STUDENT NUMBER ……………………………...

KINROSS WOLAROI SCHOOL

2022

Year 12 Physics

Trial HSC Examination

Teacher Setting Paper: Mr D. Johnston
Head of Department: Mrs C. Litchfield

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 as a separate booklet
- Answer the multiple-choice questions on the separate grid provided.
- Attempt all questions.

Total Marks – 100

Section I – 20 marks
Answer all Questions 1-20
Allow about 35 minutes for this section

Section II – 80 marks
Answer all Questions 21-36
Allow about 2 hours and 25 minutes for this section.

This examination paper does not necessarily reflect the content or format of the Higher School Certificate Examination in this subject.

Section I

Select the alternative A, B, C or D that best answers the question.

Fill in the response oval completely.

How to use the multiple choice answer sheet

Example $2 + 4 =$ A 2 B 6 C 8 D 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ~~●~~ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.

Correct

A ● B ~~●~~ C ○ D ○

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.

---

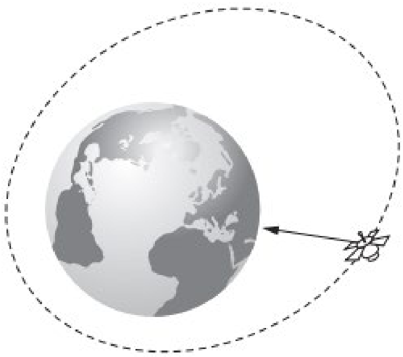
1. In 1861, James Clerk Maxwell published four equations which provided the mathematical framework for the existence of electromagnetic waves.

   Which of the following could be deduced directly from Maxwell's equations?

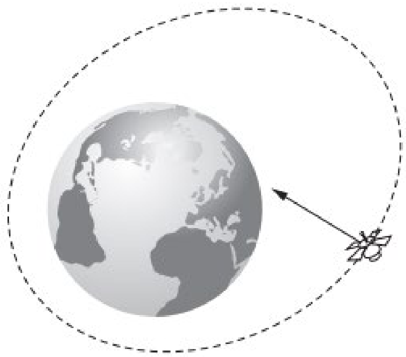
   A. Light can exhibit both wave and particle properties.
   B. All electromagnetic waves propagate at a constant speed in vacuum (which closely matched measured values).
   C. A changing magnetic field will induce stable, direct current in a nearby conductor.
   D. Since electromagnetic waves have a constant speed in vacuum, time must dilate for an observer in relative motion.

2. Which of the following diagrams best represents this satellite's acceleration at this instance of its orbit?

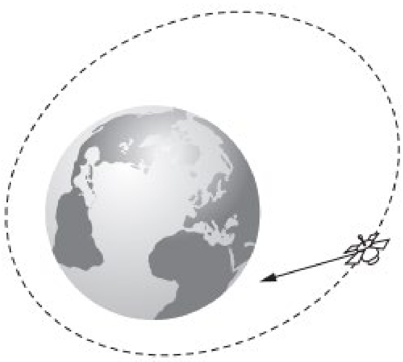
A.



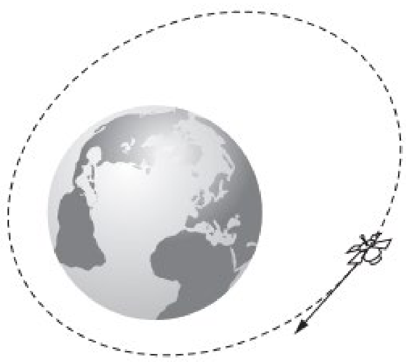
B.



C.



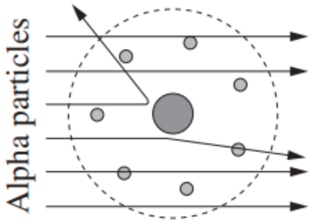
D.



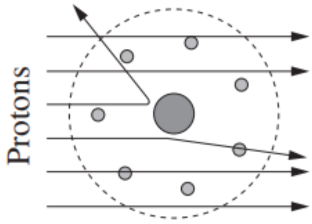
3. Geiger and Marsden carried out an experiment to investigate the structure of the atom.

Which diagram identifies the particles they used and the result that they INITIALLY expected?

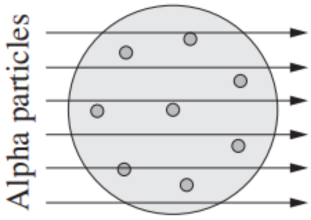
A.



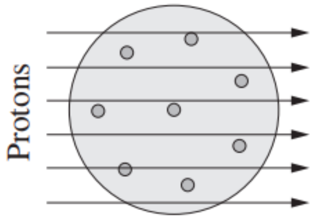
B.



C.



D.



4. A student wants to design an experiment to investigate the effect on the magnitude of induced current in a solenoid (closed circuit) when the strength of a magnetic field is varied.

Which of the following could be the independent variable for this investigation?

A. Speed of the magnet.
B. Distance between the solenoid coils and the magnetic.
C. Magnitude of the induced current.
D. Number of bar magnets (same poles aligned).

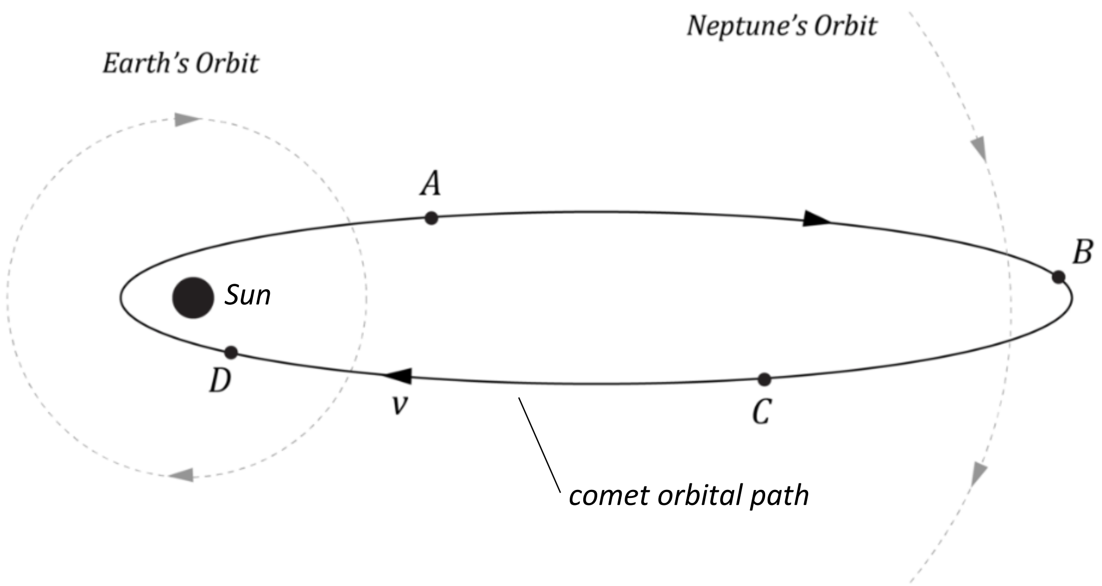
5. A satellite is in a high orbit around the Earth. A particle of dust is in the same orbit.

Which row of the table correctly compares their potential energy and orbital speed?

	Potential energy	*Orbital speed*
(A)	Different	Same
(B)	Different	Different
(C)	Same	Same
(D)	Same	Different

6. A representation of the orbit of Halley's comet is shown below.

Different positions in the orbit are designated by the letters *A, B, C* and *D.*
(The diagram is not to scale.)

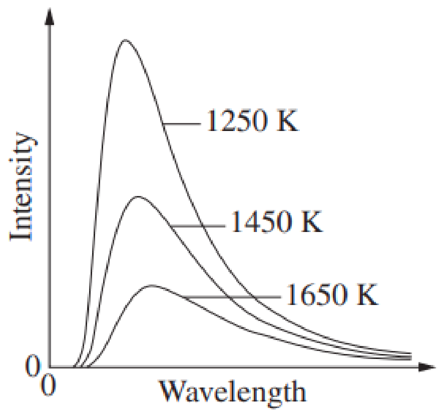


Which row in the following table correctly expresses the variations in the comet's speed and its total mechanical energy as it orbits the Sun?

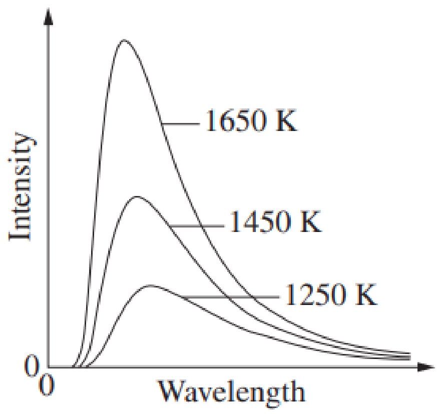
	Speed of comet	Total mechanical energy of comet
A.	$v_B > v_C > v_A > v_D$	$E_A > E_B > E_C > E_D$
B.	$v_D > v_A > v_C > v_B$	$E_A > E_B > E_C > E_D$
C.	$v_B > v_C > v_A > v_D$	$E_A = E_B = E_C = E_D$
D.	$v_D > v_A > v_C > v_B$	$E_A = E_B = E_C = E_D$

7. Which graph is consistent with predictions resulting from Planck's hypothesis regarding radiation from hot objects?

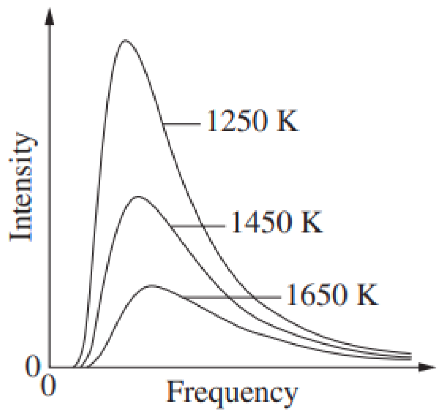
A.



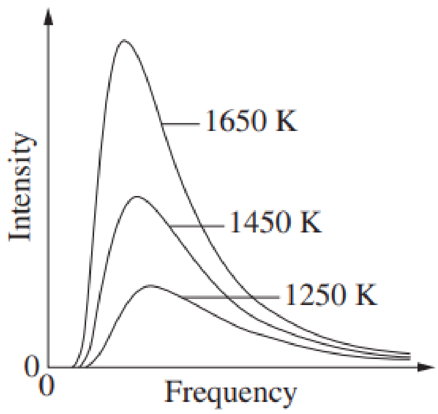
B.



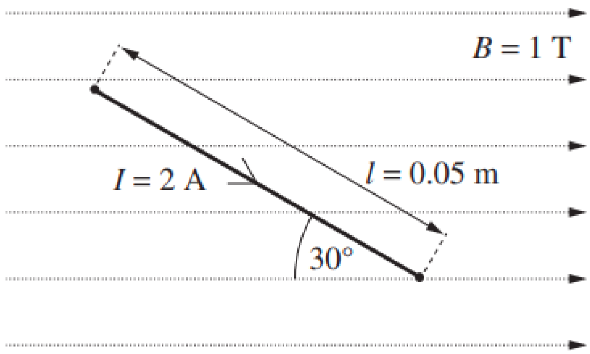
C.



D.



8. The diagram shows a current-carrying conductor in a magnetic field.



What is the magnitude of the force on the conductor?

A. 0 N

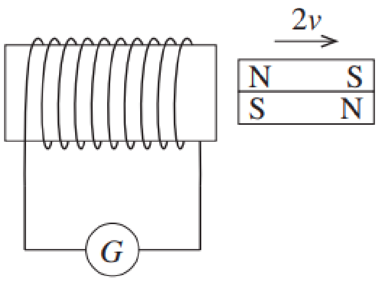
B. 0.05 N

C. 0.09 N

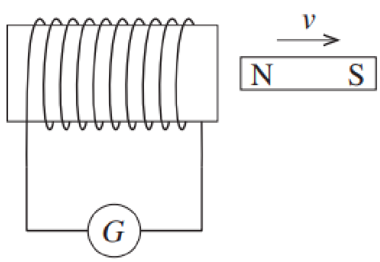
D. 0.10 N

9. Which movement of the magnet(s) will produce the greatest deflection of the galvanometer?

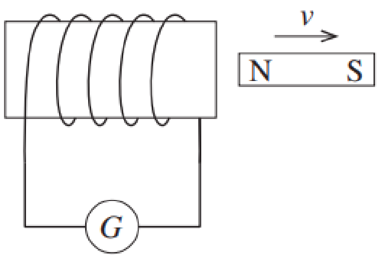
(A)



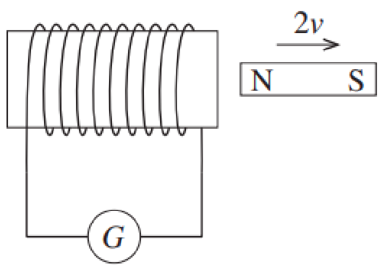
(B)



(C)



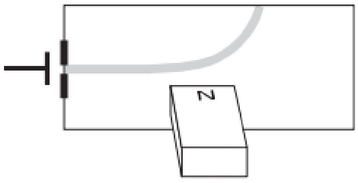
(D)



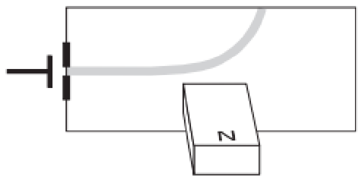
10. Cathode rays were eventually shown to consist of a stream of high-velocity, negatively-charged particles (electrons).

Which diagram correctly shows the deflection of a cathode ray by a bar magnet?

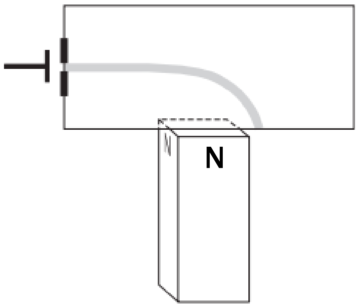
(A)



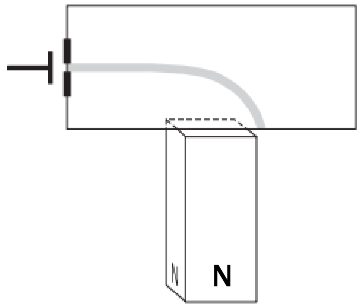
(B)



(C)

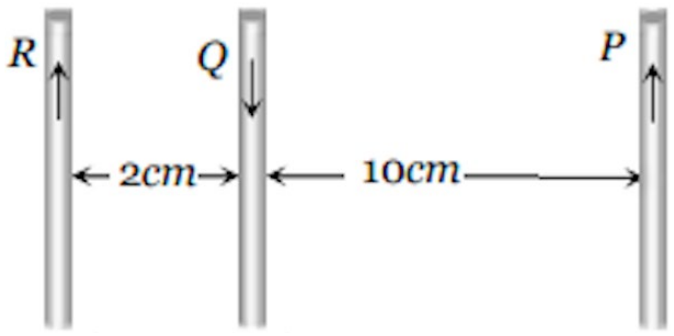


(D)



11. Three long, parallel wires, P, Q, and R are arranged near each other as shown.

If the currents in each rod are P = 2.0 A, Q = 4.0 A, and R = 6.0 A, what is the net force on P?



