible light are two types of electromagnetic wave. Both can be used for communications.

(i) Give **two** properties that are common to both visible light and microwaves.

1 .....

.....

2 .....

.....

(2)

(ii) Name **two** more types of electromagnetic wave that can be used for communications.

..... and .....

(1)

(b) Wi-Fi is a system that joins computers to the internet without using wires. Microwaves, with a wavelength of 12.5 cm, are used to link a computer to a device called a router. Microwaves travel through the air at 300 000 000 m/s.

Calculate the frequency of the microwaves used to link the computer to the router.

Show clearly how you work out your answer and give the unit.

.....

.....

.....

Frequency = ...

(3)

(c) Wi-Fi is used widely in schools. However, not everyone thinks that this is a good idea.

A politician commented on the increasing use of Wi-Fi. He said: 'I believe that these systems may be harmful to children.'

However, one group of scientists said that there is no reason why Wi-Fi should not be used in schools. These scientists also suggested that there is a need for further research.

(i) Suggest what the politician could have done to persuade people that what he said was not just an opinion.

.....

.....

(1)

(ii) Why did the group of scientists suggest that there is a need for further research?

.....

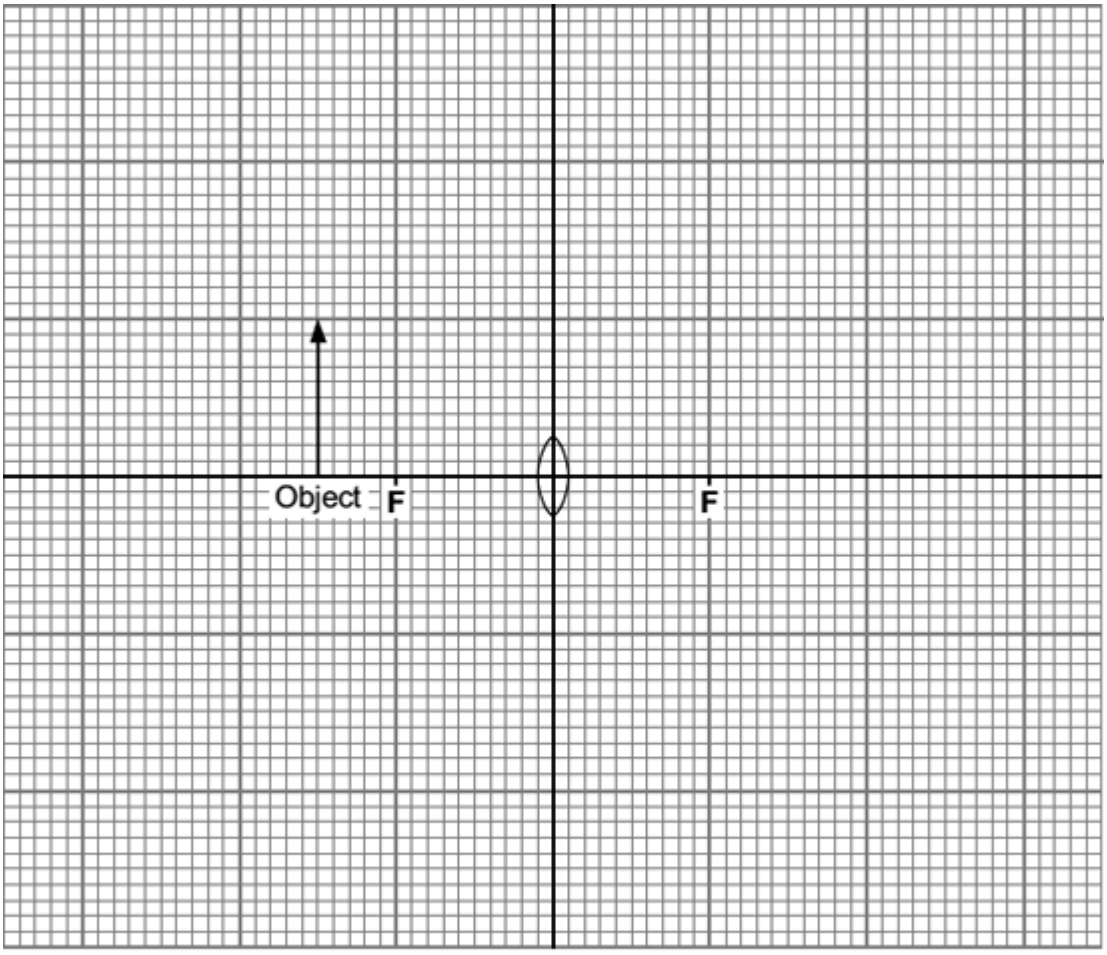
.....

(1)
(Total 8 marks)

11 A student investigated how the nature of the image depends on the position of the object in front of a large converging lens.

The diagram shows one position for the object.

(a) Use a ruler to complete a ray diagram to show how the image of the object is formed.



Key: **F** = principal focus

(4)

(b) Describe the nature of this image relative to the object.

.....

.....

.....

(2)
(Total 6 marks)

12 (a) Microwaves are one type of electromagnetic wave.

(i) Which type of electromagnetic wave has a lower frequency than microwaves?

.....

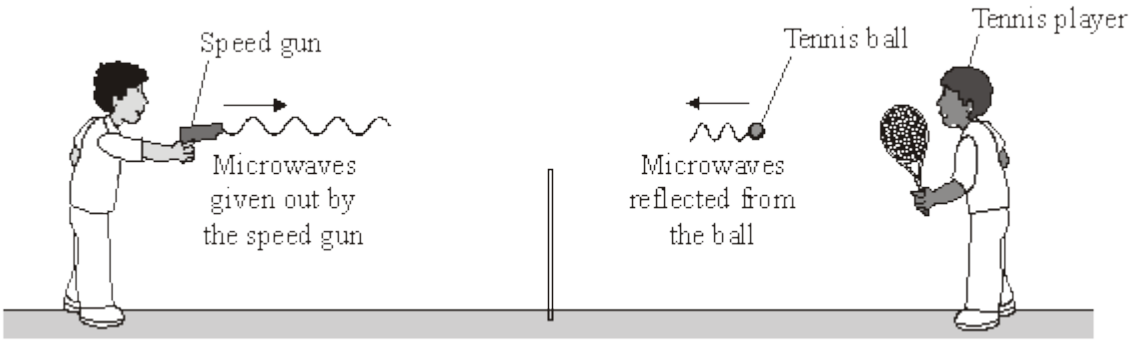
(1)

(ii) What do all types of electromagnetic wave transfer from one place to another?

