2019

HIGHER
SCHOOL
CERTIFICATE
TRIAL EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations
- Write your Student ID at the bottom of this page and at the top of page 10

Total marks: 100

Section I — 20 marks (pages 2-9)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II — 80 marks (pages 10-29)

- Attempt Questions 21–36
- Allow about 2 hours and 25 minutes for this section

STUDENT ID: _____

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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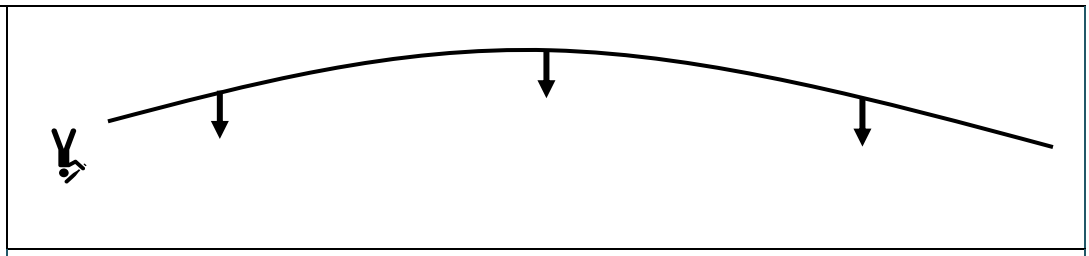
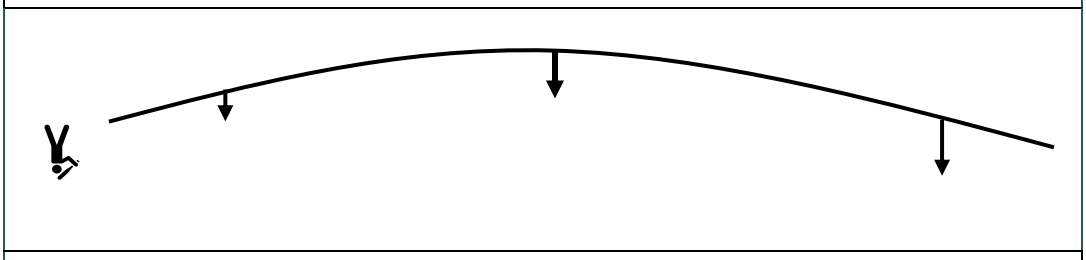
1 Which vector diagram correctly shows the force vectors acting on an object just after it was fired from a slingshot?

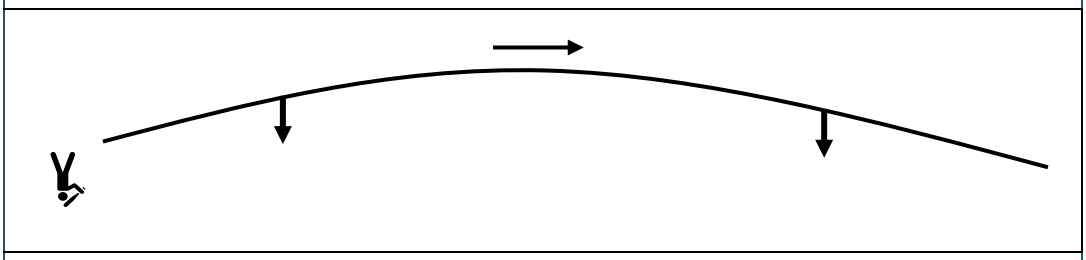
A.



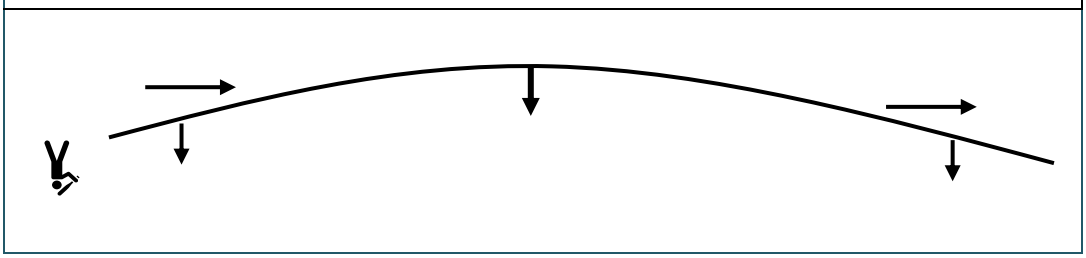
B.



C.



D.



2 'Prior to digital technology, the use of a pendulum was the most accurate method for determining the acceleration due to gravity in a school laboratory.'

Which explanation best justifies this statement?

A. Pendulums are very easy for students to set up

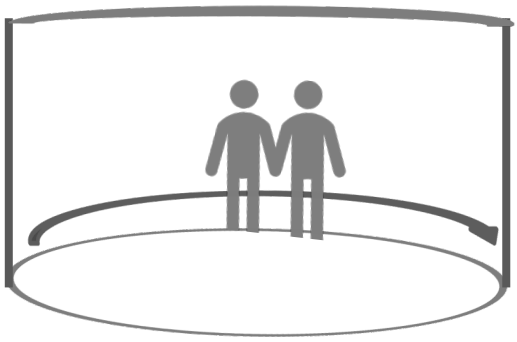
B. The equations needed for calculations are easy to use

C. Measurement errors for both variables can be minimised

D. A stop watch can be used to measure the time for one swing

3 The information below relates to Questions 3 and 4.

Children on a rotating drum ride continue to rotate, but remain suspended, when the floor is dropped away?



Which statement about the forces acting on the children best explains why this happens?

A. The gravitational force balances both the centripetal force and the horizontal forces.

B. The horizontal friction force, plus the gravitational force combine to hold them in position.

C. The centripetal force due to the drum's rotation, and the reaction force of the wall are in balance.

D. The unbalanced centripetal force pushing the children to the wall causes them to hold their position.

4 Before the floor is lowered, the drum needs to be rotated at velocity, v. This produces a centripetal force, F**.** As the floor is raised, the velocity is decreased.

What will the centripetal force be when the velocity decreases to **½** v?

A. ½ F

B. ¼ F

C. 2 F

D. 4 F

5 A communication satellite is launched and set in orbit around the Earth.

Which orbital altitude would it need to be placed in to work effectively?

A. 550 km

B. 24 600 km

C. 35 800 km

D. 45 900 km

6 In which type of star is the CNO cycle the predominant reaction?

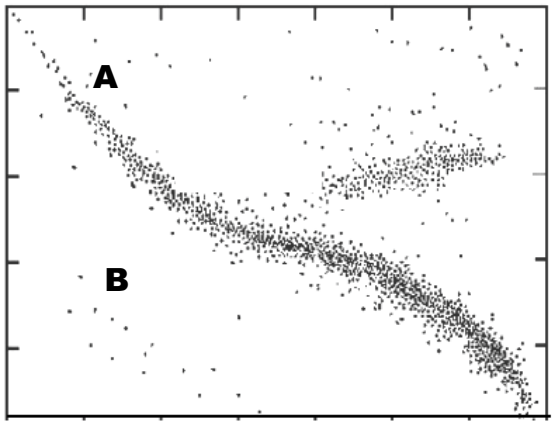
A. Low mass red giant

B. High mass red giant

C. Low mass main sequence

D. High mass main sequence

7 This is a Hertzsprung-Russell (H-R) diagram showing many star plots. The axes are not labelled.



Which group correctly compares the luminosity and surface temperature of stars plotted at positions **A** and **B**?