NOT TO SCALE

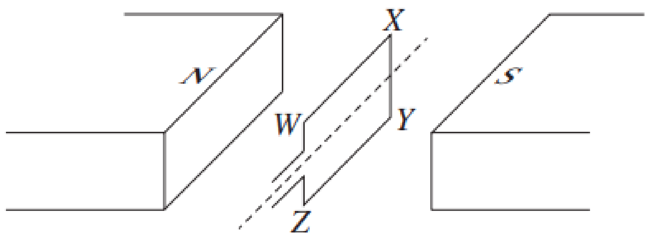
(A) 36 µN right

(B) 36 µN left

(C) 4 µN right

(D) 4 µN left

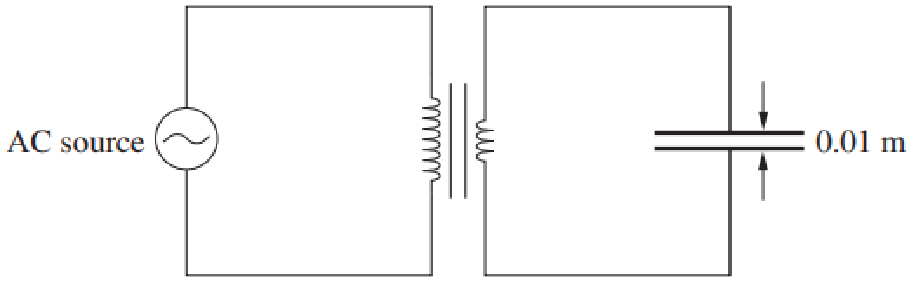
12. The diagram shows some parts of a simple DC motor.



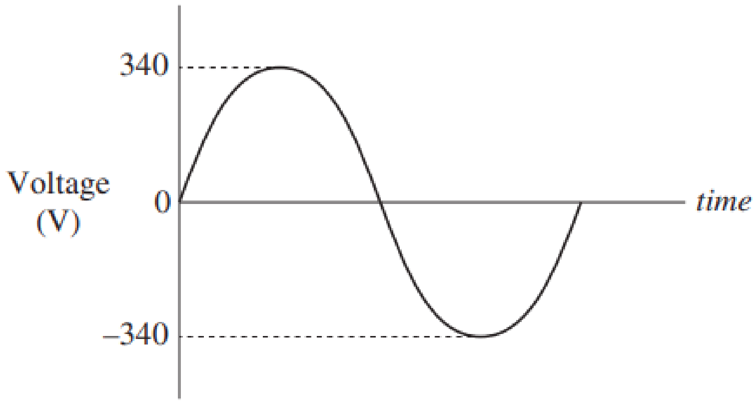
Which row of the table correctly describes the direction of force acting on side *WX* and the direction of torque this produces on the coil?

	Direction of force acting on WX	*Direction of torque produced on the coil by the force acting on WX*
A.	Remains constant	Remains constant
B.	Remains constant	Reverses every 180°
C.	Reverses every 180°	Remains constant
D.	Reverses every 180°	Reverses every 180°

13. An AC source is connected to a transformer having a primary winding of 900 turns. Connected to the secondary winding of 450 turns is a pair of parallel plates 0.01 m apart.



The AC input is shown in the graph.



What is the maximum field strength (in V m^{-1}) produced between the plates?

A. 1.7

B. 6.8

C. 1.7×10^4

D. 6.8×10^4

14. A spaceship moves close to the speed of light, relative to a planet.

The rest-frame length of the spaceship can be determined by an observer who is

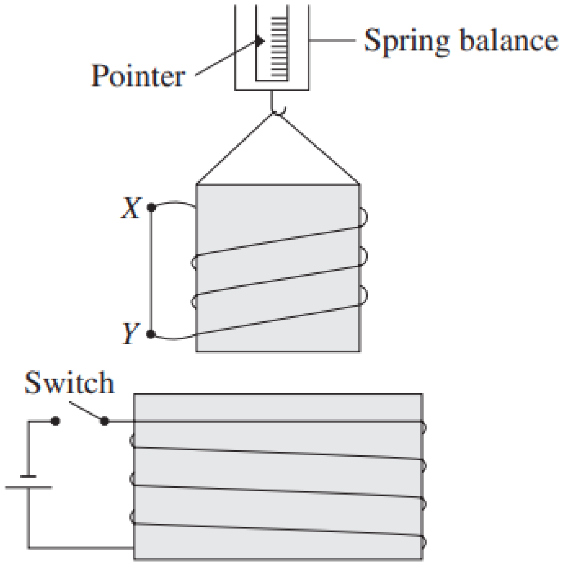
(A) on the spaceship measuring the time taken for light to travel between two points on the planet.

(B) on the planet measuring the time taken for light to travel from the front to the back of the spaceship.

(C) on the spaceship measuring the time taken for light to travel from the front to the back of the spaceship.

(D) on the planet measuring the difference in the arrival time of light from the front and the back of the spaceship.

15. An experiment is set up as shown.



When the switch is closed, the reading on the spring balance changes immediately, then returns to the initial reading.

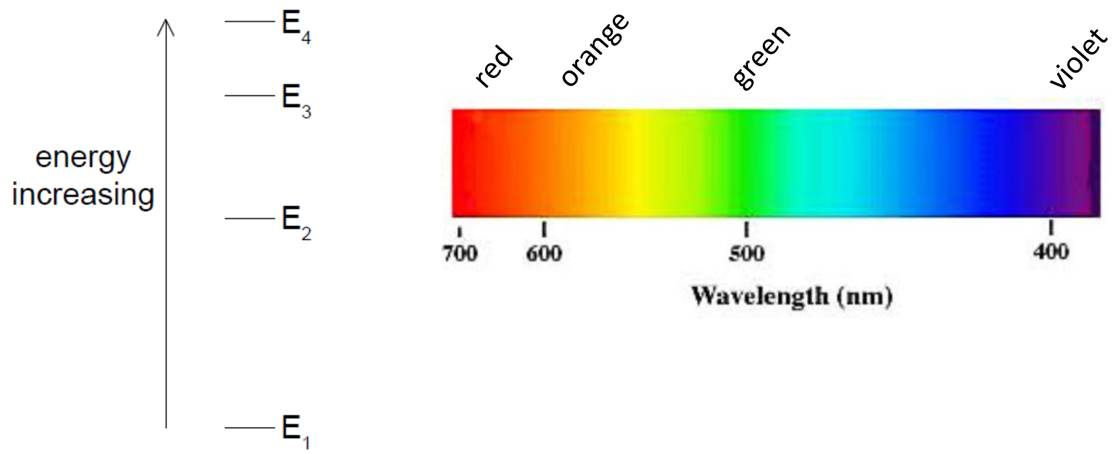
Which row of the table correctly shows the direction of the current through the straight conductor XY and the direction in which the pointer on the spring balance initially moves?

	Direction of current through the straight conductor	*Direction in which the pointer initially moves*
A.	From X to Y	Down
B.	From X to Y	Up
C.	From Y to X	Down
D.	From Y to X	Up

16. The energy levels for a hydrogen atom are shown below left (DRAWN TO SCALE).

A photon is emitted whenever an electron ‘falls’ from a higher energy level to a lower energy level.

Which transition leads to the emission of a photon in the red band of the visible spectrum?



(A) E_4 to E_1

(B) E_3 to E_2

(C) E_2 to E_3

(D) E_4 to E_2

17. A planet *X* has twice the mass and twice the radius of Earth.

What is the magnitude of the gravitational acceleration close to the surface of planet *X*?

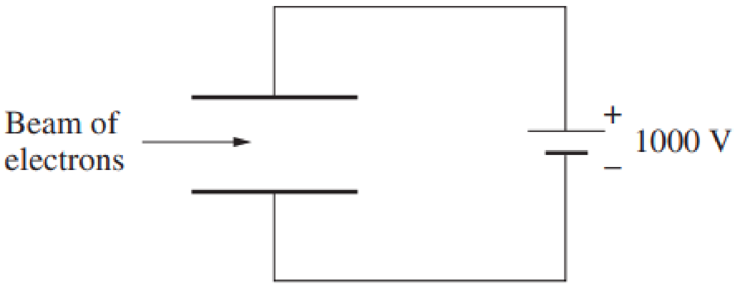
A. $\frac{1}{2}g$

B. $1\,g$

C. $2\,g$

D. $4\,g$

18. The diagram shows electrons travelling in a vacuum at 2×10^6 m s^{-1} between two charged metal plates 1×10^{-3} m apart.



A magnetic field is to be applied to make the electrons continue to travel in a straight line.

What is the magnitude and direction of the magnetic field that is to be applied?

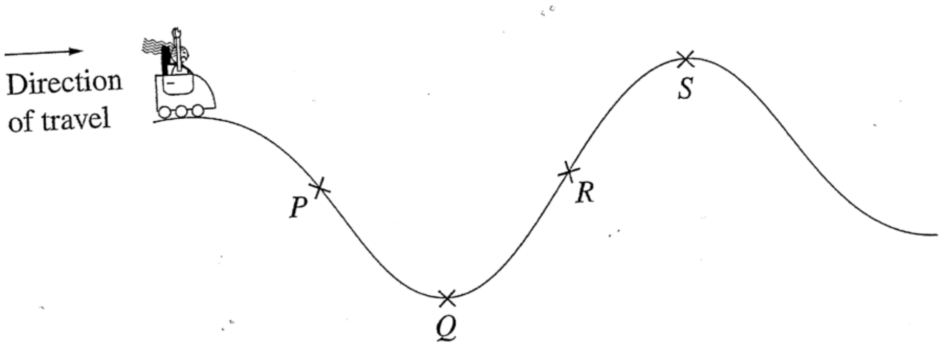
A. 5×10^{-1} T into the page

B. 5×10^{-1} T out of the page

C. 1×10^{6} T into the page

D. 1×10^{6} T out of the page

19. The diagram below shows the side view of a roller coaster track.



At which position is the normal force and the centripetal force in the same direction?

(A) Position P

(B) Position Q

(C) Position R

(D) Position S

20. The length of a spaceship is measured by an observer to be 3.57 m as the spaceship passes with a velocity of $0.7c$.

At what velocity would the spaceship be moving relative to the observer if its measured length was 2.5 m?

A. $0.490c$

B. $0.707c$

C. $0.714c$

D. $0.866c$

End of Section I

THIS PAGE IS INTENTIONALLY BLANK

Section II

80 marks

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

Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (3 marks)

A.C. transformers are utilised at electrical power stations to increase the voltage prior to long-distance transmission.

(a) State ONE advantage of transmitting electrical energy at high voltage. **1**

....

....

....

(b) A particular transformer 'steps up' the voltage to 400 kV for transmission. **2**

Given the transformer electricity input is 25 kV with a current of 40 kA, calculate the current in the transmission lines.

....

....

....

....

....

Question 22 (5 marks)

(a) Compare the force of gravity exerted on the Earth by the Moon with the force of gravity exerted on the Moon by the Earth. **2**

The mass of the Moon is 7.3×10^{22} kg and has an average orbital distance (from Earth's centre) of 382,000 km.

....

....

....

....

....

(b) An astronaut on the Moon hits a golf ball with an initial velocity of 60 m s^{-1} and at an angle 30° above horizontal. **3**

Given the Moon's surface gravity is 83% weaker than Earth's surface gravity, calculate the range of the golf ball. Assume a flat surface.

....

....

....

....

....

....

....

....

....

....

....

Question 23 (6 marks)

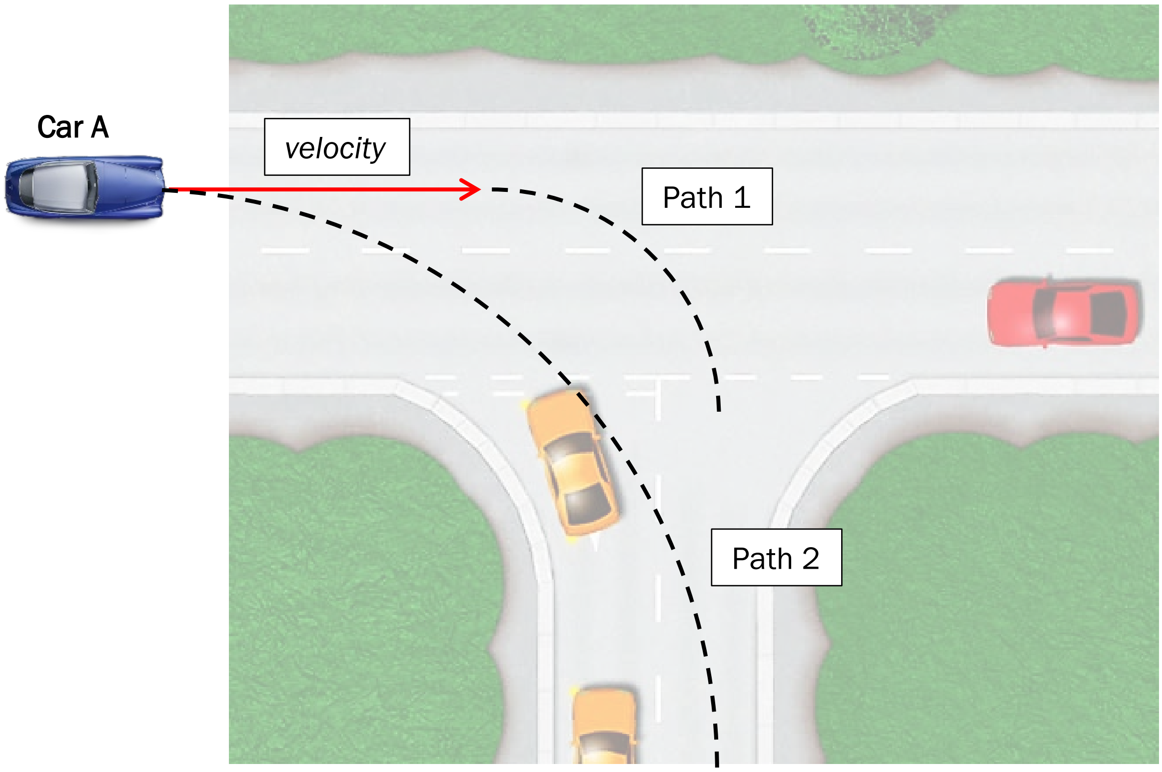
Refer to the diagram below. The car on the left, Car A, is driving in the direction shown by the vector arrow.