.....

(1)

(b) The picture shows a tennis coach using a speed gun to measure how fast the player serves the ball.



(i) The microwaves transmitted by the speed gun have a frequency of 24 000 000 000 Hz and travel through the air at 300 000 000 m/s.

Calculate the wavelength of the microwaves emitted from the speed gun.

Show clearly how you work out your answer.

.....

.....

Wavelength = ... m

(2)

(ii) Some of the microwaves transmitted by the speed gun are absorbed by the ball.

What effect will the absorbed microwaves have on the ball?

.....

.....

(1)

(Total 5 marks)

13 (a) The wavelengths of four different types of electromagnetic wave, including visible light waves, are given in the table.

Type of wave	Wavelength
Visible light	0.0005 mm
A	1.1 km
B	100 mm
C	0.18 mm

Which of the waves, **A**, **B** or **C**, is an infra red wave? .....

(1)

(b) A TV station broadcasts at 500 000 kHz. The waves travel through the air at 300 000 000 m/s.

Calculate the wavelength of the waves broadcast by this station.

Show clearly how you work out your answer.

.....

.....

Wavelength = ... m

(2)

(c) What happens when a metal aerial absorbs radio waves?

.....

.....

.....

.....

(2)

(d) Stars emit all types of electromagnetic waves. Telescopes that monitor X-rays are mounted on satellites in space.

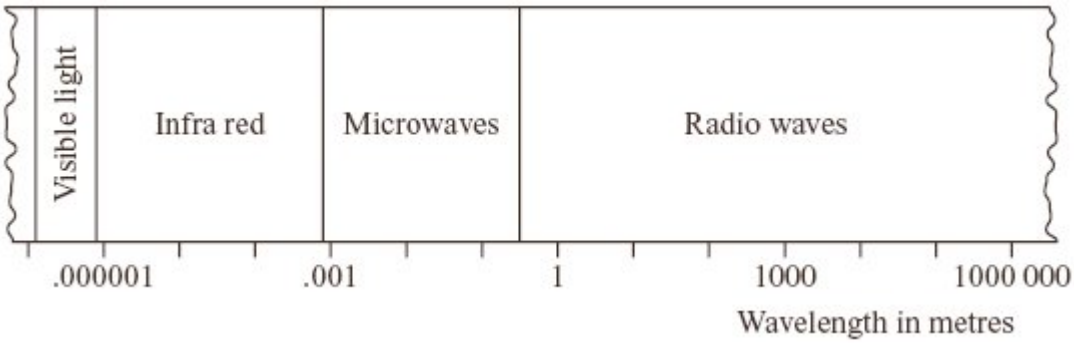
Why would an X-ray telescope based on Earth not be able to detect X-rays emitted from distant stars?

.....

.....

(1)
(Total 6 marks)

14 The diagram represents part of the electromagnetic spectrum.



(i) Visible light travels through air at 300 000 000 m/s.

Why can we assume that radio waves travel through air at the same speed as light?

.....

(1)

(ii) A radio station broadcasts at a frequency of 200 kHz.

Calculate the wavelength of the waves broadcast by this radio station. Show clearly how you work out your answer.

.....

.....

Wavelength = ……..

(2)

(iii) Draw a vertical line on the diagram above to show the position of this radio wave in the electromagnetic spectrum.

(1)
(Total 4 marks)

15 (a) Satellites fitted with various telescopes orbit the Earth. These telescopes detect different types of electromagnetic radiation.

Why are telescopes that detect different types of electromagnetic waves used to observe the Universe?

.....

.....

(1)

(b) In 2005 a space telescope detected a star that exploded 13 billion years ago. The light from the star shows the biggest *red-shift* ever measured.

(i) What is *red-shift*?

.....

.....

(1)

(ii) What does the measurement of its red-shift tell scientists about this star?

.....

.....

(1)

(c) Red-shift provides evidence for the 'big bang' theory.

(i) Describe the 'big bang' theory.

.....

.....

.....

.....

(2)

(ii) Suggest what scientists should do if new evidence were found that did not support the 'big bang' theory.

.....

.....

.....

(1)
(Total 6 marks)

16 (a) The new Tetra communications system to be used by the police transmits signals using microwaves of wavelength 75 cm.

(i) Calculate the frequency of the microwaves used by the Tetra system. Show clearly how you work out your answer.

.....

.....

Frequency = ... hertz

(2)

(b) Read the following extract from a newspaper and then answer the questions that follow.

> Residents ofStag Hill Court, a luxuryblock of flats, are shocked at the plans to site a mobile phone mast on theroof of the flats. They oppose the mast on health grounds, quoting researchin Germany that has found apossible increase in cases of cancer around mobile phone masts.
>
> Aspokesperson for the telecoms company said, 'The residents should not worry.The research carried out by our own scientists has found no link between illhealth and mobile phone masts'.
>
> This has notreassured the residents, who argue that new independent research is urgentlyneeded.

(i) Explain why living near a mobile phone mast could cause ill health.

.....

.....

.....

.....

.....

.....

(3)

(ii) Suggest **two** reasons why the residents have **not** been reassured by the research carried out by the telecoms company.

1 .....

.....

2 .....

.....

(2)
(Total 7 marks)

17 (a) The diagram shows a lens used as a magnifying glass. The position of the eye is shown and the size and position of an object standing at point **O**.

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

.....

(1)

(ii) Two points are marked as **F**. What are these points?

.....

