Mark schemes

1. (a) **both** answers correct

answers may be in either order

virtual

diminished

allow a description of diminished (eg smaller / reduced)

1

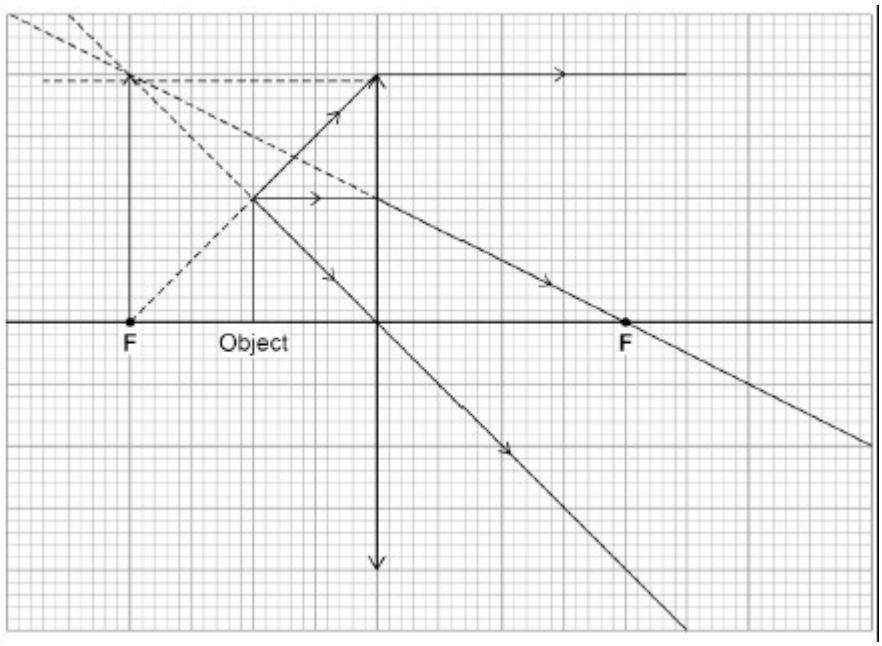
(b) any **two** correct lines drawn from the top of the object, passing through the lens and traced backwards

allow construction lines that are not dashed

*allow 1 mark for **two** correct lines drawn from the top of the object, passing through the lens BUT not traced backwards*

2

image drawn in the correct position and with the correct orientation



mark only scores if first two marks score

1

(c) (increasing the object distance) decreases the image distance more rapidly at small (object) distances / more gradually at larger (object) distances

*do **not** accept inversely proportional*

1

(d) $\frac{(2.2 - 1.4)}{2}$ **1**

uncertainty = (±) 0.4 (cm)

allow

$\frac{1.9 + 1.7 + 2.2 + 1.4}{4} = 1.8$ (1)

(2.2 – 1.8 =) (±) 0.4 (cm) (1) **1**

(e) only red is transmitted by the filter **1**

red is absorbed by the (blue) object **1**

(so) no light is reflected by the (blue) object **1**

[10]

2. (a) any **one** from:

- (sun) tan
- energy efficient lamps

allow

- *(invisible) security coding*
- *detecting forged bank notes*
- *kill microbes*
- *attract insects*
- *sterilise (surgical) equipment*
- *cause the body to produce vitamin D*
- *increasing the growth rate of plants*
- *water purification*

1

(b) 3×10^{-7} m **1**

(c) 3.0 × 108 = frequency × 3 × 10–7

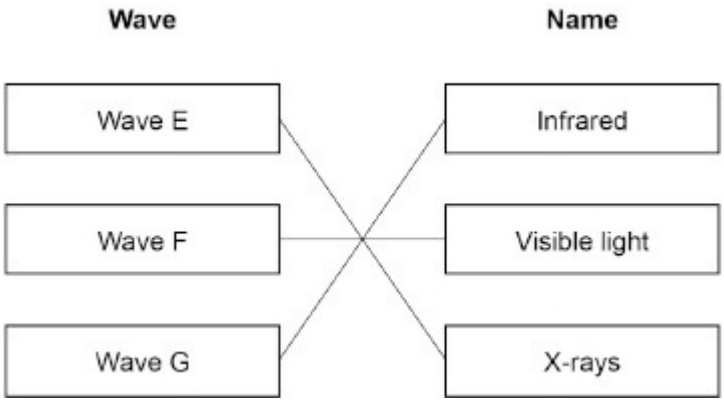
allow ecf from part (b)