The driver wants to turn right.

- The law requires the car to follow the path indicated by the dashed line, labelled ‘Path 1’.
- Many drivers, however, are tempted to follow the path labelled ‘Path 2’. This would mean ‘cutting the corner’ by turning through a larger-radius arc.

Both path options are arcs of a circle:

- Path 1 has a radius of curvature 5.0 m;
- Path 2 has a radius of curvature 20 m.



(a) On the diagram, draw a vector arrow to indicate the acceleration of Car A as it is undertaking a circular motion anywhere on Path 2. **1**

Question 23 continues on the next page

Question 23 (continued)

(b) Given Car A has a mass of 1350 kg and will maintain a speed of 20 km h^{-1}, calculate the centripetal force required to execute turns along BOTH paths. **2**

....

....

....

....

....

....

(c) From a physics perspective, explain why drivers are tempted to 'cut the corner' when turning. **3**

You should refer to speed, radius, and friction required from tyres in your response. You may also choose to refer to your calculations from (b).

....

....

....

....

....

....

....

....

....

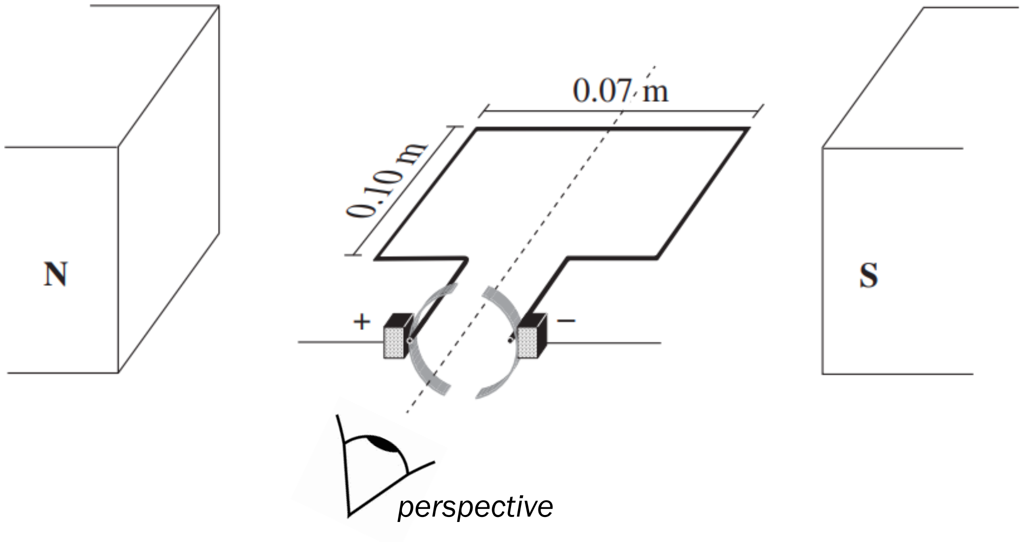
....

....

End of Question 23

Question 24 (5 marks)

A DC motor is constructed from a single 'loop' of wire with dimensions 0.10 m × 0.070 m
The magnetic field strength is 0.70 T and there is a current of 12 A in the loop whilst the motor is operating at full speed.



(a) From the perspective indicated by the 'eye' symbol, state the direction this armature will rotate. **1**

....

(b) Explain how the split-ring commutator maintains torque in a constant direction. **2**

....

....

....

....

....

(c) Calculate the magnitude of the maximum torque produced by this motor. **2**

....

....

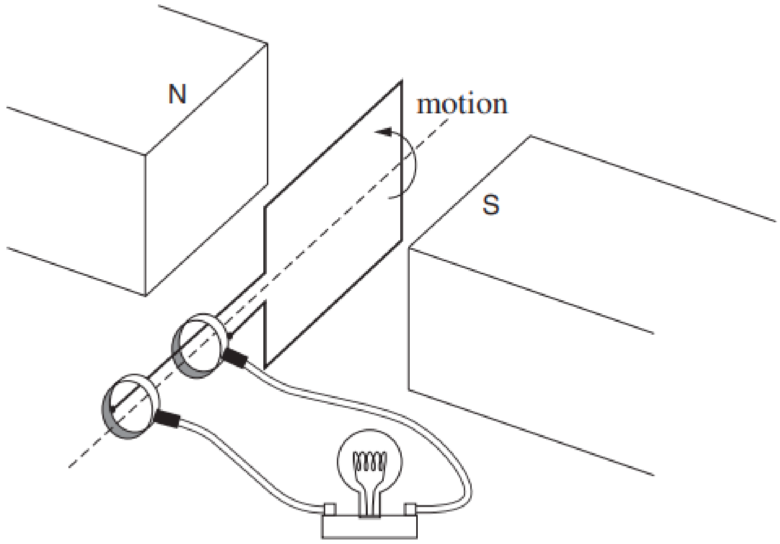
....

....

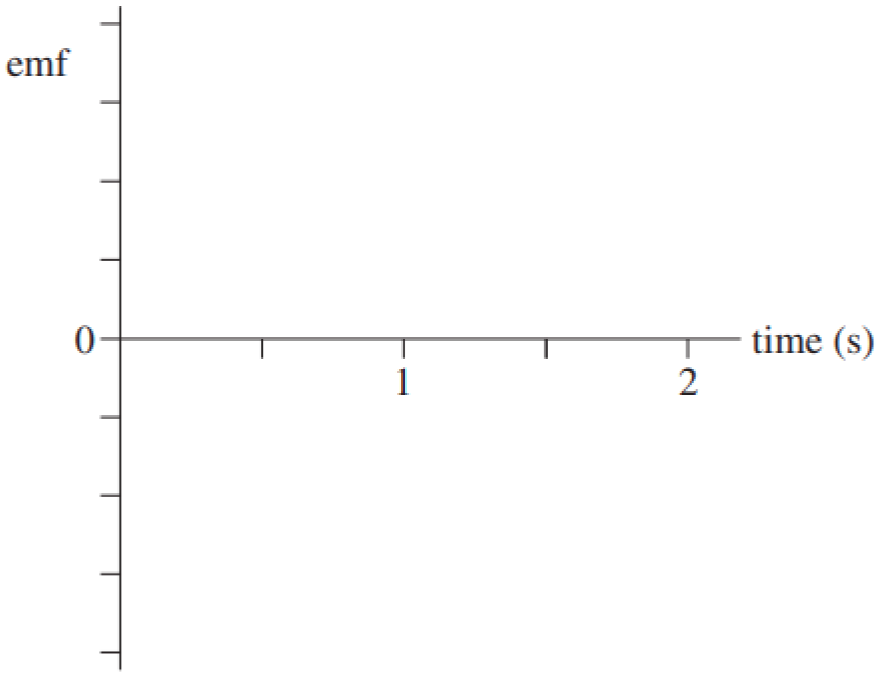
....

Question 25 (7 marks)

(a) A generator starts at the position shown and is rotated by one revolution in the first second. It is then rotated by two revolutions in the next second. **3**



Sketch a graph on the axes showing the electromotive force (emf) produced by this generator for these two seconds.



Question 25 continues on the next page

Question 25 (continued)

(b) An electric motor can be used to propel a vehicle. The electric motor can be made to operate as a generator when the vehicle is moving. This will have a braking effect on the vehicle. **4**

Explain the physics principles involved in the propelling and braking of this vehicle.

....

....

....

....

....

....

....

....

....

....

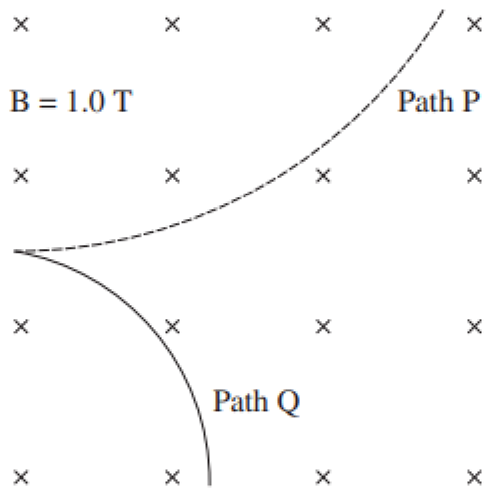
....

....

End of Question 25

Question 26 (2 marks)

The diagram shows the paths taken by two moving charged particles when they enter a region of uniform magnetic field.



How do the properties of a particle affect the radius of curvature of its path in a uniform magnetic field? **2**

....

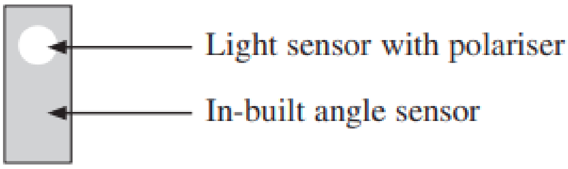
....

....

....

Question 27 (5 marks)

(a) A student was given a smartphone with a light sensor and an angle sensor, and a computer screen which emitted polarised light. A polariser was fixed over the top of the light sensor in the smartphone. **3**



Smartphone

The student wants to use this equipment to investigate Malus's Law of polarised light. Describe a procedure that is suitable for carrying out this investigation.

....

....

....

....

....

....

....

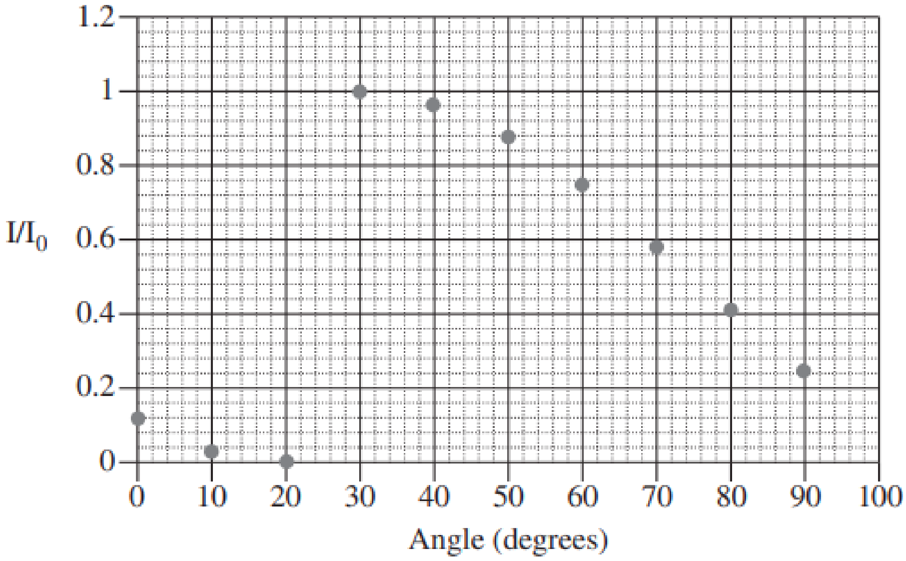
....

....

Question 27 continues on the next page

Question 27 (continued)

(b) Another student conducted an investigation into Malus' law, the results of which are shown in the graph. **2**



Based on the graph, assess the effectiveness of the experiment.

....

....

....

....

....

....

End of Question 27

Question 28 (4 marks)

Outline TWO different experiments* that provided evidence in support of Einstein's claims that time and distance are not absolute but relative. **4**

**NOT thought experiments.*

....

....

....

....

....

....

....

....

....

....

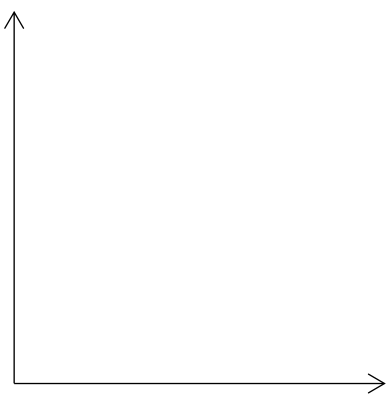
....

....

Question 29 (2 marks)

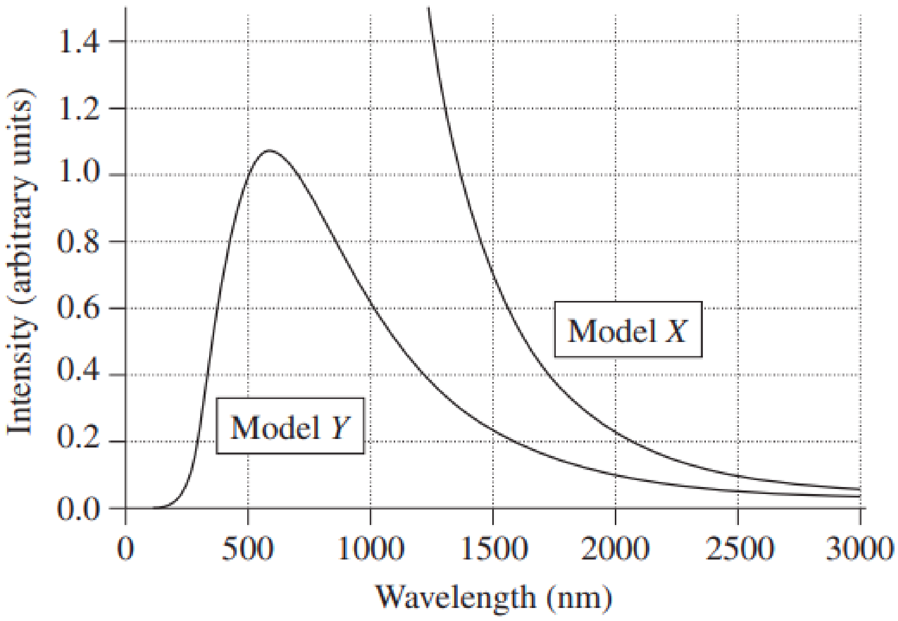
A current-carrying wire is arranged perpendicular to a magnetic field. **2**

Using the axes below, sketch the relationship between current, I, and magnetic field strength, B, if the force interaction is to remain constant.