	Stars at A		***Stars at B***	
	Luminosity	*Temperature*	*Luminosity*	*Temperature*
A.	Low	Low	High	High
B.	Low	High	Low	Low
C.	High	Low	Low	Low
D.	High	High	Low	High

8 Which experiment directly helped Ernest Rutherford develop his model of the atom?

A. Millikan's oil drop experiment

B. The Geiger-Marsden experiment

C. Chadwick's discovery of the neutron

D. Thomson's charge to mass ratio experiment

9 What is the wavelength of the spectral line produced when an electron undergoes transition from energy level n = 5 to energy level n = 2.

A. $2.39 \times 10^{6}\ m$

B. $3.29 \times 10^{6}\ m$

C. $4.34 \times 10^{-7}\ m$

D. $3.04 \times 10^{-7}\ m$

10 Which nuclear equation correctly shows the β-decay of thallium–210?

A. $^{210}_{81}\mathrm{Tl} \rightarrow {}^{210}_{82}\mathrm{Pb} + {}^{0}_{-1}\mathrm{e}$

B. $^{210}_{81}\mathrm{Tl} \rightarrow {}^{210}_{80}\mathrm{Hg} + {}^{0}_{-1}\mathrm{e}$

C. $^{210}_{81}\mathrm{Tl} \rightarrow {}^{206}_{79}\mathrm{Au} + {}^{4}_{2}\mathrm{He}$

D. $^{210}_{81}\mathrm{Tl} \rightarrow {}^{210}_{81}\mathrm{Tl} + {}^{0}_{-1}\mathrm{e}$

11 Why do some electrical appliances used in the home, use transformers?

A. They require a source of energy that is DC rather than AC.

B. They require an alternating current at a frequency other than 50 Hz.

C. They consume less energy than a similar device without a transformer.

D. They require a lower voltage than the output voltage from a power point.

12 Which wave property enabled Hertz to calculate the velocity of radio waves and compare them to the velocity of light?

A. Interference

B. Polarisation

C. Reflection

D. Refraction

13 Two parallel plates are 2 mm apart and have a potential difference of 100 V between them. An electron is placed halfway between the plates.

What is the magnitude of the force on the electron?

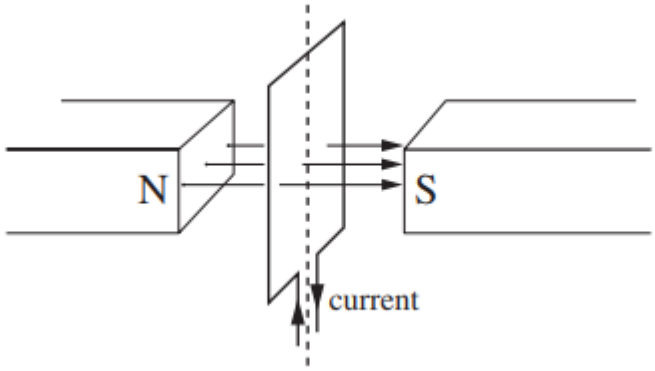
A. 8.0×10^{-18} N

B. 1.6×10^{-17} N

C. 8.0×10^{-15} N

D. 1.6×10^{-14} N

14 An electric motor is set up as shown.



When current is supplied, the coil does not turn.

Which of the following is required for the coil to start turning?

A. The magnetic field must be increased.

B. The direction of the current must be reversed.

C. The magnitude of the current must be increased.

D. The starting position of the coil must be changed.

15 An electric DC motor consists of 500 turns of wire formed into a rectangular coil of dimensions 0.2 m × 0.1 m. The coil is in a magnetic field of 1.0×10^{-3} T. A current of 4.0 A flows through the coil.

What is the magnitude of the maximum torque, and the orientation of the plane of the coil relative to the magnetic field when this occurs?

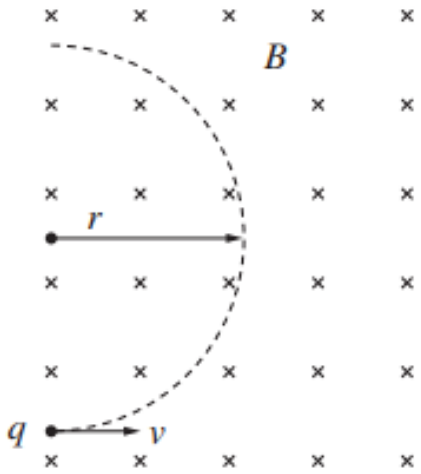
A. 0.4 N m, parallel to the field

B. 0.04 N m, parallel to the field

C. 0.4 N m, perpendicular to the field

D. 0.04 N m, perpendicular to the field

16 A charged particle, q, enters a uniform magnetic field B at velocity v. The particle follows a circular path of radius, r as shown.



If the magnitude of the magnetic field was doubled and the other variables were kept constant, what would the new radius be?

A. $\frac{r}{4}$

B. $\frac{r}{2}$

C. $2r$

D. $4r$

17 The signal from a microwave transmitter can be thought of as a beam of photons.

If the photons from the transmitter have a wavelength of 3.5×10^{-2} m, what is the approximate energy of each photon?

A. 5.68×10^{-24} J

B. 1.89×10^{-32} J

C. 2.32×10^{-35} J

D. 7.73×10^{-44} J

18 A scientist at a particle accelerator laboratory observes a subatomic particle travelling at 0.9999 c. She notes its lifetime to be 1.0×10^{-6} s.

What would the lifetime of the particle be if it were stationary in the laboratory?

A. 4.9×10^{-8} s

B. 1.4×10^{-8} s

C. 1.4×10^{-7} s

D. 1.0×10^{-6} s

19 A beam of light is emitted from a source and passes through two polarising plates set at 60° from one another.

Use Malus' Law to calculate the received intensity at a sensor placed on the opposite side of these plates.

A. $I = \frac{I_0}{2}$

B. $I = \frac{3I_0}{4}$

C. $I = \frac{\sqrt{3}I_0}{2}$

D. $I = \frac{I_o}{4}$

20 Which statement about the Michelson-Morley experiment is correct?

A. It was a valid experiment because it accounted for all the known properties of light.

B. It was an invalid experiment because it did not account for the particle nature of light.

C. It was a valid experiment because it was designed to test the principle of relativity.

D. It was an invalid experiment because it did not account for Earth moving through the aether

Question 21 (5 marks)

A satellite in a low earth orbit of 800 km is in danger of falling out of orbit. The owners decide to manoeuvre the satellite safely to a lower orbit of 600 km.