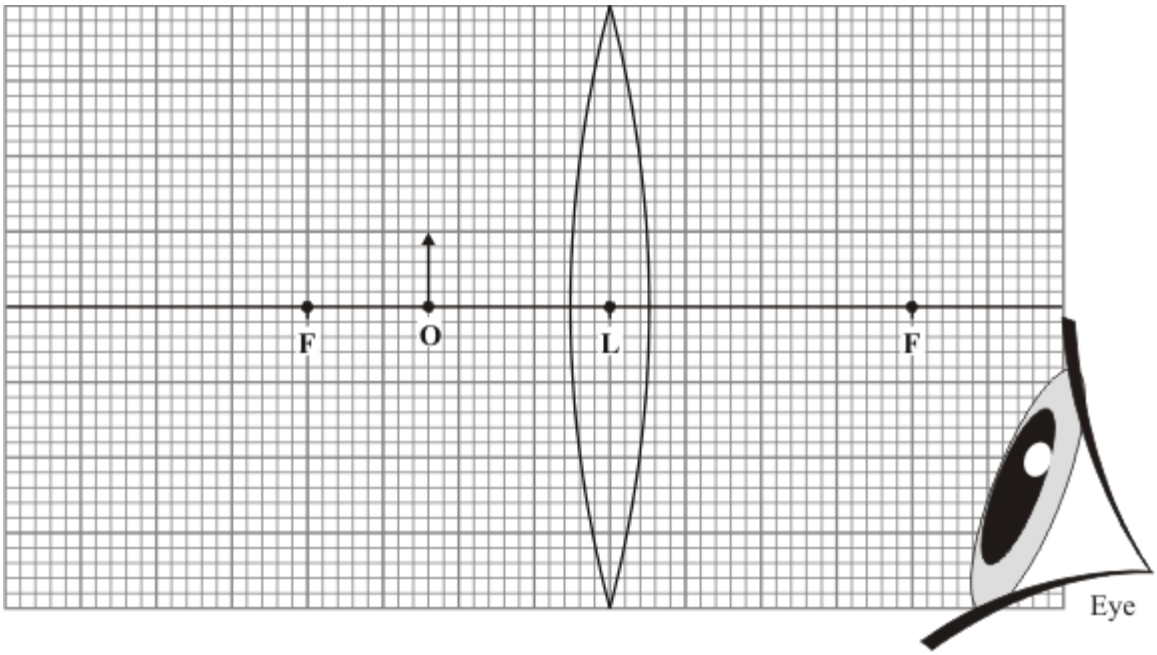
(1)

(iii) What is the name of the straight line which goes through the point **F**, through the point **L** at the centre of the lens, and through the point **F** on the other side?

.....

(1)

(iv) On the diagram, use a ruler to construct accurately the position of the image. You should show how you construct your ray diagram and how light appears to come from this image to enter the eye.



(5)

(v) The image is *virtual*. What is a *virtual* image?

.....

.....

(1)

(b) The lens shown in the diagram in part (a)(iv) can be used in a camera to produce a *real* image.

Explain why a *real* image must be produced in a camera and how the object and the lens are positioned to produce a *real* image which is **smaller** than the object.

Do **not** draw a ray diagram as part of your answer.

.....

.....

.....

.....

.....

.....

(3)
(Total 12 marks)

18 All radio waves travel at 300 000 000 m/s in air.

(i) Give the equation that links the frequency, speed and wavelength of a wave.

.....

(1)

(ii) Calculate the wavelength, in metres, of a radio wave which is broadcast at a frequency of 909 kHz. Show clearly how you work out your answer.

.....

.....

.....

Wavelength = ... metres

(2)
(Total 3 marks)

19 Microwaves are used to transmit signals to the satellite. The microwaves have a wavelength of 0.6 metres (m) and travel through space at a speed of 300 000 000 metres per second (m/s).

(i) Write down the equation which links frequency, wavelength and wave speed.

.....

(1)

(ii) Calculate the frequency of the microwaves. Show clearly how you work out your answer and give the unit.

.....

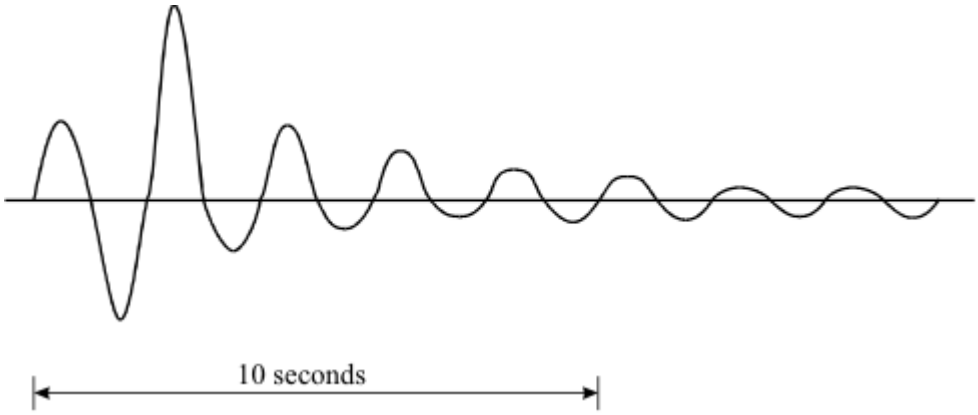
.....

.....

Frequency = ...

(3)
(Total 4 marks)

20 The vibration caused by a P wave travelling at 7.6 km/s has been recorded on a seismic chart.



(i) How many waves are produced in one second?

.....

(1)

(ii) Write down the equation which links frequency, wavelength and wave speed.

.....

(1)

(iii) Calculate the wavelength of the P wave. Show clearly how you work out your answer and give the unit.

.....

.....

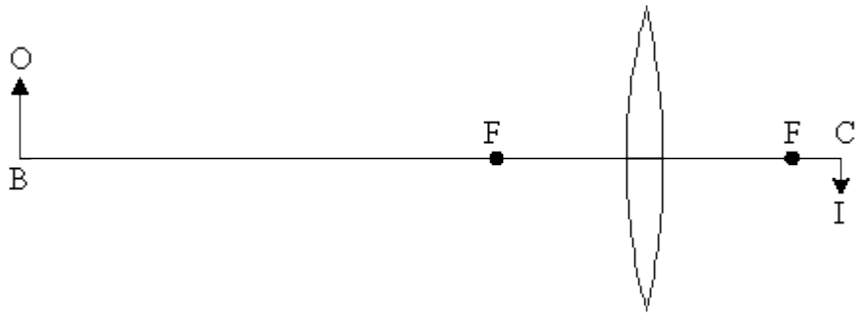
.....

