Neap

Trial Examination 2021

VCE Physics Units 3&4

Written Examination

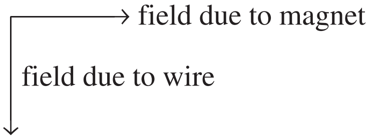
Suggested Solutions

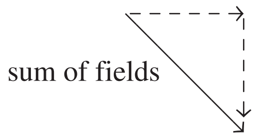
SECTION A – MULTIPLE-CHOICE QUESTIONS

Question	Answer	Question	Answer
1	B	11	A
2	D	12	B
3	C	13	A
4	D	14	D
5	A	15	D
6	A	16	A
7	C	17	C
8	B	18	A
9	C	19	D
10	B	20	C

Question 1 B

B is correct. The magnetic field due to the magnet is to the right and the magnetic field due to the wire is vertically downwards. The sum of the fields is shown below.





A, **C** and **D** are incorrect. The sum of the two fields does not correspond to the direction indicated by these options.

Question 2 D

$$E = \frac{kq}{r^2}$$
$$= \frac{8.99 \times 10^9 \times 10 \times 10^{-6}}{\left(1.0 \times 10^{-3}\right)^2}$$
$$= 9 \times 10^{10} \text{ N C}^{-1}$$

Question 3 C

C is correct. The new radius of the path of the electron needs to be found so that the exit point can be determined. The relationship for the circular force is $\frac{mv^2}{r} = Bvq,$ which reduces to $r = \frac{mv}{Bq}.$ As m and q are constant, the new speed is $\frac{v}{2}$ and the strength of the magnetic field is $\frac{B}{2},$ the new radius of the path is the same as shown in the diagram. Hence, the electron exits at point N.

A, **B** and **D** are incorrect. The electron would not exit at these positions as the radius of the path has not changed.

Question 4 D

D is correct. Potential varies linearly with distance between the plates. Point P is midway between the plates, so the potential is $\frac{V}{2}.$ The electric field strength is given by the ratio of potential difference to distance, so the electric field strength is $\frac{V}{0.2} = 5 \text{ V}.$ **A** is incorrect. This option contains the incorrect potential. **B** is incorrect. This option contains the incorrect electric field strength. **C** is incorrect. This option contains both the incorrect potential and the incorrect electric field strength.

Question 5 A

A is correct. The output is DC, so a split-ring commutator connection is used to reverse the polarity every half cycle, which converts AC to DC output. Both S and N magnets are required to produce a field across the loop. **B** is incorrect. This configuration would provide alternating positive and negative voltage output. **C** and **D** are incorrect. There is not a uniform field across the region of the coil, so any output will not be sinusoidal.

Question 6 A

From the graph, the peak value is 5.00 V.

$$\begin{aligned}\text{RMS} &= \frac{V_{\text{peak}}}{\sqrt{2}}\\ &= \frac{5.00}{\sqrt{2}}\\ &= 3.54\text{ V}\end{aligned}$$

Question 7 C

C is correct. Considering that M_2 is accelerating downwards, the tension in the string trying to pull M_1 upwards must be less than M_2g so that the net force on M_2 is downwards. **A** and **B** are incorrect. The tension is less than M_2g. **D** is incorrect. Given that $T - M_1g = M_1a$ and $M_2g - T = M_2a$, eliminating T results in $M_2g - M_1g = (M_1 + M_2)a$, which is the net force and not the tension.

Question 8 B

Impulse has the same value as the change in momentum.

$$\begin{aligned}\text{impulse value} &= (60.0 \times 4.00) - 0.00\\ &= 240\text{ N s}\end{aligned}$$

Question 9 C

Work done by gravity is equal to the area between the graph line and the domain of 6.38×10^6 m to 7.16×10^6 m.

$$\begin{aligned}\text{work done} &= \text{area of the trapezium}\\ &= \frac{10\,000 + 8000}{2} \times \left(7.16 \times 10^6 - 6.38 \times 10^6\right)\\ &= 7.02 \times 10^9\text{ J}\\ &= 7.02\text{ GJ}\end{aligned}$$

Question 10 B

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\frac{v}{c} = \sqrt{1-\frac{1}{\gamma^2}}$$

$$= \sqrt{1-\frac{1}{1.2^2}}$$

$$= 0.55$$

Thus, $v = 0.55c$.