Question 30 (3 marks)

The graph shows the curves predicted by two different models, *X* and *Y*, for the electromagnetic radiation emitted by an object at a temperature of 5000 K.



(a) Using the graph, show that *Model Y* is consistent with Wien's law for black body radiation. **1**

....

....

(b) Explain why the predictions made by *Model X* came to be known as the "ultraviolet catastrophe". **2**

....

....

....

....

....

....

Question 31 (4 marks)

Outline an historical method (other than Galileo) used to determine the speed of light. **4**

You should include at least one diagram as part of your response.

....

....

....

....

....

....

....

....

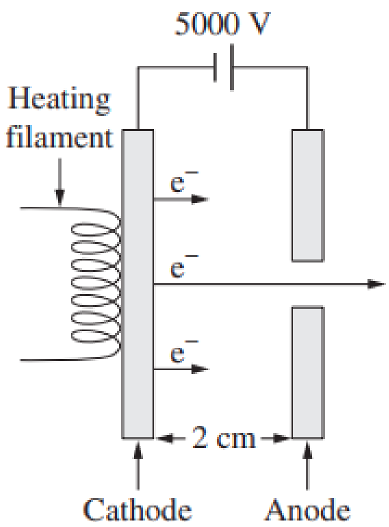
....

....

....

Question 32 (2 marks)

An 'electron gun' like that used by J. J. Thomson is represented by this diagram.



Electrons leave the cathode and are accelerated towards the anode.

(a) Show that the acceleration of the electrons as they just leave the cathode is $4 \times 10^{16}\ \mathrm{m\,s^{-2}}$. **2**

....

....

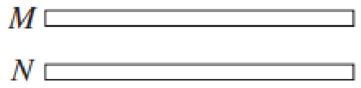
....

....

....

Question 33 (5 marks)

An electric field is produced between two charged parallel plates, *M* and *N*.



(a) The plates, *M* and *N*, are 1.0 cm apart and have an electric field of 15 V m^{-1}. **2**

Calculate the potential difference between the plates.

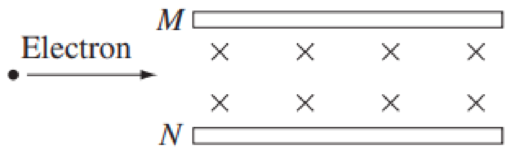
....

....

....

....

(b) The potential difference is now changed and a magnetic field of 0.5 T is placed perpendicular to the plates, as shown in the diagram below. **3**



Determine the magnitude and direction of the electric field required to allow the electron to travel through undeflected, if the electron is moving at 1×10^4 m s^{-1}.

....

....

....

....

....

....

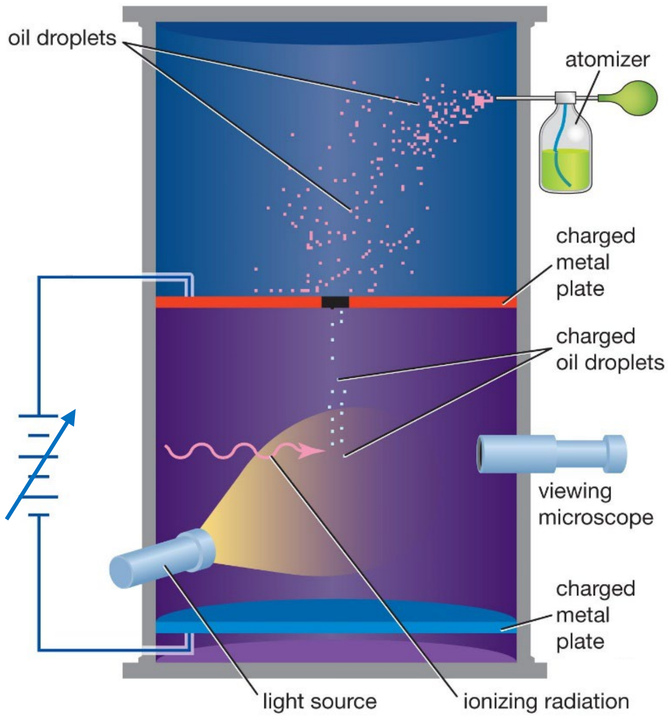
....

....

Question 34 (6 marks)

This graphic represents the apparatus used by Millikan and Fletcher in an important experiment, first conducted in 1910.

Refer to information provided in this graphic in answering the questions that follow.



© 2012 Encyclopædia Britannica, Inc.

(a) State the aim of this experiment. **1**

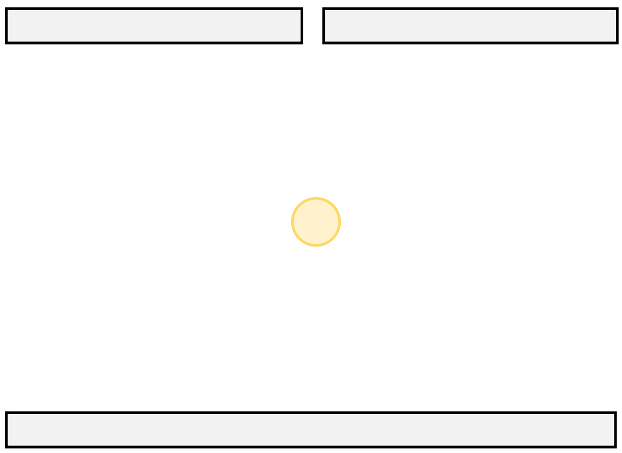
....

....

(b) Annotate the diagram below (with symbols and/or vector arrows) to show: **2**

i. the force(s) on a single negatively-charged oil drop in static equilibrium; and

ii. the charge of each of the plates (upper and lower).

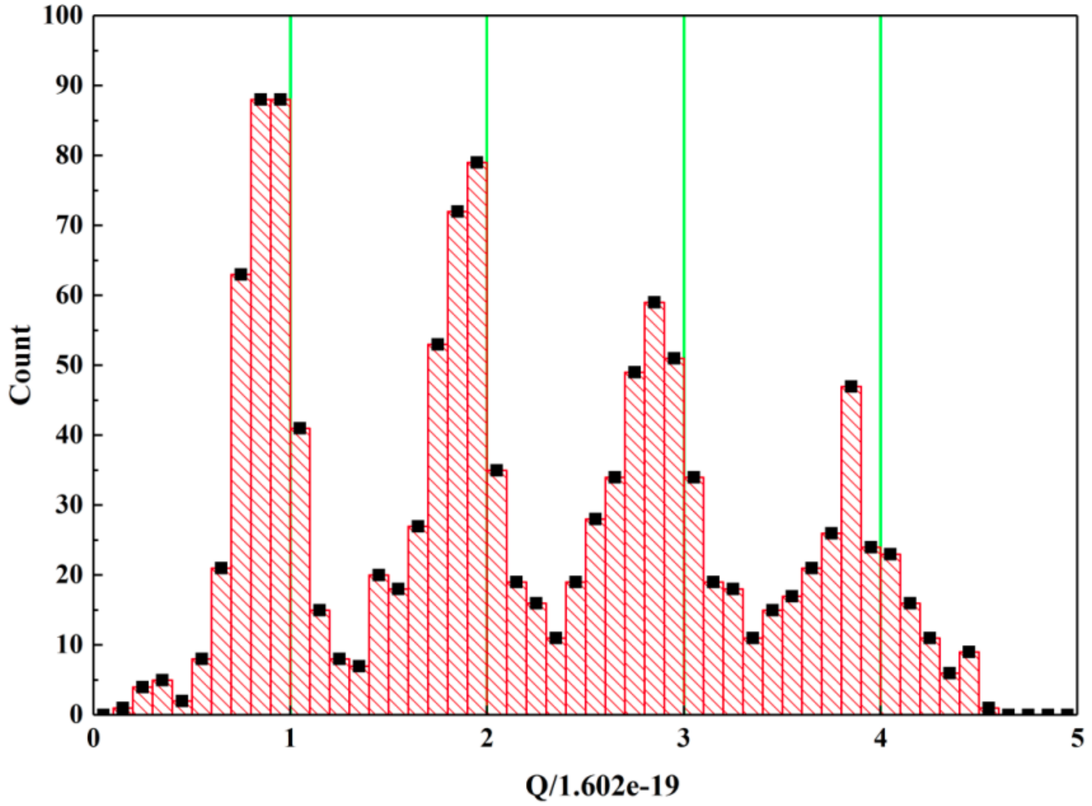


Question 34 continues on the next page

Question 34 (continued)

(c) A team of university students replicated the Millikan-Fletcher experiment. **3**

A histogram graph of their results is presented below, showing the number of instances of each particular charge ratio (i.e. charge on oil drop, Q, divided by fundamental charge) they measured.



Supporting your response with *quantitative* reference to the students' results, assess whether this experiment is consistent with the quantisation of charge.

....

....

....

....

....

....

....

....

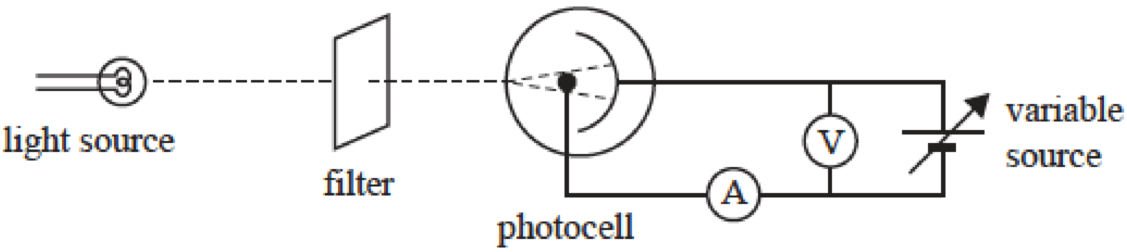
End of Question 34

Question 35 (11 marks)

Isaac carries out an experiment to investigate the photoelectric effect.

Electrons from a light source travel through a filter and are incident on a photocell. The filters allow only a specific wavelength of photon to pass. (By the wave equation, $c = f\lambda$, the frequency corresponding to each wavelength is calculated.)

For each filter, voltage is carefully adjusted until the current in the photocell circuit is zero. This voltage is recorded as the 'stopping voltage' for each filter.



Isaac's data is presented in the table below.

Filter	Wavelength (nm)	Frequency ($\times 10^{14}$ Hz)	Stopping Voltage (V)
1	500	6.0	0.160
2	429		0.520
3	400	7.5	0.720
4		8.0	0.880
5	333	9.0	1.35

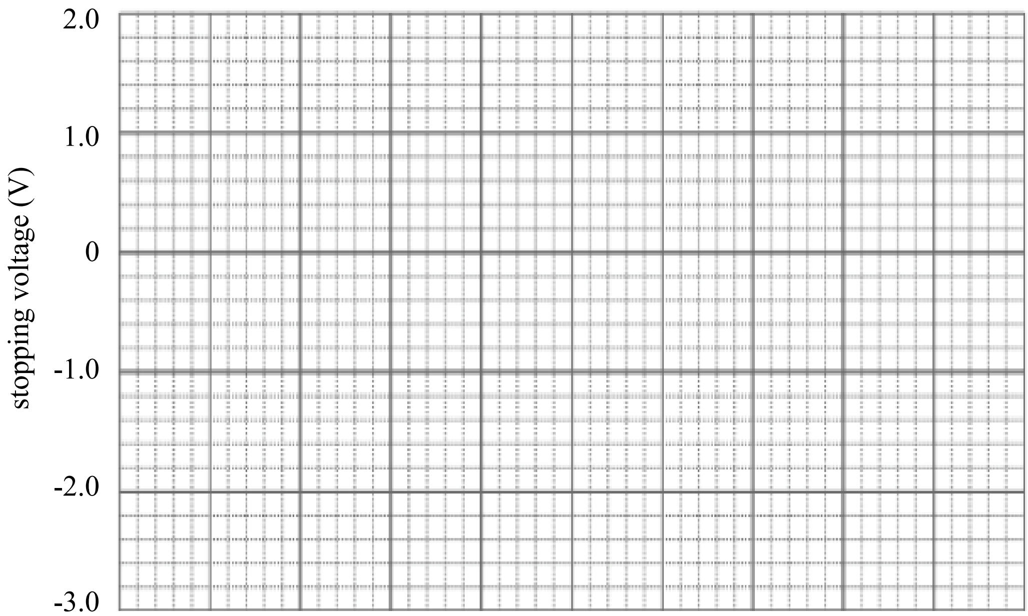
(a) Isaac was careless and forgot to record one of the wavelengths and one of the frequencies. Use the other data in the table to determine the missing values and write these into the blank cells. **1**

Question 35 continues on the next page

Question 35 (continued)

(b) Using the grid provided, plot a graph of stopping voltage as a function of photon frequency. **3**

- The voltage scale has been completed for you.
- For the frequency scale, use a range from zero to 9×10^{14} Hz.



Isaac's lab partner, Susie, suggested they review the photoelectric theory before analysing their graph:

$$K_{\max} = hf - \varphi = qV_{\text{stop}}$$

(c) Using the graph, determine:

(i) the work function, φ, of the metal in the photocell (in eV). **1**

....

....

(ii) the experimental value for Planck's constant, h. **2**

....

....

....

Question 35 continues on the next page

Question 35 (continued)

(d) They repeated the experiment with each filter but with light of DOUBLE the intensity of the original light source. **4**

Predict how a graph of stopping voltage as a function of frequency would compare to the graph you drew in part (b). Account for this with explicit reference to the relationship between intensity of incident light and kinetic energy of photoelectrons.

....

....

....

....

....

....

....

....

....

....

....

End of Question 35

Question 36 (10 marks)

(a) The image below represents an historical model of the atom.

(i) Identify TWO features of this model, labelling the diagram above. **1**

....

....

....

(ii) Outline the evidence that what is represented by the 'plums' is common to all matter. **2**

....

....

....

....

....

....

Question 36 continues on the next page

Question 36 (continued)

(b) *"The development of the model of the atom is an excellent example of the continual refining, self-correcting process that is characteristic of proper science."* **7**

Discuss this statement, referencing at least TWO examples of models of the atom that have arisen from experimental results. Your response should also include limitations of each model and how these were addressed in a subsequent model.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

End of examination

Extra writing space (if needed)

Please clearly state which question you are answering.

If you still need more space, please ask for extra writing paper.