1

$\text{frequency} = \frac{3.0 \times 10^{8}}{3 \times 10^{-7}}$ **1**

frequency = 1×10^{15} (Hz) **1**

(d)



all three lines correct for **1** mark

1

(e) in a transverse wave, the oscillations / vibrations are perpendicular to the direction of energy transfer

allow direction of wave travel for direction of energy transfer

1

in a longitudinal wave, the oscillations / vibrations are parallel to the direction of energy transfer

1

[8]

3. (a) to reduce the effect of random errors

allow gives a more accurate mean

ignore reference to anomalous results

ignore measurements are more accurate

1

(b) $\frac{(8.4+7.8+8.1)}{3} = 8.1$ (s)

1

$\frac{8.1}{10} = 0.81$ (s) = 0.81 (s)

1

frequency = $\frac{1}{0.81}$

allow a correct substitution of an incorrectly calculated value for time

1

frequency = 1.2345...

this mark may be awarded if the time is incorrectly calculated

1

frequency = 1.2 (Hz)

allow a calculated value correctly rounded to 2 sig figs

1

(c) measure the distance travelled by a wave using a metre rule

allow measure the length of the (ripple) tank using a metre rule

1

measure the time taken (for the wave to travel the measured distance) with a timer / stopwatch

1

divide the distance by the time

dependant on scoring the first two mark points

1

[9]

4. (a) it is harder to judge where the centre of a wider ray is

1

causing a larger uncertainty (in the measurements)

allow increasing random errors (in the measurements)

1

(b) line of best fit drawn and extrapolated to 80 degrees

1

41 (degrees)

allow 40 to 43 (degrees)

1

(c) **Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.

3–4

Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content:

- place a glass block on a piece of paper
- draw around the glass block
- use the ray box to shine a ray of light through the glass block
- mark the ray of light entering the glass block
- mark the ray of light emerging from the glass block
- join the points to show the path of the complete ray through the block
- and draw a normal line at 90 degrees to the surface • use a protractor to measure the angle of incidence • use a protractor to measure the angle of refraction • use a ray box to shine a ray of light at a range of different angles (of incidence)
- increase the angle of incidence in 10 degree intervals from an angle of incidence of 10 degrees to an angle of incidence of 70
- degrees.

allow use of optical pins instead of a ray box

(d) $\frac{(28 + 25 + 22)}{3} = 25$

1

3 (degrees)

allow alternative method

28 – 22 = 6 (1)

= 3 (degrees) (1)

1

(e) Velocity

1

[13]

5. (a) 320 MHz = 3.2 × 108 Hz

allow 320 000 000

1

$3.0 \times 108 = 3.2 \times 108 \times \lambda$

this mark may be awarded if frequency is incorrectly/not converted

1

$$\lambda = \frac{3.0 \times 10^8}{3.2 \times 10^8}$$

this mark may be awarded if frequency is incorrectly/not converted

1

wavelength = 0.9375

allow correct calculation using an incorrectly/not converted frequency

allow an answer that rounds to 0.94

1

metres **or** m

1

(b) (alternating) current <u>induced</u> (in the electrical circuit)

allow <u>electrons</u> vibrate / oscillate (in the electrical circuit)

1

with the same frequency as the radio wave

1

(c) Any **two** from:

- (radio waves are) transverse
  allow sound waves are longitudinal
  allow a description of transverse/longitudinal waves
- (radio waves) travel at a higher speed
  (radio waves) don't need a medium
  allow (only) radio waves travel through a vacuum
- (radio waves are) electromagnetic
  allow sound waves are mechanical