Question 11 A

A is correct. The particle only moves vertically as the transverse wave moves through it. At the instant shown, the wave is moving to the left and so the particle must rise with the crest. **B** is incorrect. The wave is moving to the left. **C** and **D** are incorrect. The particle only moves vertically as the transverse wave moves through it.

Question 12 B

B is correct. Of the four regions listed, microwaves have the lowest energy per photon. They can be used to send and receive audio, video and other data in light signal form. **A** is incorrect. X-rays do not have the highest energy per photon. **C** is incorrect. Infrared does not have more energy than ultraviolet per photon. **D** is incorrect. Gamma is not used in thermal imaging or heat mapping.

Question 13 A

A is correct. The higher frequencies refract more, which is equivalent to the prism offering a greater refractive index to them. **B** is incorrect. The speed of light varies with wavelength inside the prism and so varies for different colours. **C** is incorrect. The refractive index varies with colour and thus the wavelength of light. **D** is incorrect. The deviation of the colours increases as the angle of incidence increases.

Question 14 D

D is correct. Polarisation occurs when the plane of oscillation of light coincides with the stopping plane of the material. Thus, polarised light has its amplitude along a particular plane only. **A**, **B** and **C** are incorrect. These options do not occur in the plane of oscillation and are not subject to polarisation.

Question 15 D

D is correct. Due to the Doppler effect, both Wally and Jenny will hear increased frequencies as the source of the sound is moving towards them. However, because the car experiences a greater relative speed to the truck than Jenny does, Wally will experience the truck's horn with a higher frequency than Jenny. **A** is incorrect. Wally and Jenny will hear different frequencies due to their different relative motions. **B** is incorrect. Both Wally and Jenny will hear a higher frequency than David. **C** is incorrect. As Wally's relative speed to the truck is greater than that of Jenny's to the truck, Wally hears a higher frequency than Jenny.

Question 16 A

A is correct. The extent (spread) of diffraction is proportional to $\frac{1}{\text{gap width} \times \text{frequency}}$.

The values given in this option result in $\frac{1}{0.15 \times 100} = \frac{1}{15}$, which is the greatest ratio.

B, **C** and **D** are incorrect. These options lead to ratios smaller than the ratio given by **A**.

B results in $\frac{1}{1.0 \times 200} = \frac{1}{200}$. **C** results in $\frac{1}{1.5 \times 300} = \frac{1}{450}$. **D** results in $\frac{1}{10 \times 400} = \frac{1}{4000}$.

Question 17 C

C is correct. To find the energy released, the difference between the larger sum of the proton masses and the helium atom mass is multiplied by the square of the speed of light. **A** is incorrect. This option represents the conversion of a helium nucleus to energy. **B** is incorrect. This option represents the energy difference between a helium nucleus and a proton. **D** is incorrect. This option incorrectly represents the mass of a helium nucleus as greater than the combined mass of four protons.

Question 18 A

A is correct. The electron diffracts through the gap, which is in the y-plane. A small variation in the gap width causes a small variation in the position (in the y-direction) that the electron strikes on the screen. Thus, the momentum of the electron in the y-plane must alter for this to occur, as per the Heisenberg Uncertainty principle. **B**, **C** and **D** are incorrect. These options include the x-direction of motion. The uncertainty in the y-position of the electron in the gap affects the uncertainty in the y-direction momentum only.

Question 19 D

D is correct. The circular motion occurs in the synchrotron and is produced by a magnetic field. During its circular motion, the electron emits energy in the form of light. **A** is incorrect. The LED emits light as electrons transition from a higher energy level to a lower energy level in the atoms of the diode material. **B** is incorrect. Incandescent globes release light due to the acceleration of electrons in high temperature thermal collisions in the filament. **C** is incorrect. The laser is the result of electron transitions in atomic energy levels due to stimulated emission.

Question 20 C

C is correct. The data is precise as the results agree within the uncertainties, so the data is reliable. The data is systematically different from the accepted value of 440 Hz, so it is inaccurate and not valid. **A** and **D** are incorrect. The data is not valid. **B** is incorrect. The data is not unreliable.