KINROSS WOLAROI SCHOOL

2022

HSC Physics Trial Examination

MARKING GUIDE AND SOLUTIONS

Prepared and written by D. Johnston

Section I

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

Section II

Question 21 (a)

Criteria	Marks
Student states an acceptable advantage of high-voltage transmission - e.g. lower line currents = lower energy losses due to resistive heating (P = IV)	1

Marker's comments:

- Given the requirement was only to "state" (i.e. no explanation needed) many students could access this mark. If, however, a justification was also required, many responses would not have been sufficient.

Exemplar:

State ONE advantage of transmitting electrical energy at high voltage.

Less energy loss ~~as~~ due to ↓ lower current ∴ less heat dissipation

Question 21(b)

Criteria	Marks
Student correctly applies ideal transformer theory and states secondary current as 2.5 kA	2
Student demonstrates any correct understanding of relevant physics	1

Marker's comment:

- Several students attained only one mark due to incorrect re-arrangement of the transformer equation.

Exemplar:

A particular generator 'steps up' the voltage to 400 kV for transmission. **2**

Given the generator is producing electricity at 25 kV with a current of 40 kA, calculate the current in the transmission lines.

$V_s = 400 \times 10^3$ V

$V_p = 25 \times 10^3$ V

$I_p = 40 \times 10^3$ A

$\frac{V_s}{V_p} = \frac{I_p}{I_s}$

$\therefore \cancel{I_s = I_p \times \frac{V_s}{V_p}}$ $\quad I_s = I_p \times \frac{V_p}{V_s}$

$I_s = 40 \times 10^3 \times \frac{25 \times 10^3}{400 \times 10^3}$

$I_s = 2500$ A

$I_s = 2.5$ kA

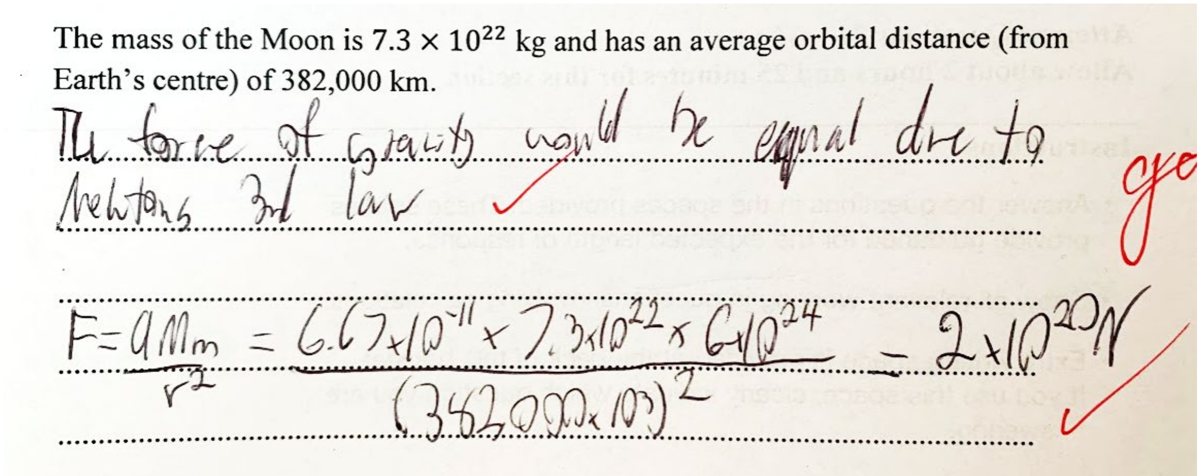
Question 22 (a)

Criteria	Marks
Student - Identifies there is ONE force of attraction, gravity acting between Earth and Moon (opposite direction, depending on frame of reference) - Quantifies force as 2.00×10^{20} N	2
Student demonstrates any relevant understanding of physics	1

Marker's comments:

- Better responses identified this question as pertaining to Newton's third law.
- Many students neglecting to (a) convert km into m and/or (b) square the distance in their final calculation.

Exemplar:



The mass of the Moon is 7.3×10^{22} kg and has an average orbital distance (from Earth's centre) of 382,000 km.

The force of gravity would be equal due to Newtons 3rd law

$F = \frac{GMm}{r^2} = \frac{6.67\times10^{-11} \times 7.3\times10^{22} \times 6\times10^{24}}{(382000\times10^3)^2} = 2\times10^{20}N$

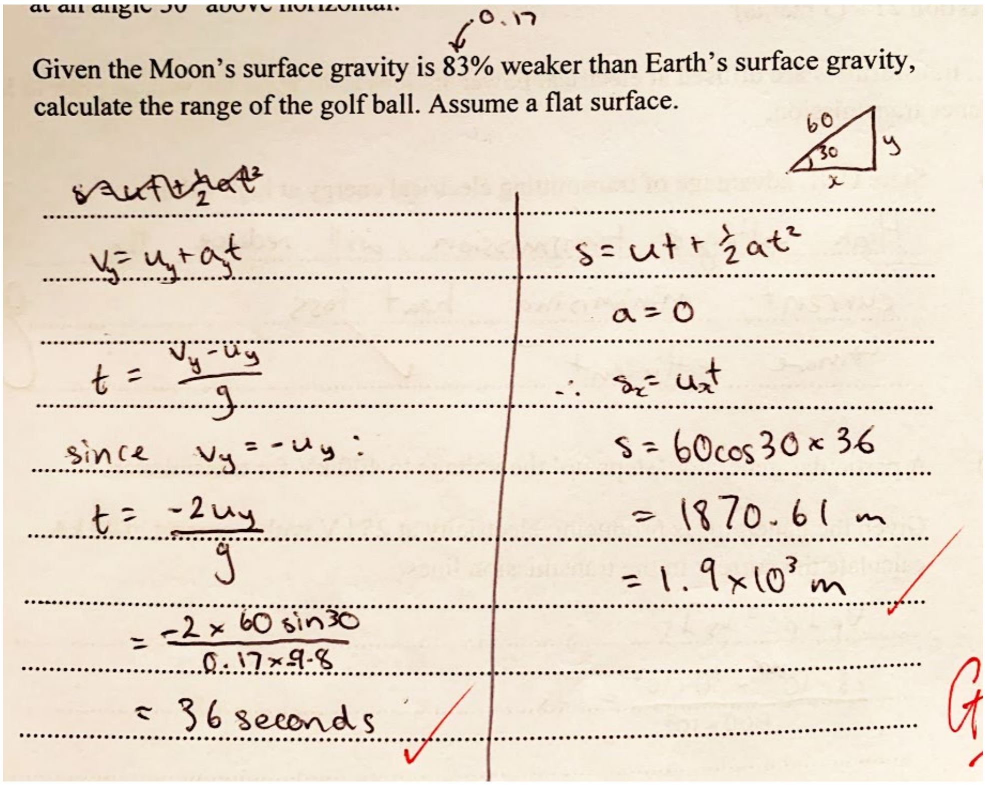
Question 22 (b)

Criteria	Marks
Student - Interprets gravitational acceleration on Moon as less than on Earth - Demonstrates application of valid projectile motion physics to solve and state a range of golf ball. - States range of golf ball as approximately 1.9 km.	3
Any TWO of above criteria	2
Student demonstrates any relevant understanding of physics	1

Marker's comments:

- Pay close attention to the wording of the question. Several students misinterpreted the data about Moon's gravity to mean "83% *of* Earth's surface gravity".

Exemplar:


0.17

Given the Moon's surface gravity is 83% weaker than Earth's surface gravity, calculate the range of the golf ball. Assume a flat surface.

60, 30, y, x

~~$s = ut + \frac{1}{2}at^2$~~

$v_y = u_y + at$

$t = \frac{v_y - u_y}{g}$

since $v_y = -u_y$:

$t = \frac{-2u_y}{g}$

$= \frac{-2 \times 60 \sin 30}{0.17 \times 9.8}$

≈ 36 seconds

$s = ut + \frac{1}{2}at^2$

$a = 0$

$\therefore s_x = u_x t$

$s = 60\cos 30 \times 36$

$= 1870.61$ m

$= 1.9 \times 10^3$ m

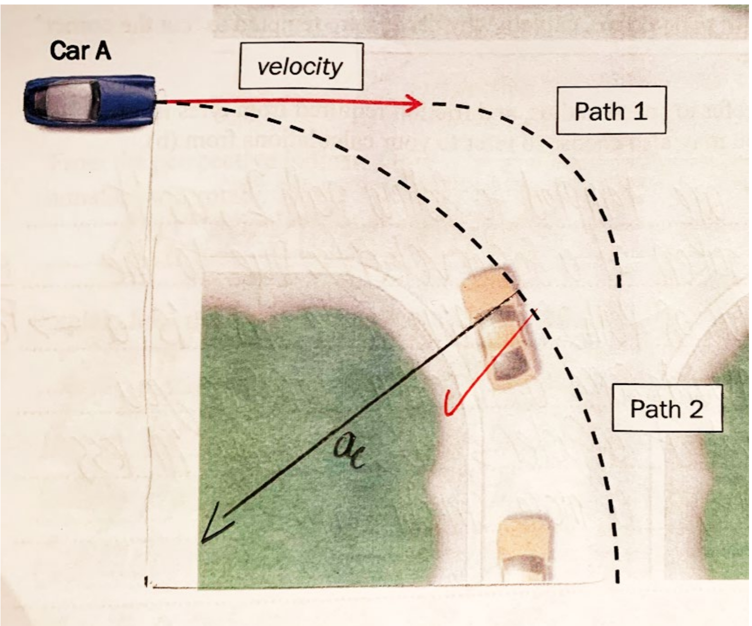
Question 23 (a)

Criteria	Marks
Student draws an acceleration vector pointing to the centre of the circular path.	1

Marker's comments:

- Some responses also labelled this vector with $\vec{a}_c$, which was not required but demonstrates understanding of the physics of the scenario.

Exemplar:



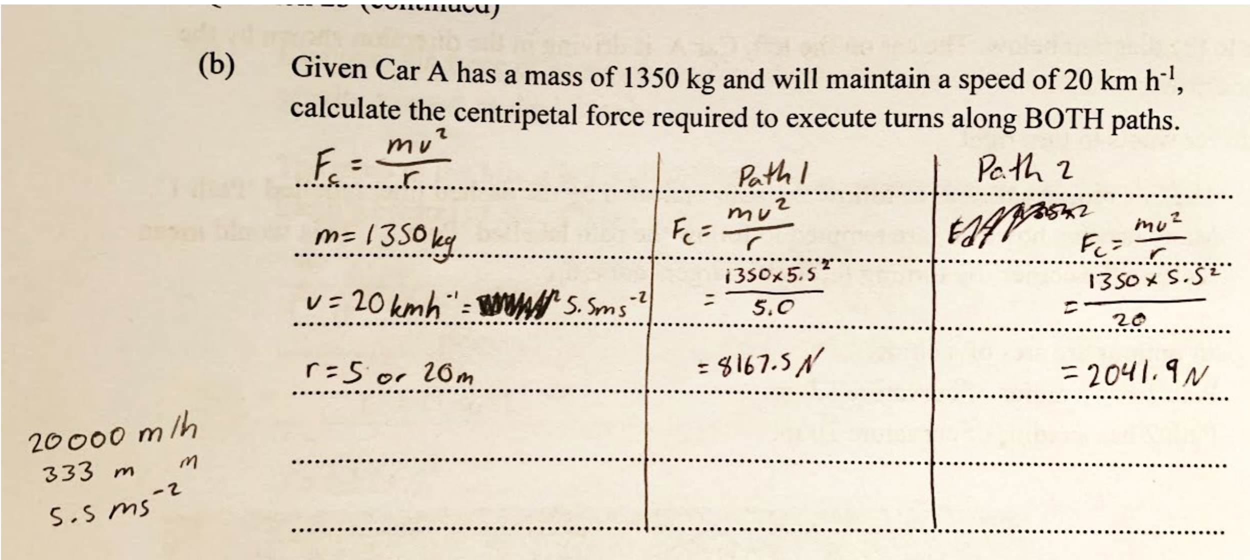
Question 23 (b)

Criteria	Marks
Student - Employs valid physics to calculate a centripetal force for both paths 1 and 2 - States $F_c(1) \cong 8.5$ kN and $F_c(2) \cong 2.1$ kN	2
Student demonstrates any relevant understanding of physics	1

Marker's comments:

- Many students overlooked the need to convert the speed of the car into SI units.
- Several students following protocol by writing out symbolic equation for centripetal force… but then forgetting to square the speed ☹.

Exemplar:



(b) Given Car A has a mass of 1350 kg and will maintain a speed of 20 km h^{-1}, calculate the centripetal force required to execute turns along BOTH paths.

$F_c = \frac{mv^2}{r}$

$m = 1350\,kg$

$v = 20\,kmh^{-1} = 5.5\,ms^{-2}$

$r = 5$ or $20\,m$

20000 m/h
333 m/m
$5.5\,ms^{-2}$

Path 1

$F_c = \frac{mv^2}{r}$

$= \frac{1350 \times 5.5^2}{5.0}$

$= 8167.5\,N$

Path 2

$F_c = \frac{mv^2}{r}$

$= \frac{1350 \times 5.5^2}{20}$

$= 2041.9\,N$

Question 23 (c)

Criteria	Marks
Student presents a logical, well-written response which - Makes explicit reference to ‘cutting the corner’ being equivalent to turning through an arc with larger radius; - Connects the radius of curvature of the path to the necessary friction from tyres; - Relates a greater radius to the ability to corner at higher speed (for a given friction), meaning drivers don’t have to slow down as much.	3
Students presents a response which meets most requirements but lacks explicit reference to all criteria and/or coherent structure	2
Student demonstrates any relevant understanding of physics.	1

Marker’s comments:

Exemplar:

You should refer to speed, radius, and friction required from tyres in your response. You may also choose to refer to your calculations from (b).

When the drivers cut the corner it allows for them to maintain a larger ~~...~~ velocity. This is because in Path 2 the radius is much larger and that will cause less of a centripetal force to be required. ~~As the~~ This is shown in calculations above. Since the friction on tyres is constant a larger radius by 'cutting the corner' will cause for a much higher possible speed before that maximum friction of tyres is acted as shown by the equation

$F = \frac{mv^2}{r}$

V. go

Question 24 (a)

Criteria	Marks
Student states counter-clockwise rotation of armature.	1

Marker's comments:

- Too many students getting this wrong. Right hand rule!!