DIAGRAM NOT TO SCALE

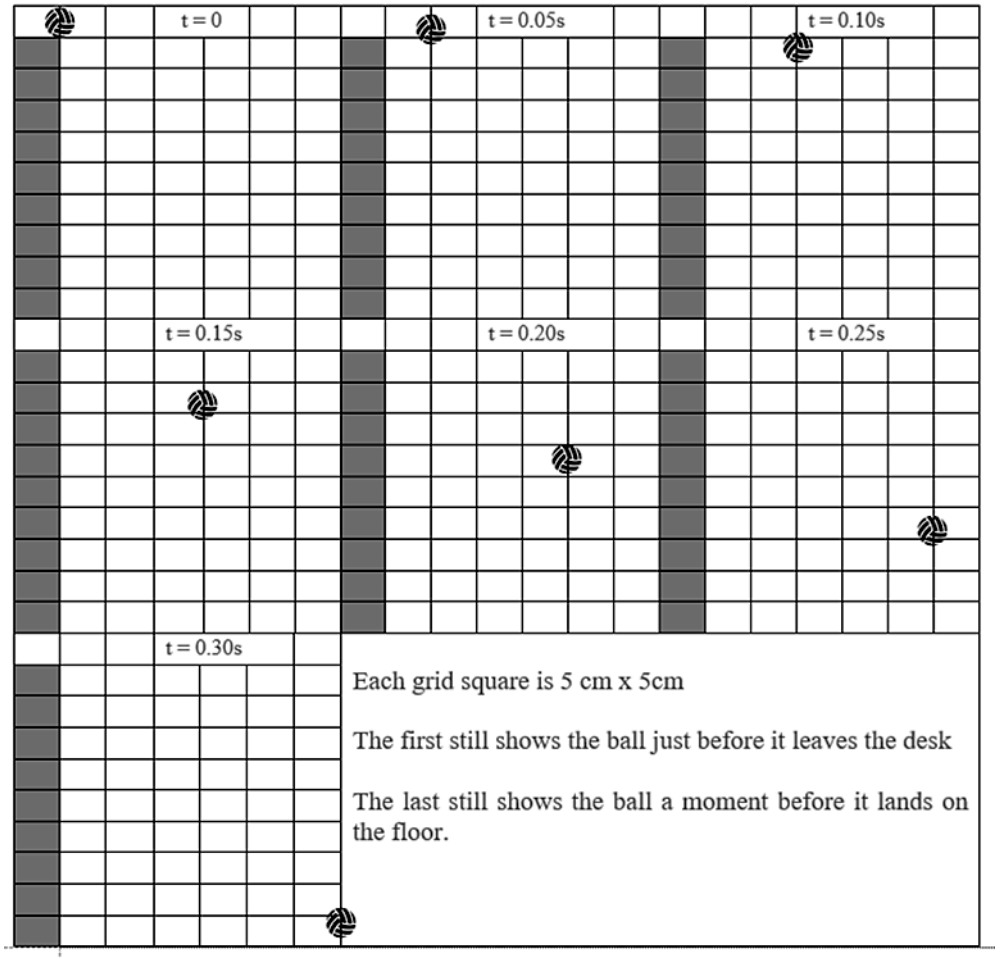
(a) Calculate the increase in velocity required by the satellite to remain in the lower 600 km orbit. **2**

(b) Explain how a change in altitude can increase the satellite's orbital velocity. **3**

Question 22 (8 marks)

Students conducted an experiment to analyse the motion of projectiles. They used their phones to film a ball rolling off a desk with various horizontal launch velocities. They used a large, scaled grid for the background.

The picture below shows the consecutive stills they produced for their first launch velocity. The time between each frame is 0.05 seconds.



(a) Calculate the ball's first launch velocity. **1**

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Question 22 continues on page 13

Question 22 (continued)

(b) Calculate the range of the ball for a horizontal launch velocity of 3 ms^{-1}. **2**

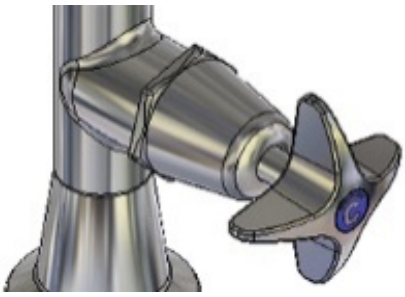
(c) Use the students' results to explain how the acceleration due to gravity could be determined. **4**

(d) Outline a source error that could impact upon the accuracy of their results. **1**

End of Question 22

Question 23 (3 marks)

Many aged care facilities house people with weakened hand grips. They use taps with long handles like Tap A rather than taps like Tap B.

Tap A	Tap B
	

3

Justify, using physics principles, why Tap A would be the better tap to have in these facilities compared to Tap B.

Question 24 (4 marks)

A distant sun has several planets orbiting it. Information on the planets' orbital radius and period are set out in the table below.

Planet	*Radius in metres*	*Period in seconds*
Hellebore	6.2×10^8	4.2×10^4
Dalia	**?**	8.4×10^4
Protist	1.56×10^9	1.68×10^5

(a) Calculate the orbital radius of Dalia. **2**

(b) Compare the gravitational field strength experienced by Hellebore and Protist. **2**

Question 25 (7 marks)

Humans are dependent on the energy from nuclear reactions that occur in the Sun. They have also built nuclear reactors on Earth to harness the energy from nuclear reactions.

(a) Explain how the production of energy in the Sun differs to that produced by built reactors. **4**

Question 25 continues on page 17

Question 25 (continued)

(b) Compare controlled and uncontrolled nuclear fission reactions. **3**

End of Question 25

Question 26 (2 marks)

Calculate the wavelength of an electron travelling at 0.78×10^6 ms^{-1}. **2**

Question 27 (3 marks)

Account for the different properties of alpha, beta and gamma radiation. **3**

Question 28 (8 marks)

Assess the contributions of Schrödinger, Bohr and Rutherford in the development of the currently accepted model of the atom. **8**

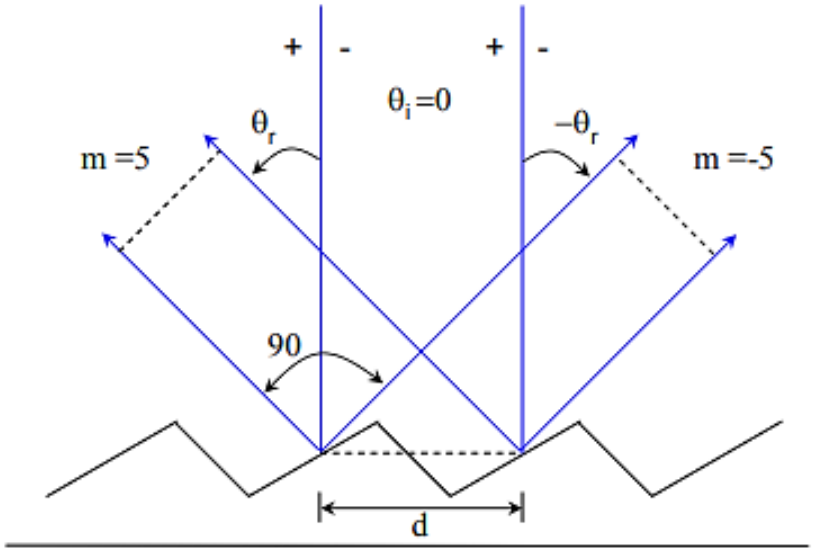
Question 28 continues on page 20

Question 28 (continued)

End of Question 28

Question 29 (4 marks)

The diagram below represents a grating with 8000 slits ruled across a width of 4 cm, where m is the diffraction order of the grating.



(a) Calculate the wavelength of light that subtends this grating at an angle of 90°. (Note that θi = 0.) **3**

(b) What colour of light does this wavelength roughly correspond to? **1**

Question 30 (5 marks)

A laser that only emits light of wavelength 550 nm is directed at a metal that must absorb a minimum of 5×10^{-19} J for electrons to be ejected from its surface.