SECTION B

Question 1 (8 marks)

a. $F_{\text{net}} = qE$

$= 1.6 \times 10^{-19} \times 1.0 \times 10^{6}$ 1 mark

$= 1.6 \times 10^{-13}$ N 1 mark

b. **i.** $F = Bvq$

$= 2.0 \times 1.0 \times 10^{6} \times 1.6 \times 10^{-19}$ 1 mark

$= 3.2 \times 10^{-13}$ N 1 mark

ii. Because the force is always perpendicular to the motion, is constant, and – for the instant shown – is downwards, the electron will move in a circular path while it is in the magnetic field. 1 mark 1 mark

c. From **part a.**, the magnitude of the electric force is 1.6×10^{-13} N to the left.
From **part b.i.**, the magnitude of the magnetic force is 3.2×10^{-13} N downwards (using the right palm rule).

magnitude of the resultant $= \sqrt{\left(1.6 \times 10^{-13}\right)^2 + \left(3.2 \times 10^{-13}\right)}$ 1 mark

$F_{\text{net}} = 3.6 \times 10^{-13}$ N 1 mark

Note: Consequential on answers to ***Questions 1a.*** *and* ***1b.i.***

Question 2 (6 marks)

a. Use $\dfrac{r^3}{T^2} = \dfrac{GM}{4\pi^2} \Rightarrow r = \sqrt[3]{\dfrac{GMT^2}{4\pi^2}}$.

$$r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times (94.2 \times 60)^2}{4\pi^2}}$$

$= \sqrt[3]{3.228 \times 10^{20}}$ 1 mark

$= 6.86 \times 10^{6}$ m 1 mark

altitude $= r -$ Earth's radius

$= 6.86 \times 10^{6} - 6.37 \times 10^{6}$ 1 mark

$= 4.85 \times 10^{5}$ m 1 mark

Note: Subtract a total of 1 mark if the final answer is not given to three significant figures. Accept minor variations in the final answer due to rounding.

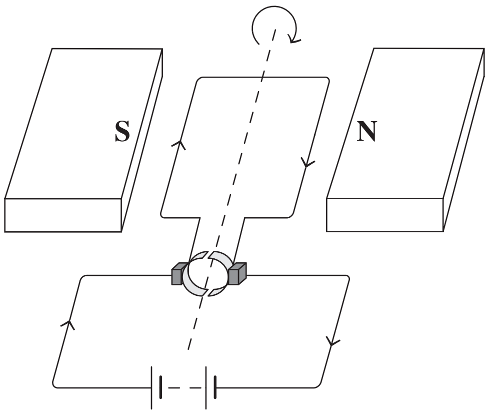
b. For any satellite, the acceleration is $a = \dfrac{v^2}{r} = G\dfrac{M}{r^2}$, which leads to the relationship

$v = \sqrt{\dfrac{GM}{r}}$. 1 mark

From this relationship, it can determined that, at an orbit of higher altitude, the satellite will travel at a lesser speed. 1 mark

Question 3 (5 marks)

a.



1 mark

b.

$$F = nIlB$$
$$= nB\frac{V}{R}l$$
$$0.32 = n \times 0.10 \times \frac{6.0}{4.5} \times 0.060$$ 1 mark
$$n = 40 \text{ turns}$$ 1 mark

c. *Any two of:*

- Reduce the number of coil turns.
- Reduce the current in the coil by reducing the battery voltage (for the same coil).
- Reduce the side length experiencing the force.
- Increase the resistance of the coils.
- Move the magnets further apart.
- Use magnets of weaker strength.
- Reduce the length of the longer sides.

2 marks

Note: For the coil to turn slower, the force acting on the side must be smaller.

Thus, $F = nIlB = nB\frac{V}{R}l$ *is used.*

Question 4 (7 marks)

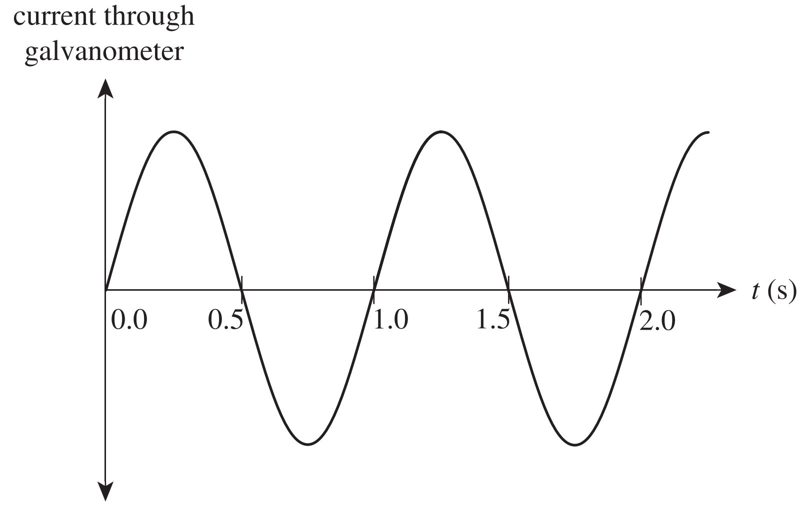
a. Initially, the magnet supplies the greatest downwards flux to the coil. As the magnet rises, the external flux continues to be downward but is decreasing. 1 mark