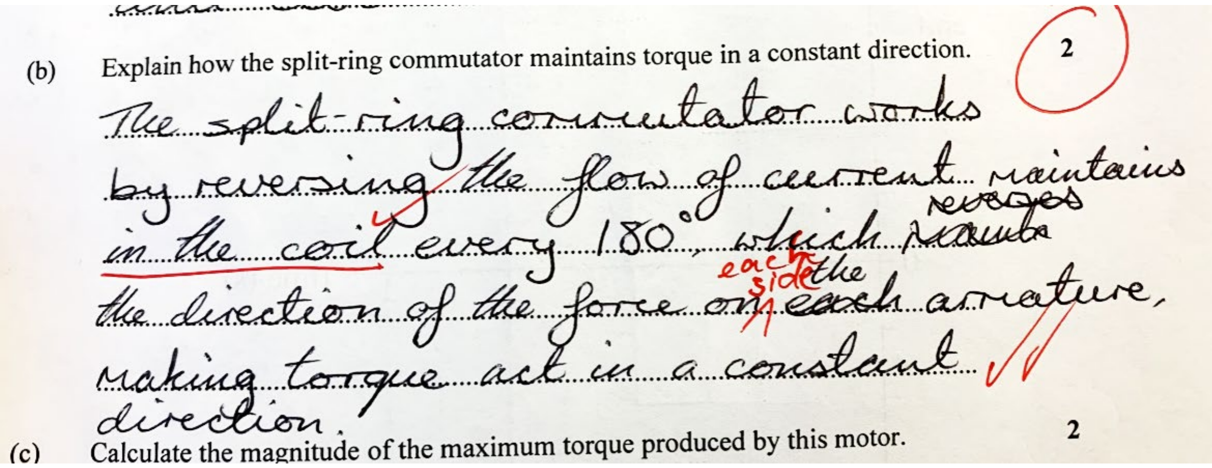
Question 24 (b)

Criteria	Marks
Student presents a coherent explanation which - Identifies that with a split-ring commutator the current in the armature coil will reverse direction every half-rotation - Relates the periodic reversal of current in armature to maintaining a force in the same direction on each 'arm' of the armature, thus maintaining torque direction.	2
Student demonstrates any relevant understanding of physics	1

Marker's comments:

- "Explain" is a high-order directive, requiring the student to make explicit connection between component and its effect, using proper terminology.
- Some responses using the phrase "commutator reverses the current" without specifying that it is only in the *armature* that the current is reversed.
- Overall, this was not answered well by the cohort.

Exemplar:



(b) Explain how the split-ring commutator maintains torque in a constant direction. 2

The split-ring commutator works by reversing the flow of current maintains in the coil every 180°, which reverses the direction of the force on each side the armature, making torque act in a constant direction.

2

(c) Calculate the magnitude of the maximum torque produced by this motor. 2

Question 24 (c)

Criteria	Marks
Student - Calculates the maximum torque magnitude as 0.059 - States valid unit for torque (e.g. N m)	2
Student demonstrates any relevant understanding of physics	1

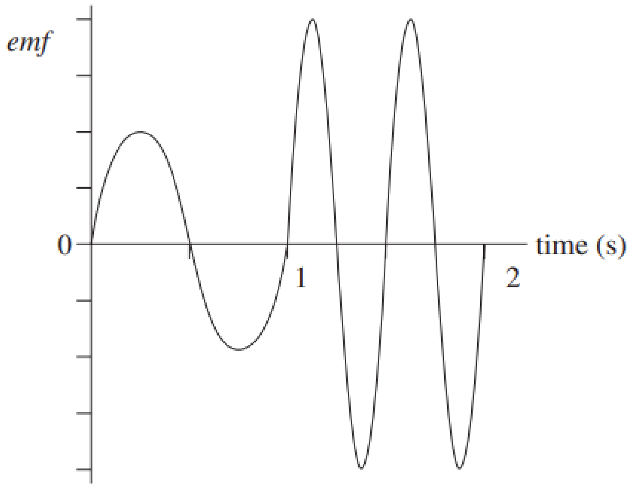
Marker's comments:

- Many students incorrectly using unit 'N' (i.e. newton) for torque.

Question 25 (a)

Criteria	Marks
• Starting from zero, produces a single period AC curve for 0–1 seconds, followed by an AC curve of twice the frequency and amplitude for 1–2 seconds	3
• Produces a correct curve for 0–1 seconds OR 1–2 seconds AND • Includes a correct feature for the other second	2
• Identifies ONE correct feature	1

Sample answer:



Marker's comments:

- This is Q27 from 2013 HSC examination
- Many students struggled with this question.

Question 25 (b)

Criteria	Marks
• Demonstrates a sound understanding of the physics principles involved in a motor and a generator • Considers the energy changes and relates these to the motion of the vehicle both in propulsion and in braking • Clearly explains the physics principles involved in the propelling and braking of the vehicle	4
• Demonstrates an understanding of the physics principles involved in a motor and a generator • Describes relevant energy changes	3
• Demonstrates an understanding of the physics principles involved in a motor or generator OR • Shows some understanding of how a motor can act as a generator	2
• Identifies some relevant information	1

Sample answer:

A motor consists of a rotating coil in a magnetic field. When power is cut, this rotation causes an emf to be produced due to a change in magnetic flux. This allows the motor to act as a generator, which has essentially the same parts as a motor.

When acting as a motor, the vehicle converts electrical energy to kinetic energy due to the motor effect, thus propelling the vehicle. When it acts as a generator, kinetic energy is converted to electrical energy, and so by Lenz's law, the motion of the rotor is opposed. This acts to slow the vehicle.

Marker's comments:

- For these types of questions, your response must make explicit reference to the physics
  - "Induced emf due to a changing magnetic flux as a result of rotating armature"
  - "By Lenz's law (conservation of energy), induced emf (i.e. 'electrical energy') from the kinetic energy of the turning armature, causing the armature to slow."
- Many students incorrectly interpreting this question as a scenario involving eddy currents.

Question 26

Criteria	Marks
• Qualitatively relates the radius of curvature of the path to two properties of the particle	2
• Relates the radius of curvature to one property of the particle	1

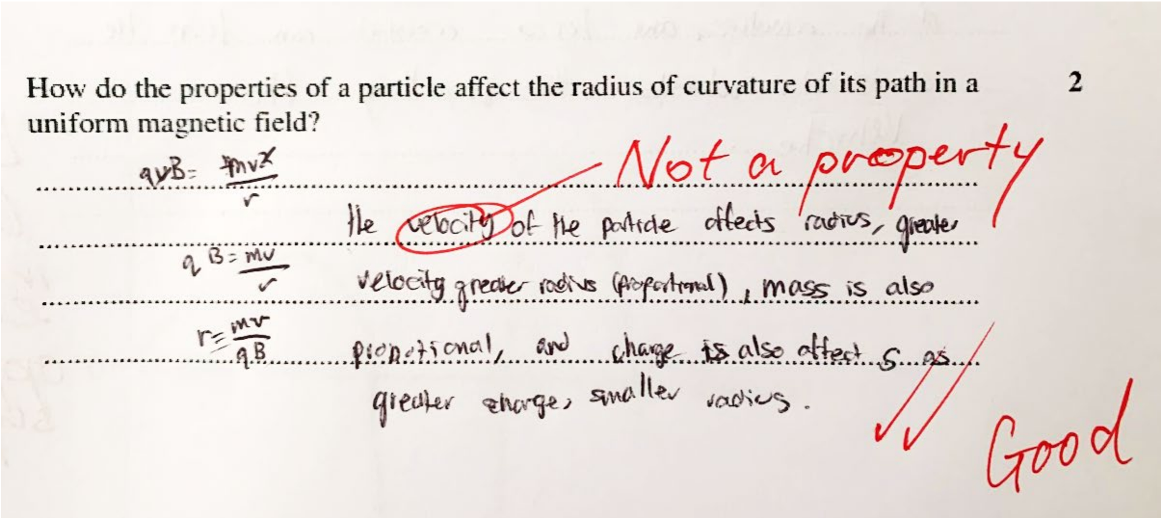
Marker's comments

- This question from 2012 HSC examination.
- Feedback from marking centre: "In better responses, candidates equated centripetal force to the magnetic force and used this to show the relationship between the radius, mass and charge of the particle in the field."
- Many responses failing to state the *effects* of the properties on the radius of curvature.
- A correctly-arranged equation of magnetic force and centripetal force (especially if 'r' was then made the subject) was sufficient to show affect of property on radius.

Sample answer:

The greater the mass of a particle travelling through a magnetic field, the greater the radius of curvature of its path, other variables being unchanged. The greater the charge of the particle, the smaller the radius of curvature of its path.

Exemplar:


How do the properties of a particle affect the radius of curvature of its path in a uniform magnetic field? 2

$qvB = \frac{mv^2}{r}$

$qB = \frac{mv}{r}$

$r = \frac{mv}{qB}$

the velocity of the particle affects radius, greater velocity greater radius (proportional), mass is also proportional, and charge is also affects as greater charge, smaller radius.

Not a property

Good

Question 27 (a)

Marking guidelines (a):

Criteria	Marks
• Describes a suitable procedure	3
• Outlines some relevant steps	2
• Provides some relevant information	1

Sample answer:

The computer is set to a constant intensity of light. The distance from the computer screen to the smartphone is measured. The phone is secured in place so that it can rotate but not change its distance from the screen. The smartphone angle sensor is set to zero when its position obtains maximum intensity. The light intensity and angle are then measured and recorded. The phone is rotated and the intensity of light at many different angles is measured. The results are plotted on a graph and the relationship determined via analysis.

Marker's comments:

- The crucial detail the marker looked for was the calibration of the angle by means of, for example, setting the 'zero' angle on the phone when the intensity was maximised.
- As with all experiment procedures, DETAIL is important.

Question 27 (b)

Marking guidelines (b):

Criteria	Marks
• Provides an explicit assessment of the effectiveness of the experiment based on the graph; and • Outlines strength(s) and/or weakness(es) of the data as shown on graph	**2**
• Identifies a strength or weakness of the data shown on the graph OR • Shows a basic understanding of Malus's Law	1

Sample answer:

The range of data is good and the points collected give a good indication of the shape of the expected curve according to Malus's Law $\left(I = I_{max}\cos^2\theta\right)$. However, the first three measurements seem to be incorrectly taken as the maximum intensity of light should be at 0° (not 30°).

Marker's comments:

- For 2 marks, needed specific reference to the data.

Exemplar:

Based on the graph, assess the effectiveness of the experiment.

The experiment was both effective and ineffective. "more effective" perhaps? The curvature of the ~~the~~ points ~~that~~ is in line with ~~the~~ Malus' law, $I = I_{max}\cos^2\theta$. But the maximum I should be at angle = 0°, therefore there must have been an error in his experiment. good

Based on the graph, assess the effectiveness of the experiment.

The experiment was not very effective. The graph fails to record the correct theoretical values at 0° and 90°, which should 1 and ~~90°~~ 0 respectively. However it does demonstrate the trend that as the angle of the polarizer increases to 90°, the intensity decreases, however it is likely that there was a systematic error with the angle measuring device due to the strong trend but inaccurate values.

Question 28

Criteria	Marks
Student presents a logical, well-written response which - Outlines correct details of TWO experiments; - Experiments selected are known to support the claim of time dilation and length contraction	4
Student presents a response which - Provides some details of TWO experiments; OR - Provides comprehensive details of ONE experiment	3
Students presents a response which meets most requirements but lacks explicit reference to all criteria and/or coherent structure	2
Student demonstrates any relevant understanding of physics.	1

Exemplar:

Outline TWO different experiments* that provided evidence in support of Einstein's claims that time and distance are not absolute but relative.

4

*NOT thought experiments

1. Muon Decay:

results from collisions of cosmic rays with molecules in upper atmosphere

Muons are a particle that ~~is radiated by the sun~~. By analysing the radioactive decay of the muons we are able to prove that both time & distance are relative. From Earth's frame of reference we can measure the distance & time of the muons using the amount of radioactive decay that has occured, but from the muon's frame of reference the muon should have already decayed. ∴ the distance & time is dilated due to the muons high speed (relativistic)

2. Atomic clock:

An atomic clock is a highly precised clock that uses the decay of a radioactive element. An experiement where 2 in-sync atomic clocks. One clock was left as a control & the other was moved at very high speeds for an extended period, on a commercial jet. Then the two clocks showed slightly different times (moved clock was behind the other clock), therefore supporting that time is relative.

V. good.

Question 29 (2 marks)

Question 29

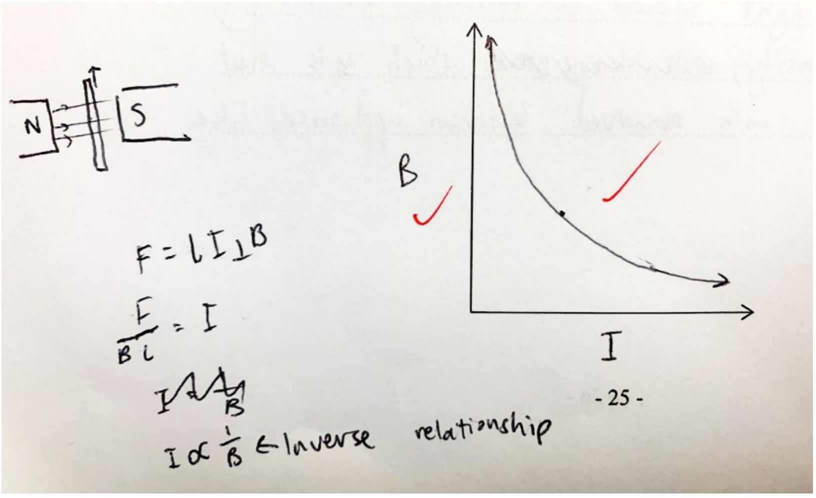
Criteria	Marks

- Sketches a graph showing relatioionship between *B* and *I* as
    ○ Inverse; or
    ○ linear (if taking inverse of one variable)
- Labels both axes.
	2

Either of the above criteria.	1

Marker's comments:
- Students who labelled axes even if unsure about relationship did the right thing; got 1 mark still.