(a) Calculate the frequency of this light. **2**

(b) Will electrons be ejected from this metal when this laser is used? Support your answer with relevant calculations. **3**

Question 31 (7 marks)

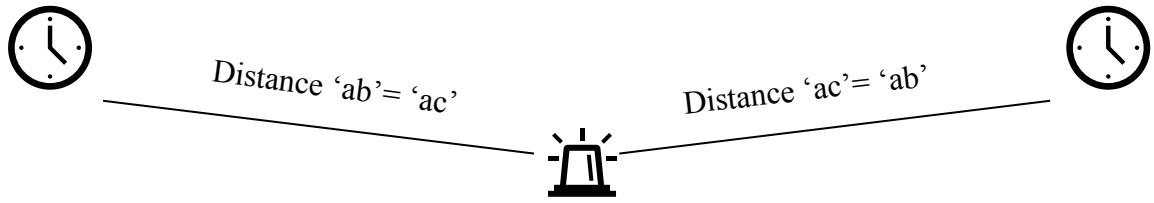
(a) Explain how the production and propagation of electromagnetic waves relates to Maxwell's predictions. **3**

(b) Describe how the study of the spectra of a star can give us information about its surface temperature, motion, and chemical composition. **4**

Question 32 (4 marks)

Consider the following thought experiment.

A scientist on board a spaceship wishes to synchronise two clocks. To achieve this, beams of light from a source placed midway between the clocks activate photocells, turning on both clocks.



The scientist observes the synchronisation of the clocks as the rocket flies past Earth at 0.8c **4**
A person on Earth observes that the clocks are not synchronised.

Account for these conflicting observations.

Question 33 (1 mark)

The primary winding of a transformer contains 2000 turns. The primary AC voltage is 23 000 volts and the output voltage is 660 000 volts.

Calculate the number of turns on the secondary winding. **1**

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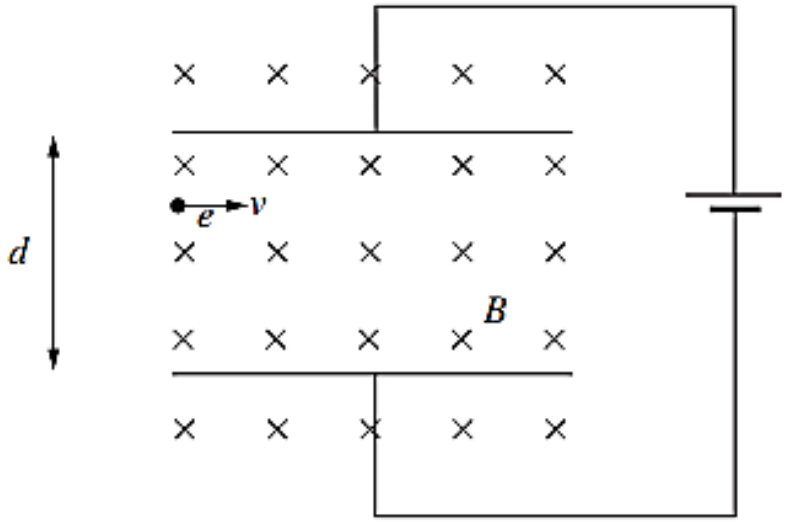
Question 34 (5 marks)

Two parallel charged plates are set up at a distance, *d*, from one another as shown in the diagram below:



The magnetic field strength, $B = 0.02\ T$, the electron's velocity, v = $3.5 \times 10^6\ ms^{-1}$, and the distance between the plates, $d = 5mm$.

(a) Indicate on the diagram the direction of force that will act on the electron moving between these plates. **1**

Question 34 continues on page 26

Question 34 (continued)

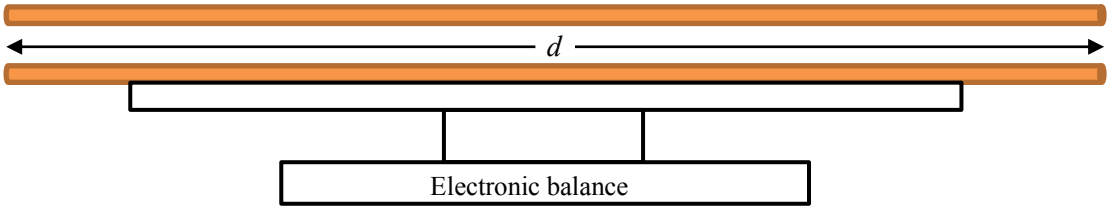
(b) Calculate the magnitude of the magnetic force on the electron. **2**

(c) Calculate the voltage that needs to be supplied to the plates to keep the electron traveling in a straight path, parallel to the plates. **2**

End of Question 34

Question 35 (8 marks)

A balance was used to investigate the relationship between current and force. The balance was set up with one copper rod fixed to it and a second rod fixed above it. Each rod was connected to a source of current.



The copper rods were rigid and remained parallel, with $d = 2.6$ m.

The current through the upper rod was kept constant at 50 A. Different currents were passed through the lower rod and the balance reading recorded for each current. The readings are given in the table below.

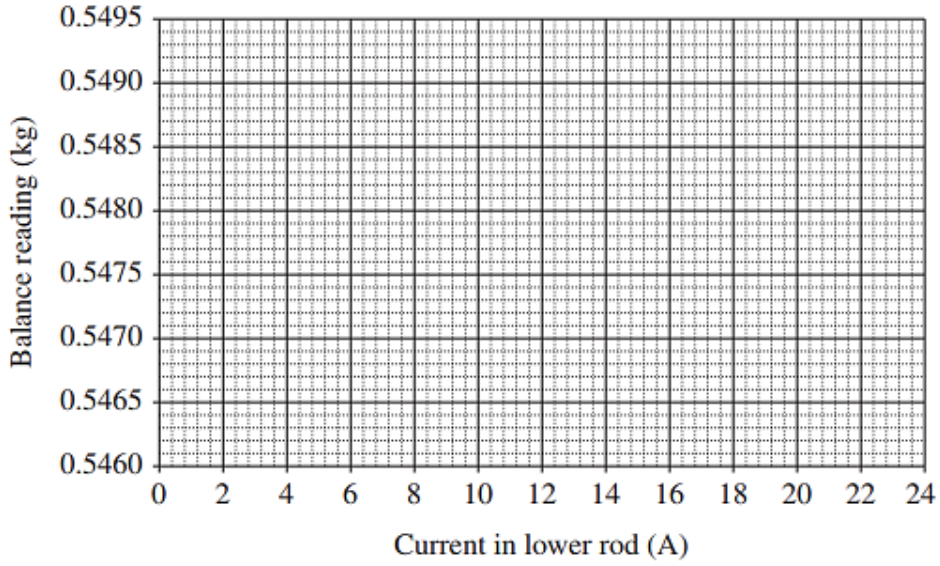
Current in lower rod (A)	*Balance reading* (kg)
2.8	0.5485
8.0	0.5480
12.2	0.5474
16.8	0.5470
20.0	0.5465

(a) Identify the relative directions of the currents in both rods AND justify your answer. **2**

Question 35 continues on page 28

Question 35 (continued)

(b) Plot the data from the table onto the graph, using the scales and axes as indicated, THEN add the line of best fit. **2**



(c) Find the mass of the copper rod on the balance. **1**

(d) Calculate the distance between the two copper rods. **3**

End of Question 35

Question 36 (6 marks)

Analyse the impact the discovery of the motor effect has had on society and the environment. **6**

End of paper

2019 HSC Trial
Physics Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (5 marks)

(a) 2 marks

Criteria	Marks
• Calculates correct answer with working	2
• Calculates either correctly	1