The coil reacts by opposing this decrease in external flux and supplies its own (induced) flux downwards to compensate for this decrease. 1 mark

Using the right hand rule, the thumb represents the direction of the induced flux, which is downwards. The curl of the fingers represents the induced current, which flows around the coil such that it points to the left on the front of the coil. 1 mark

Thus, by following the wiring convention of the coil, the current flows into Y, through the galvanometer and out from X. Thus, the needle moves to the left during the upward movement of the magnet. 1 mark

b.



3 marks

1 mark for showing two sinusoidal cycles.
1 mark for a correct horizontal scale showing a period of 1.0 seconds.
1 mark for graph starting at origin.
Note: If the graph is inverted but meets the above requirements, award full marks. If the graph profile uses straight lines instead of curved segments, award full marks.

Question 5 (7 marks)

a. $\Phi = B \times A$

$= 0.20 \times \pi \times 0.02^2$ 1 mark

$= 2.5 \times 10^{-4}$ Wb 1 mark

b. $\left|\text{EMF}\right| = N\left|\dfrac{\Delta\Phi}{\Delta t}\right|$

$= 6 \times \left|\dfrac{0 - 2.5 \times 10^{-4}}{1.5}\right|$ 1 mark

$= 1.0 \times 10^{-3}$ V 1 mark

c. The EMF is calculated according to the equation $\left|\text{EMF}\right| = N\left|\dfrac{\Delta\Phi}{\Delta t}\right|$.

Thus, the EMF is equal to the number of turns multiplied by the rate of change of magnetic flux. 1 mark

One modification would be to increase the number of loops in the coil, assuming the coil is removed at the same time. 1 mark

Another modification would be to increase the area of the loops, which increases the flux value according to magnetic flux = B × A. 1 mark

Note: No mark is awarded for a response that suggests using magnets of greater strength; the question states that the same magnet is to be used. No mark is awarded for a response that suggests pulling the magnet out at a greater speed (less time); this is not a modification of the apparatus.

Question 6 (5 marks)

a. $\frac{V_{PR}}{V_{battery}} = \frac{N_{PR}}{N_{primary}}$

$V_{PR} = 12 \times \frac{10}{1}$

$= 120 \text{ V}$ 1 mark

$\frac{V_{globe}}{V_{QS}} = \frac{N_{globe}}{N_{QS}}$

$V_{QS} = 11.5 \times \frac{10}{1}$

$= 115 \text{ V}$ 1 mark

b. The transformers are assumed ideal, so $P_{globe} = P_{QS}$.

$P_{QS} = P_{battery} - I_{line}{}^2 R_{line}$

$= V_{PR} I_{line} - I_{line}{}^2 R_{line}$

$V_{line\ loss} = I_{line} \times R_{line}$

$I_{line} = \frac{120 - 115}{5}$

$= 1.0 \text{ A}$ 1 mark

$P_{QS} = (120 \times 1.0) - (1.0^2)5$ 1 mark

$= 115 \text{ W}$ 1 mark

OR

$\frac{V_{in}}{V_{out}} = \frac{120}{12}$

$= 10$

$10 = \frac{I_{globe}}{I_{line}}$ 1 mark

$I_{globe} = 10 \times I_{line}$

$= 10 \text{ A}$ 1 mark

$P_{QS} = V_{out} \times I_{globe}$

$= 11.5 \times 10$

$= 115 \text{ W}$ 1 mark

Question 7 (5 marks)

a. total mechanical energy (TME) $= \frac{1}{2} m v^2 + mgh$

$\text{TME}_A = \text{TME}_{top}$

$\frac{1}{2} \times 0.020 \times v^2 + 0.020 \times 9.8 \times 0.50 = \frac{1}{2} \times 0.020 \times 0^2 + 0.020 \times 9.8 \times 2.20$ 1 mark