Wavelength = ...

(2)

(Total 4 marks)

21 The diagram shows the image IC formed by a lens, of an object OB a long way from it. The points F mark the focal points of the lens.



(a) Describe, either by writing below or drawing on the diagram, how the size and position of the image changes:

(i) when the object OB is moved towards the focal point F.

.....

.....

(ii) when the object OB is moved past F to a point nearer the lens than the focal point.

.....

.....

(4)

(b) Explain how a converging lens in a camera is used to produce sharp images on the film when the object is a long distance away from the camera, and when it is close to the camera.

.....

.....

.....

.....

.....

(3)
(Total 7 marks)

22 Radio waves, ultra-violet, visible light and X-rays are all types of electromagnetic radiation.

(a) Choose wavelengths from the list below to complete the table.

3×10^{-8} m 1×10^{-11} m 5×10^{-7} m 1500 m

TYPE OF RADIATION	WAVELENGTH (m)
Radio waves	
Ultra-violet	
Visible light	
X-rays	

(4)

(b) Microwaves are another type of electromagnetic radiation.

Calculate the frequency of microwaves of wavelength 3 cm.
(The velocity of electromagnetic waves is 3×10^8 m/s.)

.....

.....

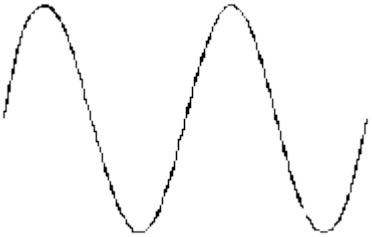
.....

.....

(4)
(Total 8 marks)

23 Some students made a small hand-turned a.c. generator, similar to a bicycle dynamo. They connected it to the Y plates of a cathode ray oscilloscope, CRO, and turned the generator slowly. The trace on the CRO looked like this:

They then turned the generator faster and the trace looked like this:



(a) Why did the trace on the CRO show:

(i) an increase in frequency;

.....

(1)

(ii) a decrease in wavelength;

.....

(1)

(iii) an increase in amplitude?

.....

(1)

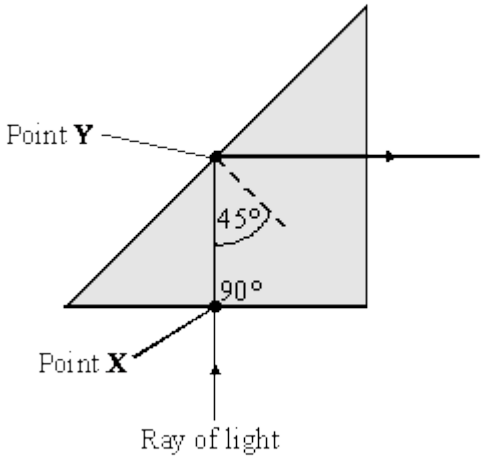
(b) One way to alter the output from the generator is to change the speed of turning. State **two** other ways to adapt parts of the generator to increase its output.

.....

.....

(2)
(Total 5 marks)

24 The diagram shows a glass prism.



(i) Explain why refraction has **not** occurred at point **X**.

.....

.....

(1)

(ii) (A) Give the full name for the process which has occurred at point **Y**.

.....

(1)

(B) Explain why this process has occurred.

.....

.....

.....

(2)
(Total 4 marks)

25 (i) Use the words frequency, wavelength and wave speed to write an equation which shows the relationship between them.

.....

(1)

(ii) Calculate the speed of a sound wave with a frequency of 250 Hz and a wavelength of 1.3 m.

Show how you get to your answer and give the unit.

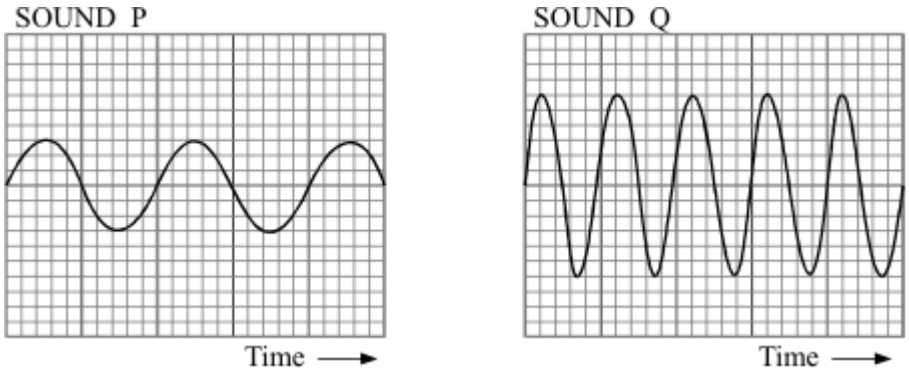
.....

.....

Speed = ...

(2)
(Total 3 marks)

26 The diagram shows the oscilloscope traces of two different sounds P and Q. The oscilloscope setting is exactly the same in both cases.



P and Q **sound** different.
Write down **two** differences in the way they sound.
Explain your answers as fully as you can.

1 .....

.....

.....

2 .....

.....

.....