Exemplar:

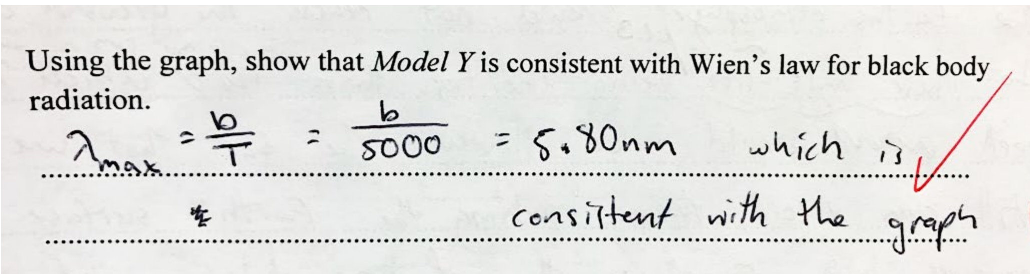


Question 30 (a)

Criteria	Marks
Student uses Wien's displacement law to show that for a 5000 K object the peak wavelength of radiation is approx. 580 nm, consistent with *Model Y*	1

Marker's comments:
- Many students very confused by this question ☹
- "Using the graph" is a directive to use specific data from the function
- Also accepted was substituting the approx. peak wavelength to show that temperature ~5000 K.

Exemplar:



Using the graph, show that *Model Y* is consistent with Wien's law for black body radiation.

$\lambda_{max} = \frac{b}{T} = \frac{b}{5000} = 580\text{nm}$ which is consistent with the graph

Question 30 (b)

Criteria	Marks
Student response - Refers to unlimited growth of intensity at decreasing wavelength (higher frequencies) according to *Model X*; - Makes connection between substantial discrepancy between predictions for intensity output at low wavelengths (e.g. ultraviolet) according to *Model X* and actual distribution curves of blackbodies.	2
Student demonstrates any relevant understanding of physics.	1

Marker's comments:

- To gain marks, response needed to show reasonable connection to the stimulus (i.e. the function shown by *Model X*)

Exemplar:

Explain why the predictions made by *Model X* came to be known as the "ultraviolet catastrophe".

Model X ~~pr~~ assumes that intensity is proportional to frequency, so as wavelength approaches the ultraviolet range, intensity ~~would~~ would approach infinity. hence "ultraviolet catastrophe" → $I \propto f^3$ ~~with infinite intensity is infred~~ as infinite ~~inf~~ intensity would also mean infinite energy from the ~~per~~ to radiation

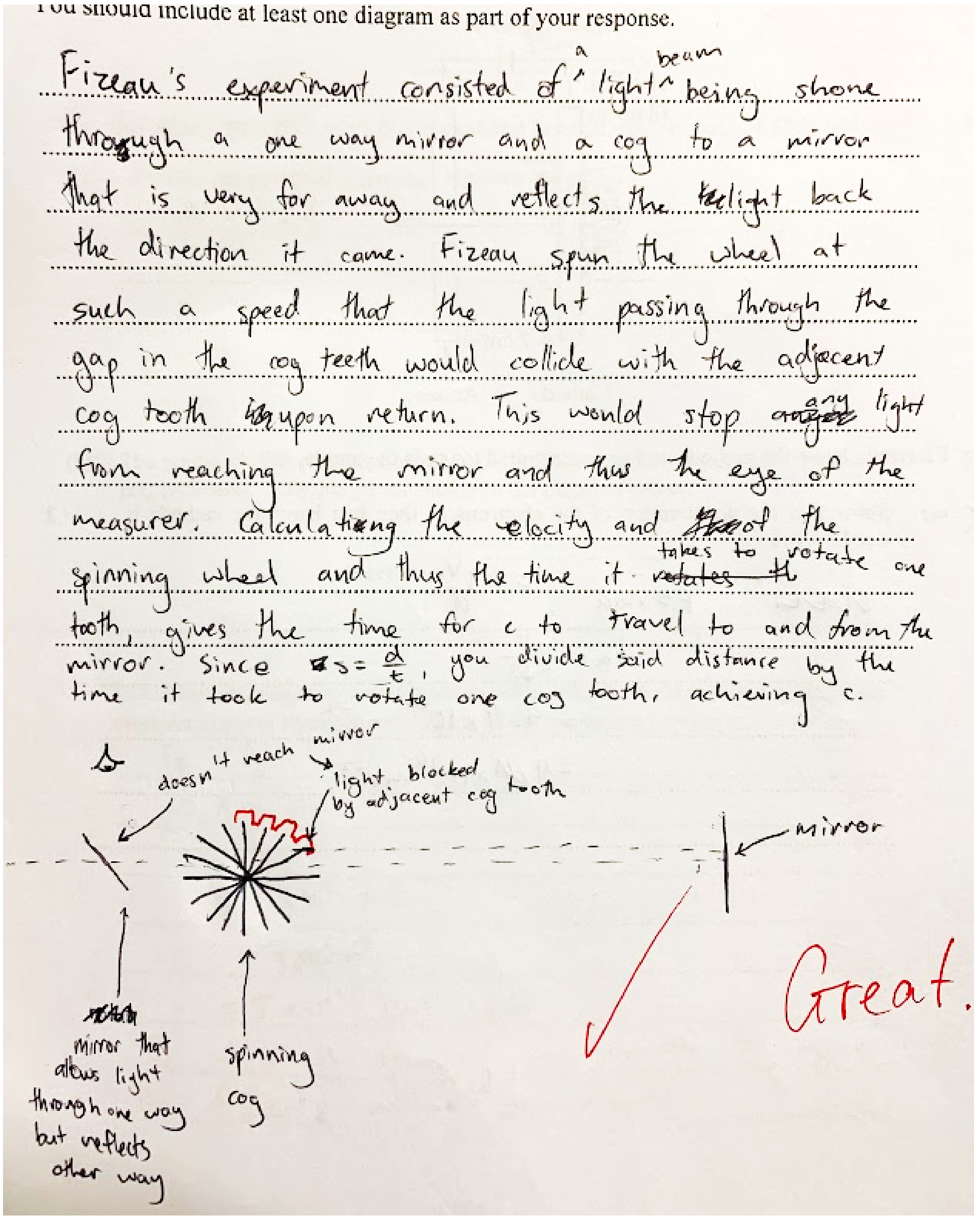
"ultraviolet catastrophe".

Model X was the classic model of Rayleigh Jeans law which stated that Intensity and wavelength were proportional. As the wavelength decreased into the ultraviolet spectrum this model it was predicted that infinite amounts of radiation would be emitted, proved false via experiments, thus ultraviolet catastrophe

Question 31

Criteria	Marks
Student presents a response which includes - Comprehensive detail of the historical method (e.g. specific and numerous details of experiment, approximate values obtained) - Diagram is clear, labelled, and corresponds correctly to the historical experiment being outlined	4
Student presents a response which includes - Reasonable detail of the historical method (e.g. some details of experiment, approximate values) - Diagram corresponds correctly to the historical experiment being outlined	3
Students presents a response which meets most requirements but lacks explicit reference to all criteria and/or coherent structure	2
Student demonstrates any relevant understanding of physics.	1

Exemplar:



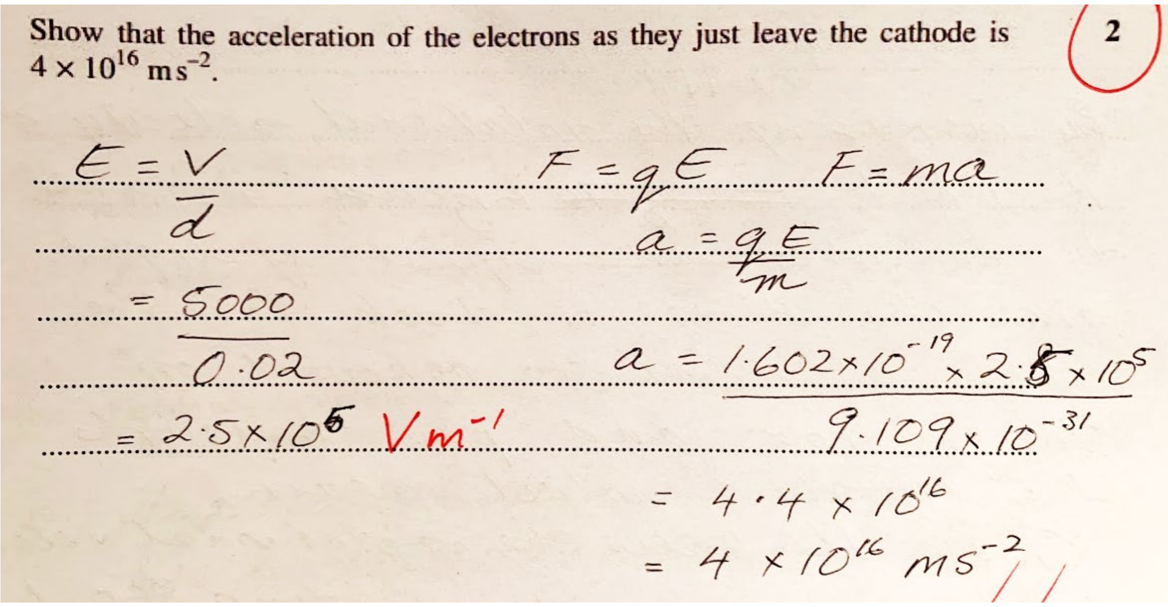
You should include at least one diagram as part of your response.

Fizeau's experiment consisted of a light beam being shone through a one way mirror and a cog to a mirror that is very far away and reflects the ~~tel~~ light back the direction it came. Fizeau spun the wheel at such a speed that the light passing through the gap in the cog teeth would collide with the adjacent cog tooth ~~in~~ upon return. This would stop ~~anyor~~ any light from reaching the mirror and thus the eye of the measurer. Calculating the velocity and ~~the~~ of the spinning wheel and thus the time it takes to rotate ~~rotates the~~ one tooth, gives the time for c to travel to and from the mirror. Since $s = \frac{d}{t}$, you divide said distance by the time it took to rotate one cog tooth, achieving c.

Question 32

Criteria	Marks
Presents a logical progression to show acceleration of electrons leaving cathode to be 4×10^{16} m s^{-2}	2
Shows any valid calculation, such as determining the correct electric field strength.	1

Exemplar:



Show that the acceleration of the electrons as they just leave the cathode is 4×10^{16} m s^{-2}. **2**

$E = \frac{V}{d}$ $F = qE$ $F = ma$

$a = \frac{qE}{m}$

$= \frac{5000}{0.02}$

$a = \frac{1.602 \times 10^{-19} \times 2.5 \times 10^{5}}{9.109 \times 10^{-31}}$

$= 2.5 \times 10^{5}$ V m^{-1}

$= 4.4 \times 10^{16}$

$= 4 \times 10^{16}$ ms^{-2}

Question 33 (a)

Criteria	Marks
Student - States potential difference as 0.15 V - Includes a valid unit for potential difference	2
Student demonstrates any relevant understanding of physics.	1

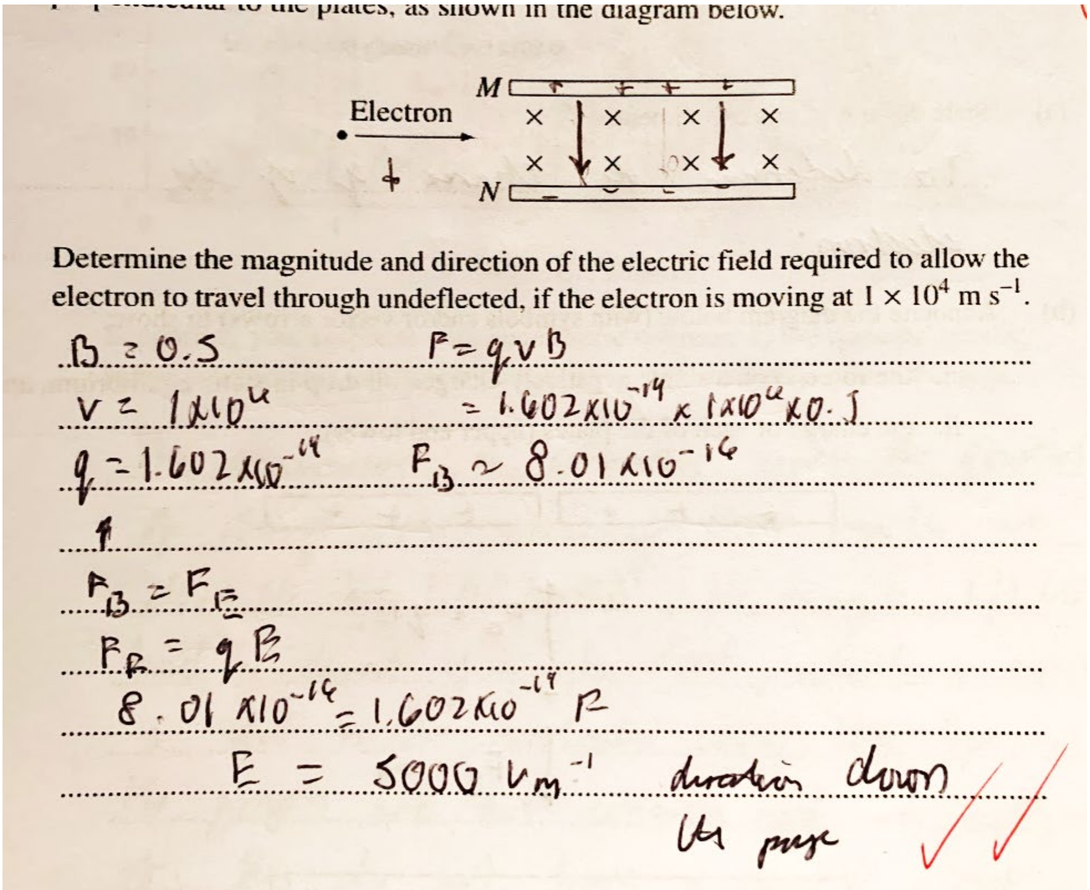
Marker's comments:

- These should have been the easiest two marks in the examination.

Question 33 (b)

Criteria	Marks
Student - States magnitude of electric field as 5000 V m^{-1}; AND - States direction of electric field as down (i.e. M is positively charged)	3
Student - States magnitude of electric field as 5000 V m^{-1}; OR - States direction of electric field as down (i.e. M is positively charged)	2
Student demonstrates any relevant understanding of physics.	1

Exemplar:


...perpendicular to the plates, as shown in the diagram below.

Determine the magnitude and direction of the electric field required to allow the electron to travel through undeflected, if the electron is moving at 1×10^4 m s^{-1}.