2

(d) accelerating

allow speeding up

1

(e) appropriate tangent drawn

1

correct reading from graph for change in distance and change in time (eg 5.6 (m) and 20 (s))

allow correct reading from their tangent for change in distance and change in time

1

gradient of tangent shown (eg 5.6/20)

allow correct gradient from their tangent

1

0.28 (m/s)

this answer only
allow 0.25 to 0.30 (m/s) if the tangent is appropriate
*allow 2.8 / 20 = 0.14 (m/s) for **1** mark*

1

(f) $0.522 - 0.122 = 2 \times 0.04 \times s$

1

$s = \frac{0.52^2 - 0.12^2}{2 \times 0.04}$

1

s = 3.2 (m)

1

$0.48 = F \times 3.2$

this mark may be awarded if the displacement is incorrectly calculated

1

$F = \frac{0.48}{3.2}$

this mark may be awarded if the displacement is incorrectly calculated

1

F = 0.15 (N)

allow a correctly calculated F using and incorrectly calculated displacement

1

OR

Alternative method 1

$t = \frac{0.52 - 0.12}{0.04}$ (1)

t = 10 (s) (1)

s = 0.32 × 10
= 3.2 (m) (1)

allow a correctly calculated displacement from an incorrectly calculated t

0.48 = F x 3.2 (1)

this mark may be awarded if the displacement is incorrectly calculated

$F = \frac{0.48}{3.2}$

this mark may be awarded if the displacement is incorrectly calculated

F = 0.15 (N) (1)

allow a correctly calculated F from incorrectly calculated values for displacement and / or t

OR

Alternative method 2

0.48 = (0.5 x m x 0.522) – (0.5 x m x 0.122) (1)

0.48 = 0.1352m – 0.0072m (1)

0.48 = 0.128m (1)

m = 3.75 (1)

F = 3.75 x 0.040 (1)

allow their calculated m

F = 0.15 (N) (1)

allow correctly calculated F using an incorrectly calculated m

(g) there is a maximum forward force (provided by the motor)

allow driving force for forward force - throughout

the car has a maximum acceleration is insufficient

1

as the speed of the car increases air resistance increases

allow friction / drag for air resistance - throughout

1

until air resistance is equal in size to forward force

allow (until) the resultant force is zero

allow forces are in equilibrium / balanced

1

so the car can no longer accelerate

allow the car travels at terminal velocity

1

[24]

6. (a) chicken

allow a correct answer indicated in Table 3 provided the answer space in blank

1

(b) 2×10^{-6}

1

(c)

*an answer 0.025 (m) scores **4** marks*

time = 8μs = 8 × 10−6 (s)

or

4 × their answer to part (b)

subsequent marks may be scored if the number of squares is miscounted or t = 2μs is used

1

distance = ½ × 6300 × 8 × 10−6

allow 8 × 103 or 8 × 10−3 or 8 × 10−9 for 8 × 10−6

1

distance = 0.0252 (m)

allow a correctly calculated answer using 8 × 103 or 8 × 10−3 or 8 × 10−9

1

distance = 0.025 (m)

allow a calculated value correctly rounded to 2 sig figs

*an answer 0.050 (m) scores **3** marks*

*an answer 0.05 or 0.0504 (m) scores **2** marks*

1

(d) to convert (the pressure variations in) sound (waves) into variations in current / p.d
allow electrical signal for variations in current / p.d.
*do **not** accept amplifies sound*
1

(e) sound (waves) cause the diaphragm to vibrate
diaphragm moves is insufficient
1

the diaphragm causes the coil / wire to vibrate
*do **not** accept moves the coil / wire up and down*
*if m.p.1 and m.p.2 do not score, allow sound (waves) cause the coil / wire to vibrate for **1** mark*
1

the coil / wire moves through the magnetic field
or
the coil / wire cuts magnetic field lines
1

a potential difference is induced (across the ends of the coil / wire)
allow induced current for induced p.d.
1

[11]

7. (a) The frequency increases and the wave speed in air stays the same
1

(b) pass through soft tissue
allow penetrate for pass through
allow skin/muscle/etc... for soft tissue
pass through tissue is insufficient
1