Sample answer:

$v = \sqrt{\frac{GM}{d}}$ where G = 6.67 x 10 $^{-11}$; M = 6 x 10^{24}; d = 6.38 x 10^6 + (0.6 or 0.8 x 10^6)

$v = \sqrt{\frac{6.67 \times 10^{-11} x\ 6.0 \times 10^{24}}{6.98 \times 10^6}}$ $\sqrt{\frac{6.67 \times 10^{-11} x\ 6.0 \times 10^{24}}{7.18 \times 10^6}}$

$v = \sqrt{\frac{400.2 \times 10^{12}}{6.98 \times 10^6}}$ $\sqrt{\frac{400.2 \times 10^{12}}{7.18 \times 10^6}}$

$v = \sqrt{57.3 \times 10^6}$ $\sqrt{55.7 \times 10^6}$

= 7.57 x 10^3 ms^{-1} 7.47 x 10^3 ms^{-1}

Therefore, an increase of 100 ms^{-1}

(b) 3 marks

Criteria	Marks
• Identifies that the lower orbit needs a higher velocity • Outlines how a change in altitude means a change in the satellite's potential energy • Correctly links the change in PE to an increase in velocity	3
• Identifies that a change in altitude means a change in the satellite's gravitational potential energy • Links this in some way to increased velocity	2
• Identifies in some way that a change in altitude means a change in the satellite's gravitational potential energy	1

Sample answer:
The satellite requires a higher velocity if it is to maintain a lower orbit. As the satellite is manoeuvred into the lower orbit, it undergoes a loss in potential energy. As energy must be conserved, this loss of potential energy is converted to an increase in kinetic energy which increases the satellite's orbital velocity.

Question 22 (8 marks)

(a) 1 mark

Criteria	Marks
• Identifies that the ball travels 5 cm every 0.05s and does calculation correctly	1

Sample answer:

v = d/t
= .05/.05
= $1ms^{-1}$

(b) 2 marks

Criteria	Marks
• Determines time of flight and then determines correct range	2
• Determines time of flight correctly OR does range calculation correctly	1

Sample answer:

$t = \sqrt{\frac{2s}{a}} \quad = \sqrt{\frac{2 \times 0.45}{9.8}}$ = 0.303 s

Therefore range = 3 x .303 = 0.91m

(c) 4 marks

Criteria	Marks
• Shows comprehensive understanding of how gravity could be determined – *Clearly describes how to accurately use students' data to get vertical distance travelled AND time taken off grids* – *Identifies correct equation to use for calculating g* – *Then clearly demonstrates how to determine g from extracted data using either a graphical method or using arithmetic average*	4
• Shows solid understanding of how gravity could be determined	3
• Shows some understanding of understanding of how gravity could be determined	2
• Provides some relevant information	1

Sample answer on next page

Sample answer:
For vertical analysis in this experiment $s = ½ gt^2$
To get a good average for all their frames they can use the concept of the equation for a straight-line y = mx to plot **s** on the y axis and $\mathbf{t^2}$ on the x axis. This means **½** g will be the gradient of the line of best fit. (OR they could use an arithmetic average by using a rearrangement of $s = ½ gt^2$; $g = 2s/t^2$ to calculate g for each time frame and then average the results)

Students need to use the scale and grid lines to measure the vertical distance to the bottom of the ball in each time interval and record their results in a table, they then need to use the time indicated on each frame; making sure they use standard SI units for each.
To plot a graph, they need to calculate t^2 for each time interval. They can then plot each t^2 against the vertical displacement for that time frame, A straight line of best fit can then be drawn, and the gradient (rise over run) determined. Once determined as m = ½ g then g = 2 x the gradient

(OR To do the arithmetic average they need to do a calculation for each time frame. Then determine the average.)

For example, in the final frame of 0.30s the distance to the bottom of the ball is 44 cm or 0.44 m then 2 x 0.44/0.09 = 9.78 ms^{-1}

(d) 1 mark

Criteria	Marks
• Identifies a source of error and links it in some way to a measurement	1

Sample answer:
Distances could be inaccurate if students are not careful to make sure they use the same point on the ball for each displacement measurement.

Question 23 (3 marks)

Criteria	Marks
• Identifies that torque is the rotational effect of a force • Describes the relationship between torque, force and perpendicular distance • Relates this to why the larger handled tap requires less applied force	3
• Identifies that torque is the rotational effect of a force • Relates torque and applied force in some way to why the larger handled tap requires less applied force	2
• Identifies in some way that torque is increased as the distance from the pivot is increased	1

Sample answer:
As torque is the rotational effect of a force, we can see from the equation: $\tau = \mathrm{Fd}$ that as d increases it will take less force to turn the device. This means it will turn more easily (with less force) when the force is applied to the end of a longer handle.

Question 24 (5 marks)

(a) 2 marks

Criteria	Marks
• Correctly calculates answer with working using Kepler's Law relationship	2
• Calculates an answer with an error using Kepler's Law relationship	1

Sample answer with thought process:

$\frac{r^3}{T^2} = \text{constant}$ $\frac{(6.2\times10^8)^3}{(4.2\times10^4)^2} = \text{constant}$ $\frac{238.3\times10^{24}}{17.6\times10^8} = 13.54 \times 10^{16}$

Therefore constant = 13.54×10^{16} rearrange equation to make radius of Dalia the subject:

$r^3 = T^2\, 13.54 \times 10^{16}$
$r^3 = (8.4 \times 10^4)^2 \times 13.54 \times 10^{16}$
$r^3 = 955.4 \times 10^{24}$
$r = \sqrt[3]{955.4 \times 10^{24}} = 9.85 \times 10^8$ m

(b) 2 marks

Criteria	Marks
• Describes the relationship between radius and gravitational strength as an inverse square relationship $g = \frac{GM}{r^2}$ • Uses inverse square to relate variations in radius of each planet to strength of field	2
• Identifies the relationship between radius and gravitational strength as an inverse square relationship	1

Sample answer:

Both Protist and Hellebore will experience a gravitational field according to: $g = \frac{GM}{r^2}$.

As Protist is 2.5 times further away from their sun than Hellebore; and gravitational field strength is an inverse square relationship meaning $g \propto \frac{1}{r^2}$.

Therefore, Hellebore will experience $\frac{1}{2.5^2}$ or about 6.3 times the gravitational field of Protist.

Question 25 (7 marks)

(a) (4 marks)

Criteria	Marks
• Shows comprehensive understanding of how the production of energy in the Sun differs to that produced by built reactors ie: – *Describes BOTH fusion reactions of small nuclei for Sun and fission reactions of large unstable nuclei for built reactors* – *Relates energy production in both cases to production of more tightly bound nuclei with less mass per nucleon* – *Describes how both reactions utilise $E = mc^2$ to convert mass loss per nucleon into energy*	4
• Shows solid understanding of how the production of energy in the Sun differs to that produced by built reactor	3
• Shows some understanding of differences by relating energy production in some way to mass loss	2
• Provides some relevant information	1

Sample answer:
Fusion reactions in the Sun involve small nuclei such as hydrogen combining to produce larger nuclei such as helium. The resultant larger nuclei are held together more tightly and have less mass per nucleon. This mass deficit is converted to energy as per $E = mc^2$. This process can occur up to a maximum of iron as it is the most tightly bound nucleus with the lowest mass per nucleon.