$v = 5.8 \text{ m s}^{-1}$ 1 mark

b. The maximum speed that the car can travel at in order to remain in contact with the crest is given by $v = \sqrt{rg} = \sqrt{0.50 \times 9.8} = 2.21 \text{ m s}^{-1}$. 1 mark

The car's speed at the top of the crest is the same as that at position A, which is 5.8 m s^{-1}. 1 mark

Hence, the car leaves the track at the top of the crest. 1 mark

Note: Consequential on answer to ***Question 7a****.*

Question 8 (3 marks)

Use $v = \dfrac{2\pi r}{T}$, where r = string length × sin(20°).

$r = 1.0 \times \sin(20°)$

$= 0.342 \text{ m}$ 1 mark

$v = \dfrac{2\pi \times 0.342}{1.95}$ 1 mark

$= 1.1 \text{ m s}^{-1}$ 1 mark

Question 9 (5 marks)

a. $v_{\text{horizontal}} = \dfrac{\text{horizontal range}}{\text{flight time}}$

$\text{flight time} = \dfrac{v_{\text{horizontal}}}{\text{horizonal range}}$ 1 mark

$= \dfrac{2.35}{1.5}$

$= 1.57 \text{ seconds}$ 1 mark

b. $\text{launch speed} = \sqrt{v_{\text{horizontal}}^{\,2} + v_{\text{vertical}}^{\,2}}$

$v_{\text{horizontal}} = \text{constant} = 1.5 \text{ m s}^{-1}$

v_{vertical} needs to be determined as the initial vertical speed.

Vertically, $a = -9.8 \text{ m s}^{-2}$, $v_{\text{final}} = -9.5 \text{ m s}^{-1}$ and t = 1.57 s. Taking upwards as positive, use $v = u + at$.

$v = u + at$

$u = v - at$

$u = -9.5 - (-9.8 \times 1.57)$

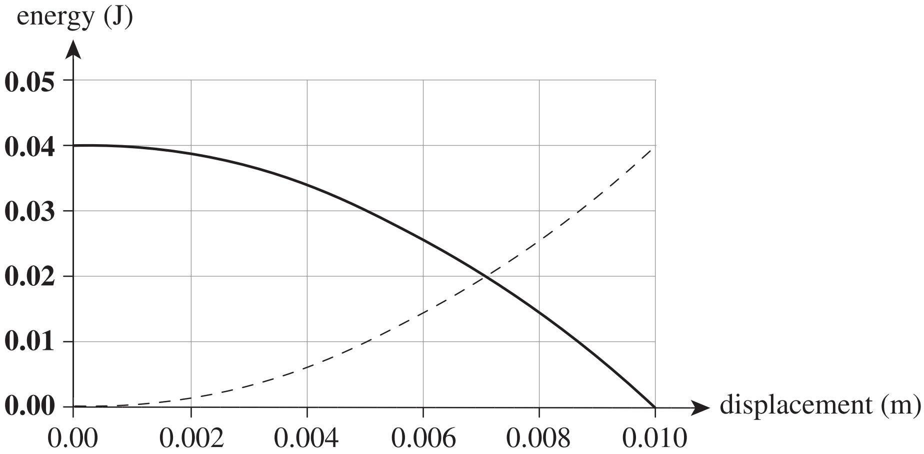
$= 5.89 \text{ m s}^{-1}$ 1 mark

$\text{launch speed} = \sqrt{1.5^2 + 5.89^2}$ 1 mark

$= 6.1 \text{ m s}^{-1}$ 1 mark

Question 10 (4 marks)

a.



$$\frac{1}{2}k(\Delta x)^2 = \frac{1}{2}\times 800\times 0.01^2$$
$$= 0.040 \text{ J}$$

2 marks

1 mark for graph varying from 0.04 J to 0 J over the 0.00–0.01 m range.
1 mark for the curved profile shown (do not accept linear profile).
Note: The dashed line represents the existing graph line in the question.

b. When fully compressed, the spring stores energy. When the spring is fully compressed and the cart is stationary, the total kinetic energy is 0 J. When the spring expands to its natural length, it passes its stored energy to the cart and ball so that the total kinetic energy is 0.040 J using energy conservation. 1 mark

During its expansion phase, the sum of the kinetic energy and the spring's elastic potential energy is a constant of 0.040 J. 1 mark