(but) absorbed by bone
allow do not pass through bone
*do **not** accept reflected by bone*
1

(c) accept a sensible practical suggestion eg
- complete the investigation standing up
- use (slightly) cooler water • do not touch the hot cube

*do **not** accept use cold water*
pour water in carefully is insufficient
ignore wear safety goggles or gloves
1

(d) distance between each side (of the cube) and the (infrared) detector
allow distance between cube and detector
1

(e) measurements (for each surface) have not been repeated (to show that they cluster closely)

*do **not** accept any answer for measurement should be repeated for any reason other than to show they cluster eg to show accuracy / average / anomalies would be wrong*

1

(f) (the student) could not conclude that black surfaces always emit more (infrared) than a white surface

a (matt) white surface (appears to) emit(s) the same amount (of infrared) as a (shiny) black surface

the conclusion is wrong is insufficient

1

(as) the reading for the matt white and shiny black would both be 66 (°C)

allow (as) the reading for the matt white and shiny black would be the same

1

(g) 0.0

allow 0

allow zero

1

(h) at night, more radiation is emitted from the Earth than absorbed from space

1

cloud reflects radiation (towards the Earth)

allow solar radiation for radiation

1

at A, (there is no cloud cover so) a larger proportion of radiation will be emitted into space

1

[12]

8. (a) an idea used to explain observations and data

1

(b) different models may be appropriate in different situations

allow one particular model may not be able to explain all observations

1

(c) new (experimental) evidence / data

1

evidence cannot be explained using an existing model
or
predictions made using old model are shown to be incorrect
allow old model based on data now shown to be incorrect

1

new model explains new evidence
or
predictions made with new model are shown to be correct

1

a suitable example given
e.g. nuclear model of the atom replacing the plum pudding model
allow tectonic plates replacing static land masses

big bang theory replacing other theories for the creation of the universe
allow heliocentric model of solar system replacing geocentric model

1

(d) velocity / speed is slower in shallow water

1

so edge of wave (front) entering shallow water slows down

1

but the part of the wave (front) in deeper water continues at a higher speed (leading to a change in direction of the wave fronts)
allow one part of the wave (front) changes speed before other parts
allow an answer in terms of wave (front) travelling from shallow to deep water

1

(e) every point on the wave (front) enters / hits the shallow water at the same time

1

and so every point slows down at the same time
allow changes speed for slows down
allow an answer in terms of wave (front) travelling from shallow to deep water

1

[11]

9. (a) random
human error is insufficient

1

(b) accept any practical suggestion that could cause a range of values
e.g. misjudging the centre of the ray
e.g. not replacing mirror / ray box in the same position

measuring the angle incorrectly is insufficient
moving the mirror / ray box is insufficient

1

(c) range = 10
or
mean of 51 calculated

1

5(°)

*an answer of 5(°) scores **2** marks*

1

(d) within experimental accuracy the angle of incidence and the angle of reflection are the same

allow the angle of incidence is nearly the same as the angle of reflection

or

the angle of reflection is usually different to the angle of incidence

allow only a few of the values are the same / similar
allow the idea of a range of values

1

relevant use of data
e.g.
at 20° / 30° / 40° there is at least one measurement of angle of reflection that is exactly the same
or
at 50° there are big differences

allow 50° includes anomalous results
an answer in terms of calculated mean(s) may score both marks
e.g.
mean calculated for one or more angle of reflection (1)
conclusion correctly stating angle i = / ≠ angle r (1)

1

(e) results could be collected for angles (of incidence) not yet measured

allow a stated angle of incidence e.g. 10° or 60°
changing the mirror is insufficient
ignore repeat the measurements

1

(f) replace the mirror with an irregular reflecting surface

allow use an irregular reflecting surface
replace mirror with paper is insufficient
*do **not** accept use a glass block*

1

[8]

10. (a) P-waves are longitudinal and
S-waves are transverse

1

(b) 0.4

1

(c) wave speed = frequency × wavelength

allow $v = f\lambda$

1

(d) 7200 = 0.4 × wavelength

1

$$\text{wavelength} = \frac{7200}{0.4}$$

1

wavelength = 18 000 (m)