Fission reactions in built reactors split very large unstable nuclei into smaller more stable nuclei. The resultant smaller nuclei are held together more tightly and have less mass per nucleon just as in fusion reactions. This mass deficit is also converted to energy as per E = mc2. Again, this process can occur down to a minimum of iron.

(b) 3 marks

Criteria	Marks
• Makes a solid comparison of controlled and uncontrolled nuclear fission reactions demonstrating solid understanding ie: – *Describes the process of a fission reaction* – *Relates the production of 3 neutrons in each uncontrolled reaction to starting a chain reaction resulting in huge release of energy such in a bomb* – *Describes the addition of a nonfissioning material in controlled reactions to absorb some of the released neutrons thus slowing the reaction rate and energy production*	3
• Makes a comparison of controlled and uncontrolled nuclear fission reactions demonstrating some understanding	2
• Provides some details about controlled and uncontrolled nuclear fission reactions	1

Sample answer on next page

Sample answer:

A fission reaction is the splitting of a larger nucleus by a neutron to produce 2 smaller nuclei plus 3 neutrons plus energy: $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{92}_{36}Kr + ^{141}_{56}Ba + 3^{1}_{0}n$ + energy

In an uncontrolled nuclear fission reaction these 3 neutrons start a chain reaction. This means the 3 neutrons produced in turn split 3 more nuclei that produce 9 more neutrons to split 9 more nuclei, then they in turn produce 27 then 81 then 243 and so on, releasing energy in an uncontrolled way such as a bomb going off. In a controlled reaction such as in a reactor, rods of nonfissioning material are inserted into the fissioning material to absorb and slow down the neutrons thus controlling the rate of reaction and energy production.

Question 26 (2 marks)

Criteria	Marks
• Uses correct equation and substitutes correctly to get correct answer including units	2
• Correct substitution with minor calculation error	1

Sample answer:

$\lambda = \frac{h}{mv}$

$\lambda = \frac{6.63 \text{ x } 10^{-34}}{9.1\text{x } 10^{-31} \times 0.78 \text{ x } 10^{6}}$

$\lambda = 9.3 \text{ x } 10^{-10}$ m

Question 27 (3 marks)

Criteria	Marks
• Correctly describes each type of radiation • Relates penetration power to size of each type of radiation • Relates ionising power to the charge of each type of radiation	3
• Correctly describes each type of radiation • Relates EITHER penetration power OR ionising ability correctly to each	2
• Relates EITHER penetration power OR ionising ability correctly to at least two types of radiation	1

Sample answer:

Alpha radiation is a helium nucleus (2 protons plus 2 neutrons) with a plus 2 charge; beta radiation is an electron with a one minus charge; and gamma radiation is a very short wavelength electromagnetic wave. Alpha radiation has the least penetration power due to its relatively large particle size having 4 nucleons; beta is the next in penetration power due to its much smaller particle size being only one electron (nearly 2000^{th} the size of one nucleon); gamma is the most penetrating as it is not a particle but a high energy EM wave. Alpha radiation is the most ionising having two protons giving it a 2 plus charge; beta is the next in ionising ability have one electron giving it a one minus charge; gamma is the least ionising having no charge as a high energy EM wave.

Question 28 (8 marks)

Criteria	Marks
• Correctly describes the currently accepted model of the atom • Relates the main aspects of the model to supporting evidence • Describes the contribution of each of the three scientists • Links each scientist's contribution to the supporting evidence • Relates the impact of each scientist's contribution to the forward development of the model	8-7
• Correctly describes the currently accepted model of the atom • Relates some aspects of the model to supporting evidence • Describes the contribution of each of at least two scientists • Links at least two scientists' contribution to the supporting evidence for the current model • Relates the impact of at least two scientists' contributions to the forward development of the model	5-6
• Correctly outlines the currently accepted model of the atom • Relates one aspect of the model to the available supporting evidence • Describes the contribution of each of at least one scientist • Relates the impact of one scientist's contribution to the forward development of the model	3-4
• Correctly identifies the currently accepted model of the atom • Identifies the contribution of each of at least one scientist	1-2

Sample answer:

The currently accepted model has a small, dense nucleus containing the positive protons and neutral neutrons in the centre of a cloud of negatively charged electrons. The cloud of electrons takes up most of the space and the nucleus makes up most of the mass.

The evidence for the main components:

- Thompson's cathode ray expt. Determined the charge to mass ratio of electrons - evidence of the electrons being very low in mass and negatively charged
- Rutherford interpreted Goldstein's discovery of positive particles later called protons.
- Rutherford's analysis of Geiger/Marsden's gold foil experiment supplied evidence of the atom being mostly empty space with a dense nucleus and with electrons around it
- Bohr used experiments with EM emissions from atoms to suggest electrons existed in certain energy levels rather than set orbits and that they could go up or down levels, emitting or releasing energy in quantised packets.
- Schrödinger and Heisenberg suggest electrons do not follow set orbits but exist in a cloud and behave as waves. They use mathematical equations to predict the likelihood of finding an electron in a certain position
- Chadwick discovers the neutron

Rutherford's interpretations of Goldstein's and Geiger/Marsden's work lead to a model of an atom made up of mostly empty space, with a small dense nucleus containing positive protons, surrounded by a cloud of electrons and the rejection of Thompson's Plum Pudding model. It solved many of the problems of Thompson's model but still had issues with why the electrons did not finish up in the nucleus.

Bohr's work with EM emissions and the concept of packets of energy lead to the development of a model that had electrons in shells or energy levels; plus, it also led to a whole new area of physics called quantum physics. This model could explain most of the properties of the current model, plus why particular elements give off specific EM emissions, but it was not consistent for all elements.

Schrödinger's model superseded Bohr's model of electrons still orbiting the nucleus but rather predicted the likelyhood of finding an electron in a particlular place. It suggested electrons move in waves without any exact location. He developed equations to predict the likelyhood of finding an electron, suggesting the cloud would be most dense closer to the positive nucleus

As each scientist contributed to the progression of the model they all made significant contributions to get us to where we are today

Question 29 (4 marks)

(a)

Criteria	Marks
• Uses correct formula • Substitutes into correct places • Calculates correct answer with working	3
• Uses correct formula • Makes progress with calculation	2
• Uses correct formula or makes some progress with calculation	1

Sample answer:

$m\lambda = d(sin\,\theta i + sin\,\theta r)$

Where m is the diffraction order, λ is the wavelength, d is the groove spacing, θi is the incident angle, and θr is the diffracted angle.

Incident angle θi = 0 and θr = 45. to get.

$$\lambda = \frac{d(\sin\theta i + \sin\theta r)}{m}$$

$$\lambda = \frac{\frac{0.04}{8000} + \sin 45}{5}$$

$$\lambda = 701.9\,nm$$

(b)

Criteria	Marks
• Provides correct answer	1

Sample answer:

Red light

Question 30 (5 marks)

(a)

Criteria	Marks
• Substitutes correctly into formula: $f = \frac{c}{\lambda}$ • Calculates correct answer with working, including correct units	2
• Substitutes correctly into formula: $f = \frac{c}{\lambda}$	1

Sample answer:

Substitutes correctly into formula: $f = \frac{c}{\lambda}$

$$\mathrm{f} = \frac{2.99 \times 10^{8}\ ms^{-1}}{550 \times 10^{-9}\ m}$$

Calculates correct answer $\mathrm{f} = 5.43 \times 10^{14}\ Hz$

Note: deduct 1 mark for incorrect units

(b)

Criteria	Marks
• Identifies electrons will not be emitted • Calculates correct energy using $E = hf$ • Justifies negative answer by comparing this energy to the minimum energy needed to eject an electron - 5.0×10^{-19}	3
• Makes significant progress with answer	2
• Makes some progress with answer	1

Sample answer:

$$E = hf$$
$$E = 6.62 \times 10^{-34} \times 5.43 \times 10^{14}$$
$$E = 3.60 \times 10^{-19} J$$

Electrons will not be ejected from the metal when the laser is used. This is because the energy of the laser is under the minimum required energy to eject an electron from its surface.