Question 11 (3 marks)

To the right is positive.

$$\sum p_{\text{initial}} = \sum p_{\text{final}}$$

$$p_{1.0} + p_{2.5} = p_{\text{couple}}$$ 1 mark

$$(1.0\times 2.0) + (2.5\times 1.5) = (1.0 + 2.5)\times v_{\text{couple}}$$

$$v_{\text{couple}} = \frac{2.0 + 3.75}{3.5}$$ 1 mark

$$= 1.6 \text{ m s}^{-1}$$ 1 mark

Question 12 (5 marks)

a. The scientists on Earth calculate a time of 13.6 years based on travelling 10.2 light years at $0.750c$. The proper length of the trip is 10.2 light years. 1 mark

The spacecraft experiences the distance to be moving past it and so it is measures a contracted (shorter length) than 10.2 light years. 1 mark

Thus, the measuring instruments on the spacecraft will record a lesser time than 13.6 years. 1 mark

OR

In comparison to the measurement of time recorded by the spacecraft, the measurement of time recorded by the scientists on Earth will be a dilated value. 1 mark

The time interval in the question is in the spacecraft's frame, so the scientists on Earth are in a moving frame relative to the spacecraft. 1 mark

Thus, the measuring instruments on the spacecraft will record a lesser time than 13.6 years. 1 mark

b.

$$\text{kinetic energy} = (\gamma - 1)mc^2$$

$$= (1.51 - 1) \times 5000\,000 \times (3 \times 10^8)^2 \quad \text{1 mark}$$

$$= 2.30 \times 10^{23} \text{ J} \quad \text{1 mark}$$

Question 13 (4 marks)

a.

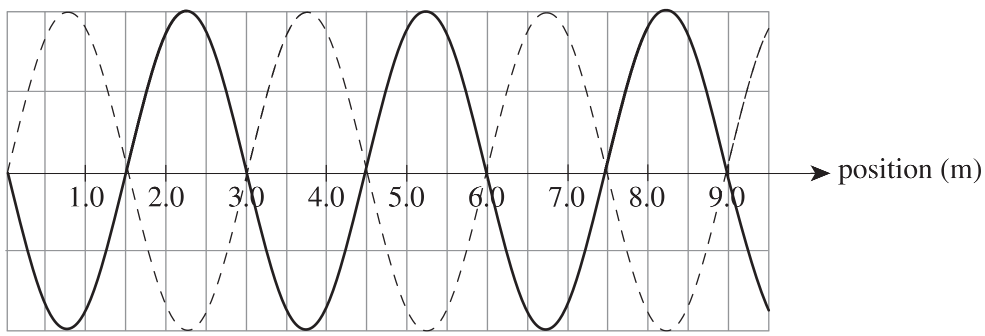
$$\text{wave speed} = \frac{\text{wavelength}}{\text{period}}$$

$$\text{period} = \frac{\text{wavelength}}{\text{wave speed}}$$

$$= \frac{3.0 \text{ m}}{6.0 \text{ m s}^{-1}} \quad \text{1 mark}$$

$$= 0.50 \text{ s} \quad \text{1 mark}$$

b.



2 marks

1 mark for shifting the graph to the right by 1.5 m.

1 mark for showing the same amplitude as the original graph.

Note: The dashed line represents the existing graph line in the question.

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Question 14 (6 marks)

a. The wave from L_1 travels an extra 1.6 m (5.4 – 3.8 = 1.6) compared to the wave from L_2. 1 mark

The wavelength of the sound is $\lambda = \frac{340}{850} = 0.4$ m. 1 mark

The path difference of 1.6 m = 4λ. 1 mark

The two waves meet in phase. Zara is at a position of constructive interference and so she hears a louder sound compared to the sound from L_1 only. 1 mark

b. path difference = 6.0 – B = (0.5, or 1.5, or 2.5 …)λ

Using the 0.5 wavelength:

$6.0 - B = (0.5 \times 0.75)$ 1 mark

$B = 6.0 - 0.375$

$= 5.6\,\text{m}$ 1 mark

OR

Using the 1.5 wavelength:

$6.0 - B = (1.5 \times 0.75)$ 1 mark

$B = 6.0 - 1.125$

$= 4.9\,\text{m}$ 1 mark

OR

Using the 2.5 wavelength:

$6.0 - B = (2.5 \times 0.75)$ 1 mark

$B = 6.0 - 1.875$

$= 4.1\,\text{m}$ 1 mark

OR

Using the 3.5 wavelength:

$6.0 - B = (3.5 \times 0.75)$ 1 mark

$B = 6.0 - 2.625$

$= 3.4\,\text{m}$ 1 mark

Note: Accept working and results for suitable wavelengths/path differences. Only one is required.