(Total 5 marks)

Mark schemes

1

(a) (i) frequency

1

wavelength

1

(ii) 10^{-15} to 10^{4}

1

(b) 2.0×10^{5}

correct substitution of
*3.0×10^{8} / 1500 gains **1** mark*

2

Hz

1

(c) (i) (skin) burns

1

(ii) skin cancer / blindness

1

(d) (i) any **one** from:

- (detecting) bone fractures
- (detecting) dental problems
- treating cancer

1

(ii) any **one** from:

- affect photographic film
- absorbed by bone
- transmitted by soft tissue
- kill (cancer) cells

*answer must link to answer given in **(d)(i)***

1

(iii) 9 / 36 = 0.25
0.5 / 2 = 0.25
4 / 16 = 0.25

accept:
36 / 9 = 4
2 / 0.5 = 4
16 / 4 = 4

2

conclusion based on calculation

*two calculations correct with a valid conclusion scores **2** marks*

*one correct calculation of k scores **1** mark*

1

[13]

2 (for both fibres) increasing the wavelength of light decreases and then increases the percentage / amount of light transmitted

*accept for **1** mark:*

(for both fibres) increasing the wavelength (of light) to 5 (x 10^{-7} metres), decreases the (percentage) transmission

1

(for both fibres) the minimum transmission happens at 5 (x 10^{-7} metres)
or
maximum transmission occurs at 6.5 (x 10^{-7} metres)

*accept for a further **1** mark:*

(for both fibres) increasing the wavelength of the light from 5 (x 10^{-7} metres) increases the amount of light transmitted

increasing wavelength (of light), decreases the percentage transmitted is insufficient on its own

1

the shorter fibre transmits a greater percentage of light (at the same wavelength)

*accept for **1** mark:*
Any statement that correctly processes data to compare the fibres

1

[3]

3 (a) 10^{-15} metres to 10^{4} metres

1

(b) (i) any **one** from:

- (TV / video / DVD) remote controls
  mobile phones is insufficient
- (short range) data transmission
  accept specific example, eg linking computer peripherals
- optical fibre (signals)
  *do **not** accept Bluetooth*

1

(ii) 0.17

*an answer 17 cm gains **3** marks*

*an answer given to more than 2 significant figures that rounds to 0.17 gains **2** marks*

*allow **1** mark for correct substitution, ie $3 \times 10^{8} = 1.8 \times 10^{9} \times \lambda$*

3

(c) (maybe) other factors involved

accept a named 'sensible' factor, eg higher stress / sedentary lifestyle / overweight / smoking more / diet / hot office / age

not testing enough people is insufficient

unreliable data is insufficient

1

[6]

4

(a) (i) gamma

accept correct symbol

1

(ii) any **one** from:

- (ultraviolet has a) higher frequency

  ultraviolet cannot be seen is insufficient

- (ultraviolet has a) greater energy

- (ultraviolet has a) shorter wavelength

  ignore ultraviolet causes cancer etc

1

(b) 1.2×10^7 / 12 000 000

*allow **1** mark for correct substitution, ie $3 \times 10^8 = f \times 25$*

2

hertz / Hz / kHz / MHz

*do **not** accept hz **or** HZ*

*answers 12 000 kHz **or** 12 MHz gain **3** marks*

for full credit the numerical answer and unit must be consistent

1

(c) (i) away (from each other)

accept away (from the Earth)
accept receding

1

(ii) distance (from the Earth)

accept how far away (it is)

1

speed galaxy is moving

1

(iii) (Universe is) expanding

1

[9]

5 (a) C or 0.18 mm

1

(b) 0.6 (m)

*allow **1** mark for correct substitution and/or transformation **or 1** mark for changing frequency to Hz*
*answer 600 gains **1** mark*

2

(c) creates an alternating current

accept 'ac' for alternating current
accept alternating voltage

1

with the same frequency as the radio wave

accept signal for radio wave

*accept it gets hotter for **1** mark provided no other marks scored*

1

(d) X-rays cannot penetrate the atmosphere

accept atmosphere stops X-rays

*do **not** accept atmosphere in the way*

or

X-rays are absorbed (by the atmosphere) before reaching Earth

<u>ignore</u> explanations

1

[6]

6 (a) (i) to check rise in temperature (of other thermometers) was due to the (different wavelengths of) light

accept as a control / comparison

to measure room temperature is insufficient

1

(ii) any **two** from three:

- different colours produce different heating effects / (rises in) temperatures
- red light produces the greatest heating effect / (rise in) temperature

or

- violet produces the least heating effect / (rise in) temperature
- all colours produce a greater heating effect than outside the spectrum

an answer

the longer the <u>wavelength</u> the greater the (rise in) temperature

or

the lower the <u>frequency</u> the greater the (rise in) temperature gains both marks

2

(b) move a thermometer into the infrared region / just beyond the red light

allow use an infrared camera / infrared sensor

1

the temperature increases beyond 24(°C)

accept temperature higher than for the red light

1

(c) $v = f \times \lambda$

9.4×10^{-6}

accept 9.375×10^{-6} or 9.38×10^{-6}

or

0.0000094

accept 0.000009375

***or** 0.00000938*

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

ie $3 \times 10^{8} = 3.2 \times 10^{13} \times \lambda$

2

(d) at night the surroundings are cooler

accept at night the air is colder

there is no heat from the Sun is insufficient

or

at night there is a greater temperature difference between people and surroundings

1

(so surroundings) emit less infrared (than in daytime)

accept camera detects a greater contrast

or

gives larger difference in infrared emitted (between people and surroundings)

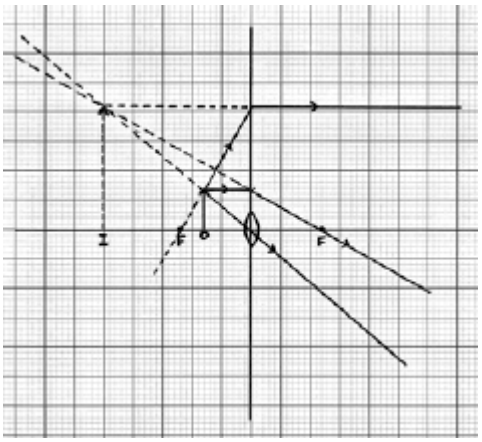
1

[9]

7 (a) (i) **two** correct rays drawn

***1** mark for each correct ray*

- ray parallel to axis from top of object **and** refracted through focus **and** traced back beyond object
- ray through centre of lens **and** traced back beyond object
- ray joining top of object to focus on left of lens taken to the lens refracted parallel to axis **and** traced back parallel to axis beyond object



2

an arrow showing the position **and** correct orientation of the image for their rays

*to gain this mark, the arrow must go from the intersection of the traced-back rays to the axis **and** the image must be on the same side of the lens as the object and above the axis*