Question 31 (7 marks)

(a)

Criteria	Marks
• Outlines how EM waves are produced and propagated • Outlines Maxwell's predictions/equations that relate to production and propagation • Relates Hertz's confirmation of Maxwell's theories to EM waves	3
• Outlines how EM waves are either produced or propagated • Outlines at least one of Maxwell's predictions/equations • Relates Hertz's confirmation in some way	2
• Outlines at least one of Maxwell's predictions/equations • Relates Hertz's confirmation in some way	1

Sample answer:
Hertz found EM waves could be produced by an oscillating electric field. He confirmed their existence, production and that they travelled at the accepted speed of light.

Maxwell's prediction of electromagnetic waves resulted from his formulation of a complete and symmetric theory of electricity and magnetism, known as Maxwell's equations.

The waves predicted by Maxwell would consist of oscillating electric and magnetic fields—defined to be an electromagnetic wave (EM wave). Electromagnetic waves would be capable of exerting forces on charges great distances from their source, and they might thus be detectable. They could be produced by an oscillating electric charge. Maxwell equation calculates the speed of EM waves correctly.

(b)

Criteria	Marks
• Describes how both the wavelengths and intensity of a star's spectra are used to gain information about a star • Shows comprehensive understanding of how the spectra of a star can give information about surface temperature, motion, and chemical composition	4
• Outlines how both the wavelengths and intensity of a star's spectra are used to gain information about a star • Shows sound understanding of how the spectra of a star can give information about surface temperature, motion, and chemical composition	3
• Shows some understanding of how the spectra of a star can give information about surface temperature, motion, and chemical composition	2
• Provides some relevant information	1

Sample answer on next page

Sample answer:
Wein's Law states that the wavelength of maximum energy emitted from a perfect black body is inversely proportional to the temperature of the body. The spectra of a star can be used to determine the wavelength of maximum intensity it can then be substituted into Wein's equation:

$$T = \frac{0.0029}{\lambda_{max}} \text{ to calculate temperature}$$

If the spectral lines in a star's spectrum are uniformly shifted to the red end (moving away)or shifted to the blue end (moving towards) it can tell us relative the relative motion translational motion of the star. The degree of shift depends on the velocity. A complicating factor is the fact that the motion may not be directly away from us.

If we obtain a spectrum from a distant star that is rotating in the same plane as us then the light gathered is a combination of light from across the disc of the star. As part of the star appears to rotate towards us its light will be blue shifted. The light from the part of the star rotating away from us will be redshifted. The section in the middle of the disc that is moving tangentially to us will not exhibit Doppler-shift.

The presence of a spectral line corresponding to a specific energy transition for an ion, element or molecule in the spectrum of a star indicates that the specific ion, atom or molecule is present in that star. This allows spectral class to be determined

Question 32 (4 marks)

Criteria	Marks
• Identifies the constancy of the speed of light • Describes the principal of relativity • Relates above to show how EACH observation is correct in their frame of reference	4
• Identifies the constancy of the speed of light • Relates the principal of relativity in some way to show how EACH observation is correct in their frame of reference	3
• Relates the principal of relativity in some way to show how EACH observation is correct in their frame of reference	2
• Relates the principal of relativity in some way to show how ONE observation is correct in their frame of reference	1

Sample answer on next page

Sample answer:
The speed of light is constant in all inertial reference frames, and as such is independent of the relative speed of the source and the observer. The principal of relativity states that if you are moving at a constant velocity you cannot conduct an experiment to prove you are moving within your frame of reference.

Within the scientist's inertial reference frame, the light source is equidistant from the clocks. Therefore, when the light pulse travels from the source to the detectors, it takes an equal time to reach each. If the relative motion of the train effected the time taken to get to each clock, then the principal of relativity would not be held.

The Earth observer in their inertial frame, outside the train, sees clock A as moving towards the original source of light. This decreases the distance the light must travel, relative to the distance to clock B, which is moving away from the original position of the light. As a result, they see the light arriving at clock A first.

The relativity of simultaneity states that whether or not two events are seen by you to be simultaneous depends upon where you are standing. Both the scientist and the observer are correct in their frame of reference

Question 33 (1 mark)

Criteria	Marks
• Provides correct answer	1

Sample answer:

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\frac{23000}{66000} = \frac{2000}{N_s}$$

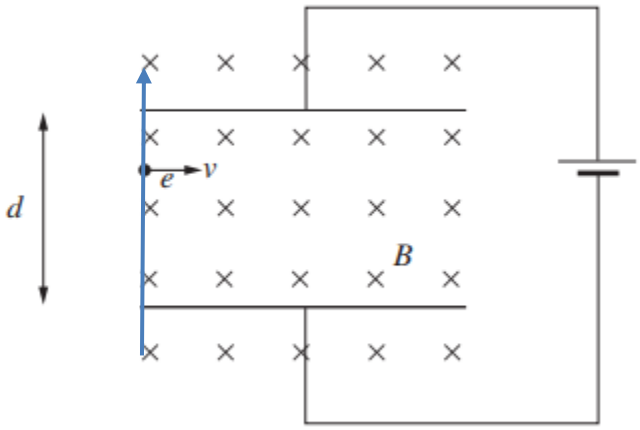
$$N_s = 57391 \text{ turns}$$

Question 34 (5 marks)

(a)

Criteria	Marks
• Provides correct answer	1

Sample answer:
According to the right hand push rule, the force acting on the electron will move towards the top of the page.



(b)

Criteria	Marks
• Provides correct answer	2
• Makes some progress towards answer	1

Sample answer:
$F = q \times v \times B \times sin\theta$
$F = 1.602 \times 10^{-19} \times 3.5 \times 10^{6} \times 0.02 \times \sin(90)$
$F = 1.1214 \times 10^{-14} N$

(c)

Criteria	Marks
• Provides correct answer	2
• Makes some progress towards answer	1

Sample answer on next page

To keep the electron travelling on a straight path, the plates must be able to create an electric field that will apply a force that opposes the one found above.
The equation for this force is:

$$E = \frac{\Delta V}{d}$$

$$Where\ \ E = \frac{F}{q}$$

$$\frac{1.1214 \times 10^{-14} N}{1.602 \times 10^{-19}} = \frac{\Delta V}{5 \times 10^{-3} m}$$

$$V = \frac{1.1214 \times 10^{-14} N}{1.602 \times 10^{-19}} \times (5 \times 10^{-3} m)$$

$$V = 350 volts$$

Question 35 (8 marks)

(a)

Criteria	Marks
• Describes why the current in each rod is travelling in opposite directions	2
• Identifies that the current in each rod is travelling in opposite directions	1