Question 15 (3 marks)

Plucking the string sends pulses in both directions, which continually reflect off the fixed ends of the string and interfere with each other upon return. 1 mark

The pattern of interference results in a standing wave of nodes and antinodes. 1 mark

The possible frequencies of the standing waves conform to

$\text{frequency} = \dfrac{n \times \text{wavespeed}}{2 \times \text{string length}}$, where $n = 1, 2, 3, \ldots,$ which are the natural or resonant frequencies. 1 mark

Question 16 (3 marks)

To find the angle of incidence, θ, $n_{\text{water}} \times \sin(\theta) = n_{\text{sapphire}} \times \sin(r)$, where r is the angle of refraction in sapphire. It is also the critical angle given by $i_{\text{critical}} = \sin^{-1}\left(\dfrac{1.00}{1.77}\right) = 34.4°$. 1 mark

$1.33 \times \sin(\theta) = 1.77 \times \sin(34.4)$ 1 mark

$\sin(\theta) = 0.7519$

$\theta = 48.8°$ 1 mark

Question 17 (7 marks)

a. The wave model predicts that light of any colour results in a photocurrent. 1 mark

Trials 1 and 2 indicate that red light shone through low to high intensity does not result in any electrons being released. This conflicts with the wave model prediction. 1 mark

The wave model predicts that increasing the intensity of light results in released electrons being more energetic than the use of light of lower intensity. Thus, a greater stopping voltage is required for the same colour of light used at higher intensity. 1 mark

Comparing trial 6 with trial 5, and trial 4 with trial 3, shows that a higher intensity does not yield electrons of higher energy, as the same stopping voltage is measured. This also conflicts with the wave model prediction. 1 mark

b. Using data for either colour (green or violet), use the equation $qV_{\text{stopping}} = hf - W$.

Method 1:

$0.38 = (4.14\times10^{-15}\times6.000\times10^{14}) - W$ 1 mark

$W = 2.48 - 0.38$ 1 mark

$W = 2.1 \text{ eV}$ 1 mark

Method 2:

$1.6\times10^{-19}\times0.38 = (6.63\times10^{-34}\times6.000\times10^{14}) - W$ 1 mark

$W = 3.37\times10^{-19}\text{ J}$

$= \dfrac{3.37\times10^{-19}}{1.6\times10^{-19}}$ 1 mark

$= 2.1 \text{ eV}$ 1 mark

Method 3:

$1.6\times10^{-19}\times1.00 = (6.63\times10^{-34}\times7.500\times10^{14}) - W$ 1 mark

$W = 3.37\times10^{-19}\text{ J}$

$= \dfrac{3.37\times10^{-19}}{1.6\times10^{-19}}$ 1 mark

$= 2.1 \text{ eV}$ 1 mark

Method 4:

$1.00 = (4.14\times10^{-15}\times7.50\times10^{14}) - W$ 1 mark

$W = 3.10 - 1.00$ 1 mark

$W = 2.1 \text{ eV}$ 1 mark

Question 18 (5 marks)

a. $\lambda = \dfrac{h}{p}$ and $p = mv$

Given that $KE = \dfrac{1}{2}mv^2 = \dfrac{p^2}{2m}$, then $p = \sqrt{2mKE}$.

$KE = qV$ and thus:

$\lambda = \dfrac{h}{\sqrt{2mqV}}$ 1 mark

$= \dfrac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times10\,000}}$ 1 mark

$= 1.2\times10^{-11}\text{ m}$ 1 mark

b. $p = \dfrac{h}{\lambda}$

$= \dfrac{6.63\times10^{-34}}{1.23\times10^{-11}}$ 1 mark

$= 5.4\times10^{-23}\text{ kg m s}^{-1}$ 1 mark

Note: Consequential on answer to ***Question 18a****.*

Question 19 (3 marks)

The emission spectrum represents the particular photon energies emitted when electrons transit from a higher energy level to a lower energy level. Given that the colours are specific, the energy levels of the electrons must be specific too. 1 mark