1

(ii) (x) 3.0

accept 3.0 to 3.5 inclusive

or

$$\frac{\text{their image height}}{\text{object height}}$$

correctly calculated

*allow **1** mark for correct substitution into equation using their figures*

ignore any units

2

(b) any **two** from:

in a camera the image is:

- real not virtual
- inverted and not upright

  accept upside down for inverted
- diminished and not magnified

  accept smaller and bigger
  accept converse answers but it must be clear the direction of the comparison

  both parts of each marking point are required

2

[7]

8 (a) any **two** from:

- travel (at same speed) through a vacuum / space

  *do **not** accept air for vacuum*
- transverse
- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- travel in straight lines

2

(b) can pass through the ionosphere

accept atmosphere for ionosphere

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

accept travel in straight lines

accept not refracted / reflected / absorbed by the ionosphere

1

(c) $v = f \times \lambda$

1.2×10^6 / 1200 000

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

ie $3.0 \times 10^8 = f \times 2.5 \times 10^2$

2

hertz / Hz

*do **not** accept hz **or** HZ*

*accept kHz **or** MHz*

*answers 1.2 MHz **or** 1200 kHz gain all **3** marks*

for full credit the unit and numerical value must be consistent

1

[6]

9

(a) two rays drawn from the bulb and reflected by the glass

*angle **I** = angle **R** judged by eye*

*allow **1** mark for one incident and reflected ray even if angle **I** doesn't equal angle **R***

2

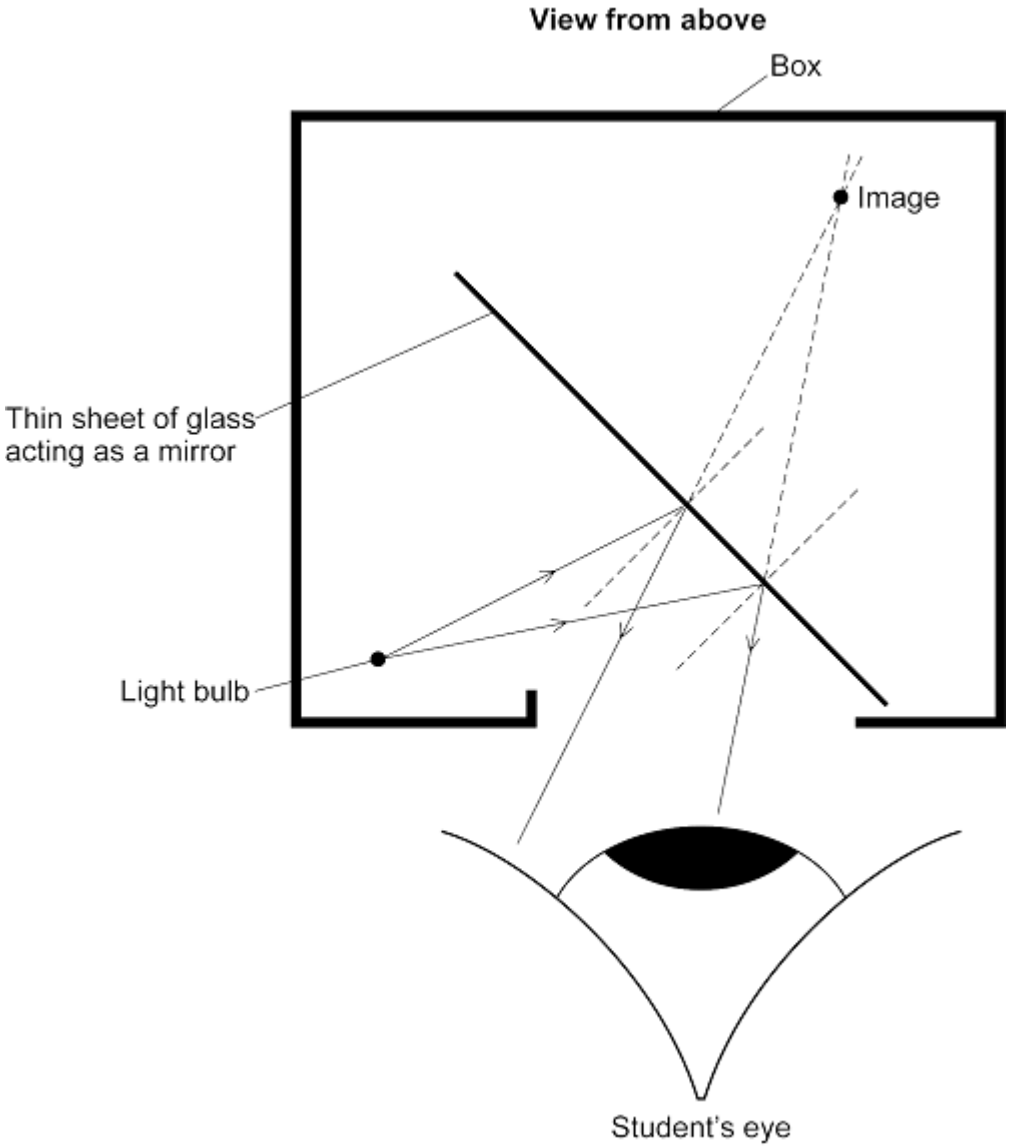
at least one arrow drawn in correct direction

any conflicting arrows negate this mark

ignore any arrows drawn on construction lines behind the glass

1

position of image correct



judged by eye

1

(b) image is formed by virtual / imaginary rays crossing

accept construction lines only show where the light seems to come from

accept the image is behind the glass / mirror

accept image is seen through the glass / mirror

accept (real) rays of light do not pass through the image

accept (real) rays do not cross

accept the image is a reflection (of the object)

accept the image is formed by reflection

*do **not** accept a virtual image can't be formed on a screen*

*do **not** accept the object / image is reflected*

1

[5]

10 (a) (i) any **two** from:

- travel at the same speed (through a vacuum)

  accept travel at the speed of light

  accept air for vacuum

- can travel through a vacuum / space

  *do **not** accept air for vacuum*

- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- can be transmitted
- transverse

  accept any other property common to electromagnetic waves

  accept travel at the same speed through a vacuum for both marks

  *do **not** accept both radiated from the Sun*

2

(ii) infra red

***both** required for the mark*

radio(waves)

accept IR for infra red

1

(b) 2 400 000 000

*correct transformation and substitution gains **1** mark*

ie $\frac{300000000}{0.125}$ ***or*** $\frac{300000000}{12.5}$

*an answer of 24 000 000 gains **1** mark*

***either** 2 400 000 kHz*

***or** 2 400 MHz scores **3** marks but the symbol only scores the 3rd mark if it is correct in every detail*

2

hertz

accept Hz

*do **not** accept hz*

1

(c) (i) presented (scientific) evidence / data

do an experiment / investigation is insufficient

1

(ii) to find out if there is a hazard (or not)

accept to find out if it is safe

accept not enough evidence to make a decision

not enough evidence is insufficient

1

[8]

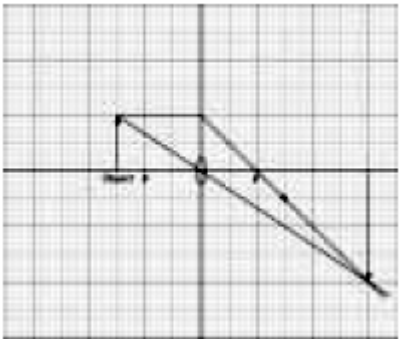
11 (a) any **two** for **1** mark each

deduct (1) from the first two marks if a ruler has not been used but the intention is clear

ray from the object's arrowhead

- through centre of lens
- parallel to the axis then, when it reaches the lens, through F on the right
- through F on the left then, when it reaches the lens parallel to the axis

*example of a **4** mark response*



*if more than two construction lines have been drawn all must be correct to gain **2** marks*

construction lines drawn as dashed lines do not score credit

2

image shown as vertical line from axis to where their rays intersect

image need not be marked with an arrowhead but, if it is, it must be correct

1

ray direction shown

only one correct direction

arrow needed but there must not be any contradiction

1

(b) any **two** from:

- inverted

  accept 'upside down'

- magnified

  accept 'bigger'

- real

  accept 'not virtual / not imaginary'
  *one correct feature gains **1** mark*
  ignore any reference to position
  an incorrect feature negates a correct response

2

[6]

12 (a) (i) radio(waves)

1

(ii) energy

correct answer only

1

(b) (i) 0.0125 (m)

*allow **1** mark for correct transformation <u>and</u> substitution*

2

(ii) make it hot(ter)

*do **not** accept cook it*
accept (air) particles inside ball will move faster
accept water in the ball gets hotter

1

[5]

13 (a) C or 0.18 mm

1

(b) 0.6 m

*allow **1** mark for correct transformation and substitution*
*allow **1** mark for changing frequency to Hz*
*answer 600 gains **1** mark*

2

(c) creates an alternating current

accept 'ac' for alternating current

accept alternating voltage

1

with the same frequency as the radio wave

accept signal for radio wave

or it gets hotter

1

(d) X-rays cannot penetrate the atmosphere

accept atmosphere stops X-rays

*do **not** accept atmosphere in the way*

or X-rays are absorbed *(*by the atmosphere*)*

before reaching Earth
ignore explanations

1

[6]

14 (i) all electromagnetic waves travel at the same speed through a vacuum, (so assume same speed in air)

accept 'all parts of spectrum' for electromagnetic waves

1

(ii) 1500 (m)

allow 1 mark for correct transformation and substitution

allow 1 mark for using 200 000 Hz

*answers 1 500 000 = **1** mark*

2

(iii) line drawn at correct position

anywhere between 1000 and next section (10 000)

accept their value for (a)(ii) drawn in
the correct position

1

[4]

15 (a) stars / galaxies / sources emit all / different types of electromagnetic waves / radiation

accept two or more named electromagnetic waves

accept answers in terms of frequencies / wavelengths

1

(b) (i) wavelength (of light) increases

accept frequency decreases

or

light moves to red end of spectrum

*accept redder but do **not** accept red alone*

1

(ii) it is the star (detected) furthest from the Earth

accept galaxy for stars

or

it is moving away the fastest

ignore reference to universe expanding

1

(c) (i) all matter compressed to / starts at / comes from a single point

*do **not** accept increasing gravitational pull*

accept everything / the universe for all matter

1

(massive) explosion sends matter outwards

accept explosion causes universe to expand

*ignore explosion creates the universe **or** further reference to star / Earth formation*

1

(ii) check validity / reliability of the evidence

or

change the theory to match the new evidence

accept comparison of new and old evidence

1

[6]

16 (a) (i) 400 000 000

or

correct equivalent

*allow **1** mark for correct transformation **and** substitution (of 75)*

*answer 4 000 000 gains **1** mark only*

2

(b) (i)

*any mention of alpha, beta, gamma waves scores **0** marks*

emit / uses / transmit / receive micro<u>waves</u>

accept radiation for microwaves throughout

ignore radio waves

1

some microwave / energy absorbed by / enters the body

ecf for their given electromagnetic wave

*do **not** accept goes <u>through</u> the body*

1

raises temperature of (body) cells / tissue / water

accept reference to water molecules vibrating fast<u>er</u>

accept it could cause mutation / harm / kill cells

*do **not** accept answers in terms of ionisation*

ignore references to cancer

1

(ii) any **two** from:

- research (may be) biased
  or may have been misled in the past
  accept not independent
  ***or** may be lying*
- some research suggests a link
- long-term effect not proven / studied
  accept not studied for long enough
- residents may not have seen the research

2

[7]