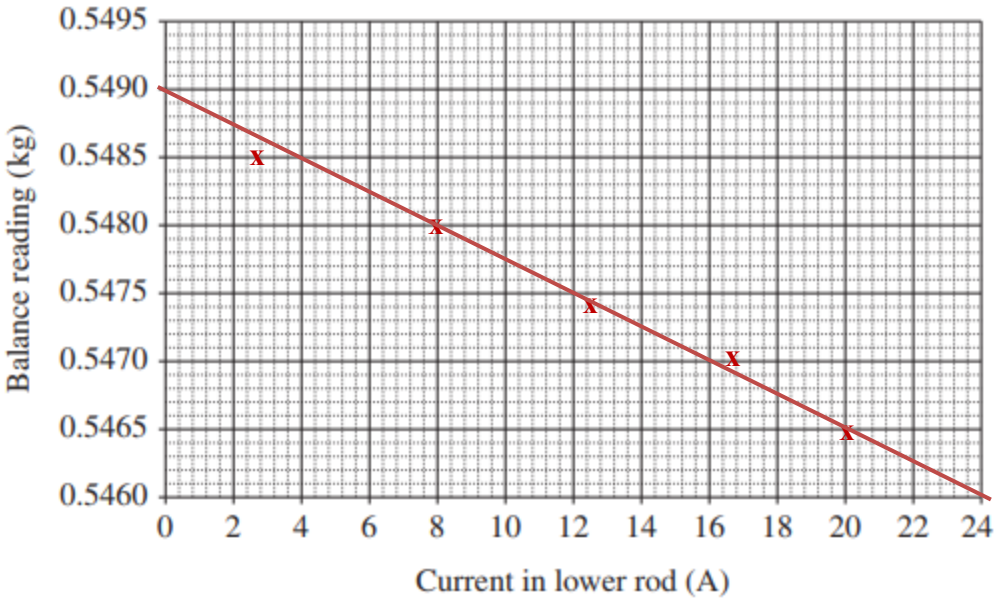
Sample answer:
The current must be travelling in opposing directions through the two rods, as the weight reduces as the current increases, signifying an attractive force between the two rods. This requires the two rods to be of opposing magnetic poles.

(b)

Criteria	Marks
• Correctly plots all points • Correctly draws in the line of best fit	2
• Plots enough points to draw a reasonable line of best fit	1

Sample answer on next page

Sample answer:



(c)

Criteria	Marks
• Provides an answer by extending the line of best fit to the *y*-axis	1

Sample answer:
0.5490 kilograms (from graph above)

(d)

Criteria	Marks
• Calculates correctly the distance between the two copper rods using graph figures	3
• Makes significant progress towards answer	2
• Makes some progress towards answer	1

Sample answer:
At say, 22A the scale reads 0.5464kg.

Use this (or a correct mass from student's graph) to subtract from the original mass 0.5490 (or whatever the student got from extending the line of best fit.)

$$0.5490 \; - \; 0.5464 \; = \; 2.6 \times 10^{-3} \; kg$$

Then gravity must be considered:

F= mg

$$2.6 \times 10^{-3} \; N \; \times \; 9.8 \; \mathrm{m}s^{-2} \; = \; 2.548 \times 10^{-2} \; \mathrm{N} \; .$$

From this:

$$\frac{F}{l} = \frac{KI_1I_2}{d}$$

$$\frac{2.548 \times 10^{-2}}{2.6} = \frac{2 \times 10^{-7} \times 22 \times 50}{d}$$

$$d = \frac{2 \times 10^{-7} \times 22 \times 50 \times 2.6}{2.548 \times 10^{-2}}$$

$$d = 0.022 \; m$$

Note these values may change depending on the points picked by students for extrapolation, consider any values indicated on their graphs.

Question 36 (6 marks)

Criteria	Marks
• Describes the motor effect • Shows comprehensive understanding of the impact the discovery of the motor effect has had on society and the environment • Fluently uses physics concepts in their explanation and links them to their effects on society and the environment	5-6
• Describes the motor effect • Shows sound understanding of the impact the discovery of the motor effect has had on society and the environment • Uses physics concepts in their explanation and links them to their effects on society and the environment.	3-4
• Describes the motor effect • Shows some understanding of the impact the discovery of the motor effect has had on society and the environment	2
• Provides some relevant information	1

Sample Answer: Answers will vary

Key concept: The motor effect allows for the generation of electricity on a mass scale.

Possible Societal Advantages
- This increased accessibility allows electricity to be used for cooking, lighting, refrigeration, improving the standard of living.
- Microwaves, air conditioning, computers increase ease and convenience of everyday life
- Increased reliability and affordability of products
- Medical imaging techniques -> improved ability to diagnose disease, thus better prognosis.

Societal Disadvantages
- Electricity is dangerous and causes many deaths every year.
- Automation of industry decreases demand for unskilled labour -> unemployment
- Increased dependence on electricity, blackouts cause things such as riots.
- Invention of new leisure activities such as TV and computer games -> obesity

Environmental Advantages
- Most environmental advantages of the motor effect are sadly related to us fixing mistakes that our adoption of electricity caused in the first place.

Environmental Disadvantages
- Increased demand for AC electricity has led to the increased burning of FF's to generate electricity.
- Increased emission of air pollution – enhanced greenhouse effect, photochemical smog, formation and effects of acid rain
- There has also been the destruction of natural habitats and loss of wildlife to mine/deforest and construct dams for hydroelectricity.

2019 HSC Trial
Physics
Mapping Grid

Question	Marks	Content	Syllabus outcomes
Section I			
1	1	5.1.1	PH12-6,12
2	1	5.adi2,3	PH12-4,12
3	1	5.2.2	PH12-6,12
4	1	5.2.3	PH12-6,12
5	1	5.3.3	PH12-6,12
6	1	8.1.7	PH12-6,15
7	1	8.1.6	PH12-6,15
8	1	8.2.2	PH12-15
9	1	8.3.3	PH12-6,15
10	1	8.4.1	PH12-6,15
11	1	6.13	PH12-4
12	1	7.2	PH12-5,13
13	1	6.11	PH12-3,4
14	1	6.12	PH12-4,5,13
15	1	6.13.1	PH12-4,5
16	1	6.13.2	PH12-2,4,14
17	1	7.11	PH12-4,14
18	1	7.14	PH12-4,14
19	1	7.4	PH12-3,4,7
20	1	7.3.1	PH12-3,4,7
Section II			
21 (a)	2	5.3.2	PH12-6,7,12
21 (b)	3	5.3.5.c-e	PH12-6,7,12
22 (a)	1	5.1.1,2	PH12-4,5,6,7,12
22 (b)	2	5.1.1,2	PH12-5,6,7,12
22 (c)	4	5.1.1,2,3	PH12-5,6,7,12
22 (d)	1	5.1.3	PH12-2,5,12
23	3	5.2.5	PH12-6,7,12

24 (a)	2	5.3.5.e	PH12-6,12
24 (b)	2	5.3.1,2	PH12-6,12
25 (a)	4	8.4.4,5; oe3	PH12-6,7,15
25 (b)	3	8.4.3	PH12-6,7,15
26	2	8.3.4	PH12-6,15
27	3	8.4.1	PH12-6,7,15
28	8	8.3.1,5; 8.5.1,3	PH12-7,15
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31	7	7.11	PH12-1,3,4,5, 14
32	4	7.14	PH12-4,7,14
33	1	6.13.1	PH12-4
34	5	6.5	PH12-1,2,4,13
35	8	6.13, 6.17	PH12-1,3,4,5,12
36	6	6.13.1, 6.14.1	PH12-3,4,5,13