The energy levels are not random but are the result of electrons having specific de Broglie wavelengths. 1 mark

These energies are manifested as standing waves, where the circumference of the standing wave is a whole number of wavelengths. 1 mark

Question 20 (16 marks)

a. For the parameters listed, the relationship is $\Delta x = \frac{\lambda L}{d}$. 1 mark

Increasing the width of the hair without altering any other parameters will cause a decrease in Δx. 1 mark

Thus, there will be more dark and bright spots across the width of the screen. 1 mark

b. The dependent variable is Δx, the distance between the central and the first maxima of intensity, as it is affected by the width of the hair in its diffraction angles. 1 mark

The independent variable is *d,* the width of the hair, as this is altered by the students. 1 mark

c.

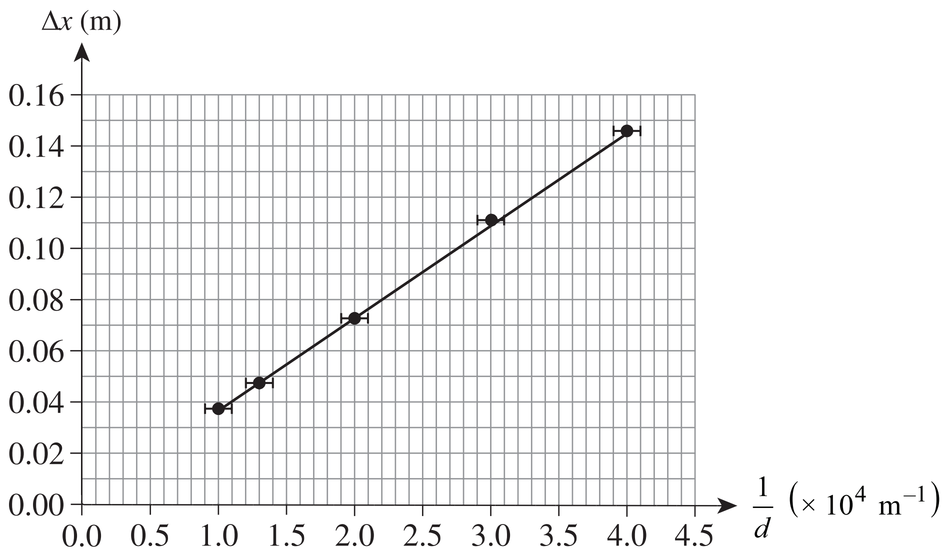
Δx (m)	d (m)	$\frac{1}{d}$ (m^{-1}) $\pm 0.1 \times 10^4$
0.146	25×10^{-6}	$\mathbf{4.0 \times 10^4}$
0.111	33×10^{-6}	$\mathbf{3.0 \times 10^4}$
0.072	51×10^{-6}	$\mathbf{2.0 \times 10^4}$
0.048	76×10^{-6}	$\mathbf{1.3 \times 10^4}$
0.037	98×10^{-6}	$\mathbf{1.0 \times 10^4}$

2 marks

1 mark for correct values.

1 mark for values given to two significant figures.

d.



6 marks

1 mark for correct y-axis scale.

1 mark for correct x-axis scale.

1 mark for correctly plotted points.

1 mark for plotted points occupying at least half the vertical and half the horizontal planes of the grid included in the Question Booklet.

1 mark for x-direction uncertainty bars.

1 mark for straight line of best fit drawn through uncertainty bars.

Note: Consequential on answer to ***Question 20c****. A mark may be awarded for a line of best fit that fits the plotted points regardless of correct or incorrect plotting of data.*

e.

$$\text{gradient} = \frac{(0.146 - 0.037)}{\left(4.0 \times 10^{-4} - 1.0 \times 10^{4}\right)}$$

$$= 3.6 \times 10^{-6} \text{ m}$$

$$\Delta x = \frac{\lambda L}{d}$$

$$\lambda = \frac{\Delta x d}{L}$$

$$= \frac{\text{gradient}}{L}$$

$$= \frac{3.6 \times 10^{-6}}{5.50}$$

$$= 6.6 \times 10^{-7} \text{ m}$$

3 marks

1 mark for attempting to calculate the gradient.

1 mark for giving the gradient within the range between 3.4 and 3.9 ($\times 10^{6}$ m).

1 mark for giving the final answer within the range between 6.2 and 7.1 ($\times 10^{-7}$ m).