17 (a) (i) converging / convex / biconvex

1

(ii) focal (points) **or** foci

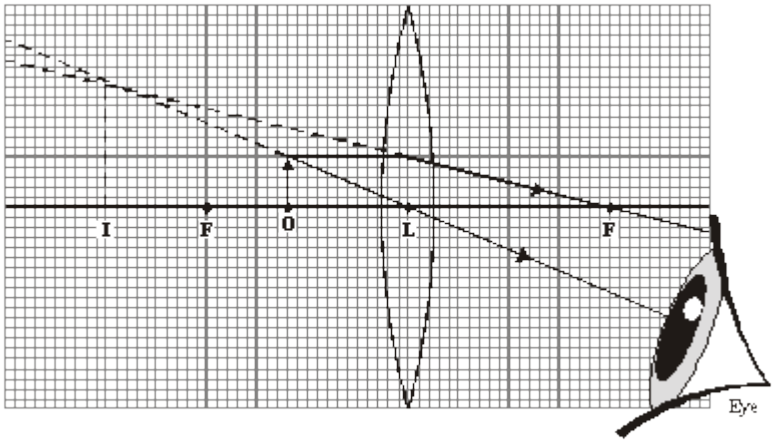
*accept focuses **or** focus (point)*

1

(iii) (principal) axis

1

(iv)



all lines drawn with a ruler for full marks

no ruler, penalise **1** mark from first four

last mark can still be awarded

double refraction drawn could get **4** out of 5 marks

ray that continues from the top of the object through L to the eye

1

horizontal ray from the top of the object, refracted by the lens and continued through F on the r.h.s. to the eye

1

back projections of these rays (shown as dotted lines)

1

image 25 mm high at 61 mm left of L
(tolerance 1 mm ± vertically, 2 mm ± horizontally)

1

at least one arrow shown on real ray and towards the eye
*but do **not** credit if contradicted by other arrow(s)*

1

(v) formed where imaginary rays intersect / cross **or** not formed by real rays

accept (virtual image) is imaginary
accept cannot be put on screen
*do **not** credit just '… is not real'*

1

(b) (the image) needs to fall on film / sensors / LDRs / CCDs

accept just 'charged couples'
*do **not** credit '… solar cells'*
*do **not** accept virtual image cannot be stored*

1

either to cause a (chemical) reaction **or** to be digitalised

for credit response must be appropriate to camera type

1

object (should be) on the far side of F / the focus (from the lens)

***or** … more than the focal length (away from the lens)*
allow 'beyond the focus'

or object should be more than twice the distance / 2F (from the lens) (2 marks)

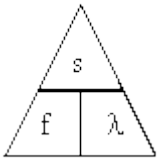
***or** … more than twice the focal length (away from the lens)*
*(**2** marks)*

1

[12]

18 (i) speed = frequency × wavelength

accept the equation rearranged
*accept v **or** s = f × λ*
do not allow w for wavelength
do not accept



unless subsequent calculation correct

1

(ii) 330 (m)

allow 1 mark for

$$\lambda = \frac{300\,000\,000}{909\,000}$$

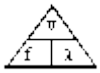
***or** 300 000 000 = 909 000 × λ*
***or** answer of 330000(m) **or** 330033(m)*

2

[3]

19 (i) wave speed = frequency × wavelength

accept correct transformation
accept $v = f \times \lambda$
accept s for speed
accept m/s = Hz x m

accept  *if subsequent use of*  *is correct*

1

(ii) 500 000 000

*credit for **1** mark correct transformation in words **or** numbers **or** correct substitution*

2

Hertz

***3** marks for 500 000k Hz **or** 500 MHz*

numerical answer **and** *unit must be consistent for full credit*

1

[4]

20 (i) 0.5

1

(ii) wave speed = frequency × wavelength

accept $v = f \times \lambda$

accept s for v

accept m/s = Hz × m

accept

providing subsequent method correct

1

(iii) 15.2 km

both numerical answer and unit are required for both marks

numerical answer and unit must be consistent

*allow **1** mark for 15.2 with incorrect or no unit*

*allow **2** marks for an answer of 1.52 km if the answer to (b)(i) was given as 5*

***r** 1 mark for correct transformation*

***or** 1 mark for correct use of speed = distance/time*

unit on its own gains no credit

2

[4]

21 (a) (i) Image distance increases
Image size increases
Remains inverted
Remains real

for 1 mark each

2

(ii) Image distance decreases
Image size decreases
Becomes upright
Becomes virtual

for 1 mark each

2

(b) Move lens with respect to film
Closer for distant objects
Further for near objects

for 1 mark each

3

[7]

22 (a) radio – 1500
ultra violet 3×10^{-8}
visible – 5×10^{-7}
X-rays – 1×10^{-11}

4

(b) 1×10^{10}Hz 10^{10}HzOK

for 4 marks

else 1×10^{10}

for 3 marks

else 3×10^{8}/0.03

for 2 marks

else v = frequency × wavelength or $3 \times 10^{8} = 0.03f$
any answer with unit Hz scores 1, 2 or 3

for 1 mark

4

[8]

23 (a) (i) more turns **or** waves per second

*accept spinning **or** turning **or** faster*

1

(ii) less time spent cutting field lines

*accept shorter time in field **or** when the frequency increases (the wavelength decreases)*

1

(iii) more energy given

accept more KE put in
accept a higher voltage produced
do not credit more power

1

(b) more coils

1

more powerful magnets

accept put in better bearings
*do not credit reduce friction **or** add soft iron core*

1

[5]

24 (i) (incident) ray along the normal

or *(incident) ray at 90° (to the surface)*

1

(ii) (A) total internal reflection

all three words required do not credit total internal refraction

1

(B) **EITHER**

angle of incidence is greater than the critical angle

or *angle of incidence is greater than 42°*

2

OR

angle of incidence is 45°

1

[4]

25 (i) (wave) speed = frequency × wavelength

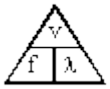
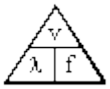
or *any correctly transposed version*

accept $v = f \times \lambda$

or *transposed version*

accept $m/s = 1 / s \times m$

or *transposed version*

or  **or** 

but only if subsequently used correctly

1

(i) 325

1

metres per second

or *m / s* ***or*** *0.325 km/s for 2 marks*

1

[3]

26

- Q is louder
- Q is higher (pitch/note but not frequency)

  [if loudness and pitch both mentioned but direction wrong / absent credit 1 mark]
- louder because bigger amplitude/height
- higher pitch because higher frequency/shorter wavelength/waves closer together
- factor of 2 mentioned w.r.t either

  (NB converse answer for P)

  each • for 1 mark

[5]