*allow up to full marks for ecf using their answer to part **(b)***
a method shown as
7200 × 2.5 = 18 000
*scores **0** marks*

*an answer 18 000 scores **3** marks*

1

(e) because S-waves cannot travel through a liquid

1

and S-waves do not travel through the (outer) core

*allow some (seismic) waves cannot travel through a liquid and do not go through the core for **1** mark*

1

(f) magnetic field around the coil changes
or
the magnetic field (lines) cut by the coil

allow the generator effect

1

(g) because the magnet changes direction

1

(h) stationary

1

(i) any **two** from:

- stronger magnetic field
  allow stronger magnet
  allow heavier magnet
  bigger magnet is insufficient

- more turns on the coil
  bigger coil is insufficient
  *do **not** accept more coils of wire*

- turns pushed closer together

- spring with a lower spring constant
  allow less stiff spring
  allow weaker spring
  *do **not** accept add an iron core*

2

[13]

11.

(a) gamma rays

1

(b) can travel through the atmosphere

1

(c) explosion of a red super giant
or
a supernova

1

(d) 1.2 × 109 Hz

1

(e) 3.0 × 108 = 1.2 × 109 × λ
*an answer of 0.25 (m) scores **3** marks*
*allow ecf from **(d)***

1

$$\lambda = \frac{3.0 \times 10^{8}}{1.2 \times 10^{9}}$$

1

λ = 0.25 (m)

1

(g) same as the radio wave

1

(f) expansion due to fusion energy

1

in equilibrium with gravitational collapse

*forces acting inwards equal forces acting outwards gains **1** mark*

1

(h)

Level 2: Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	3-4
~~**Level 1:** Facts, events or processes are identified and simply stated~~ but their relevance is not clear. **No relevant content**	1-2
Indicative content	0
• Sun goes from main sequence to red giant • then from red giant to white dwarf • when the Sun changes to a red giant the surface temperature will decrease • and the relative luminosity will increase • when changing from a red giant to a white dwarf the surface temperature increases • and the relative luminosity decreases	

4

[14]

12. (a) light (inside the tin can) is reflected many times before incident on the hole

1

at each reflection energy / light is absorbed so (very) little light / energy leaves the hole

1

(b) the object absorbs all of the radiation incident on it
or
the object does not reflect or transmit any radiation
or
the object is the best possible emitter of radiation

1

(c) the intensity of every wavelength increases

1

the shorter the wavelength the more rapid the increase in intensity

1

the peak intensity occurs at shorter wavelength

1

(d) accept any value between 1600 (°C) and 10 000 (°C)

1

(e) the temperature has increased

1

as 200 years ago the energy / radiation from space = energy / radiation emitted (and reflected) into space

1

but now less radiation is emitted so there is a net absorption

allow energy for radiation

1

[10]

13. (a) in a longitudinal wave the oscillations / vibrations are parallel to the direction of energy transfer.

accept wave travel for energy transfer throughout

1

in a transverse wave the oscillations / vibrations are perpendicular to the direction of energy transfer.

1

(b) accept any sensible suggestion eg a vibrating drum skin does not move the air away to create a vacuum (around the drum)

1

(c) **Level 3 (5–6 marks):**

A detailed explanation linking variations in current to the pressure variations of a sound wave, with a logical sequence.

Level 2 (3–4 marks):

A number of relevant points made, but not precisely. A link between the loudspeaker and a sound wave is made.

Level 1 (1–2 marks):

Some relevant points but fragmented with no logical structure.

0 marks:

No relevant content.

Indicative content

the current in the electrical circuit is varying

the current passes through the coil

the coil experiences a force (inwards or outwards)

reversing the current reverses the force

the size of the current affects the size of the force

the varying current causes the coil to vibrate

the (vibrating) coil causes the cone to vibrate

the vibrating cone causes the air molecules to move

the movement of the air molecules produces the pressure variations in the air needed for a sound wave

the air molecules bunch together forming compressions and spread apart forming rarefactions

6

[9]