$B = 0.5$ $\quad F = qvB$

$v = 1 \times 10^4$ $\quad = 1.602 \times 10^{-19} \times 1 \times 10^4 \times 0.5$

$q = 1.602 \times 10^{-19}$ $\quad F_B = 8.01 \times 10^{-16}$

$F_B = F_E$

$F_E = qE$

$8.01 \times 10^{-16} = 1.602 \times 10^{-19} E$

$E = 5000\ Vm^{-1}$ direction down the page

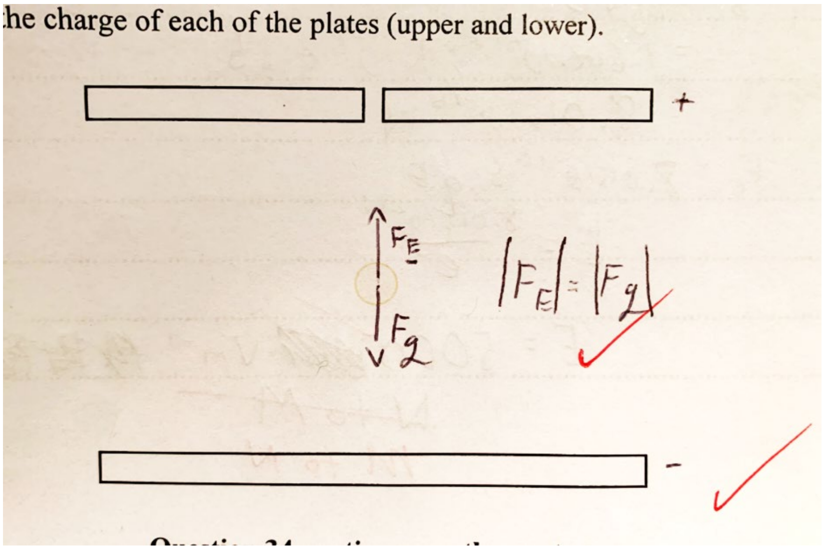
Question 34 (a)

Criteria	Marks
States aim of Millikan-Fletcher experiment as determining the fundamental charge (charge on an electron).	1

Question 34 (b)

Criteria	Marks
Student - Draws two equal-magnitude but opposing force vectors (clearly labelled) acting on oil drop (weight down; electric up); AND - Annotates the top plate as '+' and the bottom as '–'.	2
Student - Draws two equal-magnitude but opposing force vectors (clearly labelled) acting on oil drop (weight down; electric up); OR - Annotates the top plate as '+' and the bottom as '–'.	1

Exemplar:



Question 34 (c)

Criteria	Marks
Student response includes - Quantitative, specific reference to high frequency of charge ratios approximately integer (i.e. charges of oil drops are multiples of fundamental charge); AND - An assessment of the consistency of these data with charge being quantised	3
Student response includes - Some reference to high frequency of charge ratios approximately integer (i.e. charges of oil drops are multiples of fundamental charge); AND - An assessment of the consistency of these data with charge being quantised	2
Student demonstrates any relevant understanding of physics.	1

Marker's comments:

- Use the language of the question. For example, better responses in this case used the word "consistent" in forming their assessment of the experiment.
- In the HSC, "assess" means you must make an explicit judgement.
  For example, these are all considered assessments:
    - "That data is, overall, supportive of a claim that charge is quantised."
    - "According to this data alone, there is insufficient evidence to support quantisation of charge."
    - "This experiment is consistent with the quantisation of charge."

Exemplars:

This experiment is consistent with the quantisation of charge. ~~A high~~ The highest counts of charge ratio are all seen close to or at a whole number multiple of the fundamental charge, for example counts of 90 at 0.8 to 1.0, or 80 from ~~a~~ 1.9 to 2.0. Low counts are seen in between whole numbers such as below 10 from 1.3 to 1.4, and also quantisation decreases as the multiples increase, supporting the idea that lower numbers of electrons are more commonly lost, and never more than 4.

End of Question 34

-31-

Supporting your response with *quantitative* reference to the students' results, assess whether this experiment is consistent with the quantisation of charge.

~~At $\frac{Q}{e^-}$ = ..~~

The most common instances of $\frac{Q}{e^-}$ were at whole numbers which makes sense according to quantisation of charge, at higher $\frac{Q}{e}$ ~~of~~ there was higher discrepency ~~..~~ most likely due to ~~the~~ increased error. Overall the experiment shows a quantisation of charge and a fundamental charge $= 1.602 \times 10^{-19}$ $\therefore$ results ~~..~~ are consistent with quantisation of charge

1, 2, 3, 4

most commonly at 1, 2

End of Question 34

assess whether this experiment is consistent with the quantisation of charge.

~~This experiment is consistent with the quantist quantisation of charge, with the histogram peak intensities giving~~ The experiment is consistent with the quantisation of charge, with the histograms highest ~~peaks~~ ~~giving discrete~~ intensities surrounding "discrete charge ratio's." This can be seen on the graph at $Q/e = 1$ ~~with the graph peak~~ which has the highest count of oil drops measured with that Q/e ratio.

nice

Question 35 (a)

Criteria	Marks
Student records: - Frequency of filter 2 as 7.0 (x 10^{14} Hz) AND - Wavelength of filter 4 as 375 (nm)	1

Question 35 (b)

Criteria	Marks

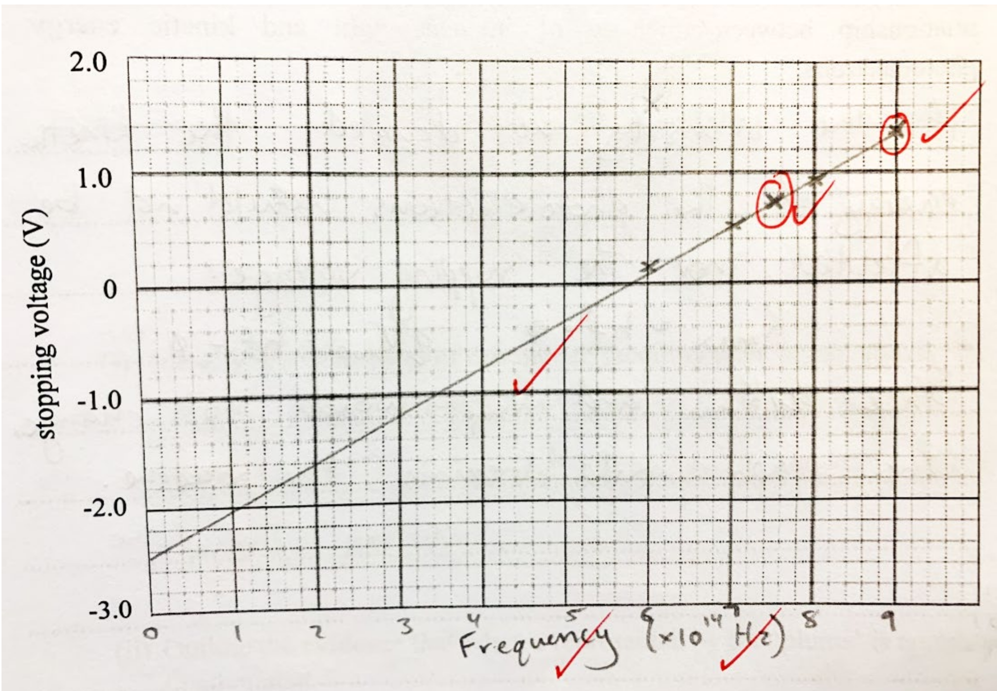
Student constructs a graph with
- Horizontal axis labelled as frequency (including unit)
- Linear scale for frequency, starting from zero
- Precision in plotting
  o Marker checked data point for filters 3 and 5
- Linear trendline
  o extrapolated to BOTH axis intercepts
  o is the best fit for the data
	3

Constructs a graph following most convention and requirements	2
Attempt to construct a graph using the data provided	1

Marker's comments:

- As I've come to expect from this cohort, the overall standard of graphing was excellent.

Exemplar:



Question 35 (c) (i)

Criteria	Marks
Student reads *y*-intercept of trendline and states work function as approx. 2.2 eV	1

Marker's comments:

- Given this graph is the stopping voltage for a single electron, the work function (in eV) can be read directly from the intercept.

Volts to eV calculation with coulombs

The energy E in electron-volts (eV) is equal to the voltage V in volts (V), times the electrical charge Q in coulombs (C) divided by $1.602176565\times10^{-19}$:

$$E_{(eV)} = V_{(V)} \times Q_{(C)} / 1.602176565\times10^{-19}$$

So

$$\text{electronvolt} = \text{volt} \times \text{coulomb} / 1.602176565\times10^{-19}$$

or

$$\text{eV} = \text{V} \times \text{C} / 1.602176565\times10^{-19}$$

Question 35 (c) (ii)

Criteria	Marks

Student
- Shows use of graph in determining gradient by selecting two points on the trendline; AND
- States experimental value for Planck's constant as either:
  ○ 4.2×10^{-15} eV s
  ○ 6.7×10^{-34} J s
	2

Student
- Shows use of graph in determining gradient by selecting two points on the trendline; OR
- States approx. experimental value for Planck's constant as either:
  ○ 4.2×10^{-15} eV s
  ○ 6.7×10^{-34} J s
	1

Marker's comments:

- "Using the graph" does not mean select a single data point and substitute into an equation.
- An acceptable alternative was to use the critical frequency (i.e. K = 0 → V_{stop} = 0) and the work function from part (i) to solve for Planck's constant.

Question 35 (d)

Criteria	Marks
• Explanation involves graphs being same, particle theory, and increase in the number of photoelectrons, and an equation	4
• Description of the process with three features	3
• Outline of the process	2
• One relevant statement	1

Sample answer

If the intensity of the light doubles, there would be no change to this graph, so the two graphs would be the same. This supports the particle theory of light. This is because the energy of the photons depends on their frequency E = hf, not the intensity of the light source. This means increasing the light intensity would produce more photons and kick out more photoelectrons, but the KE of these electrons is still the same.

Marker's comments:

- Overall, LOTS of misconceptions here. Revision required.

Exemplars:

~~voltage values~~ the graph wouldnt change as intensity doest affect the ~~eqn~~ $K = hf -$ work so the kinetic energy of the released photo electrons would stay the same. The only change you could make is the wavelength of the incident light with higher frequencys meaning higher kinetic energy.

good.

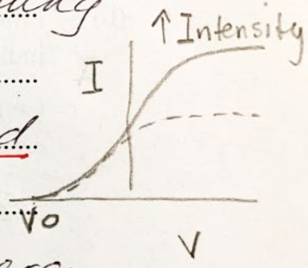
If the intensity was doubled, the kinetic energy of the photoelectrons would not be affected, nor the stopping voltage:

$K_{max} = hf - \phi$ $qV_{stop} = hf - \phi$

Since K_{max} and V_{stop} would not change, the graph would remain the same.

the graph shown on the previous page. Account for any difference(s) with explicit reference to the relationship between intensity of incident light and kinetic energy of photoelectrons.

Doubling the intensity means that more photons hit the metal doubling the photocurrent
Since the frequency has not changed the stopping voltage remains the same therefore kinetic energy does not change. The frequency reflects the energy of the photon which is not effected by intensity. Therefore the graph would not change



End of Question 35

V. good.

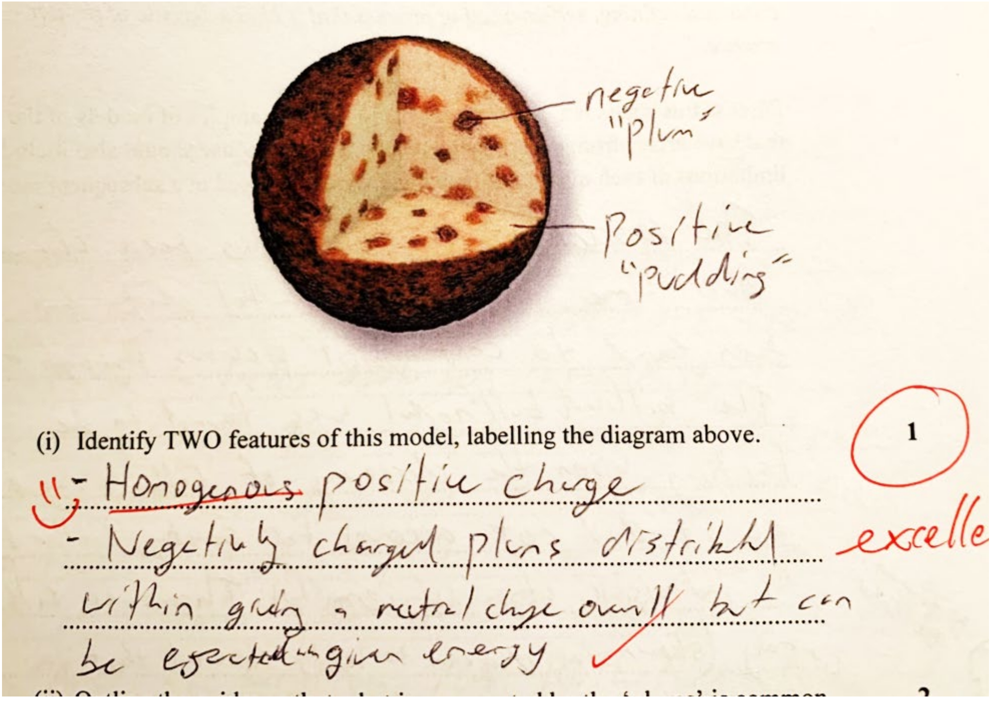
Question 36 (a) (i)

Criteria	Marks
Student identifies TWO correct features of the 'plum pudding' model.	1

Marker's comments:

- Marker decided to relax the requirement to label the image.

Exemplar:



Question 36 (a) (ii)

Criteria	Marks
Student provides detail of valid evidence for the electron being common to all matter (e.g. cathode-ray experiments showing same cathode rays independent of metal used for cathode)	2
Student provides something relevant though lacks clarity and/or detail	1

Marker's comments:

- The emphasis here was on the electrons being *common* to all matter.

Exemplars:

to all matter.

The 'plums', electrons, are shown to be common to all matter through the a cathode ray experiment, in which the negatively beam which came out of the cathode was the same regardless of the cathodes metal material.

to all matter.

Through the use of the cathode ray experiment when altering the metal used, the stream of electrons (plums) remain unchanged thus is common to all matter.

Question 36 (b)

Criteria	Marks
Student presents a response which - Conveys a thorough understanding of TWO recognised models of the atom; - Refers explicitly to the limitations of each model; - Refers explicitly to how a subsequent model addressed limitations; - Is given in the context of the stimulus statement.	6 - 7
Student presents a response meeting most criteria though possibly lacking in clarity and/or specific detail	4 – 5
Student response is an attempt, including some relevant detail.	2 – 3
Any relevant information	1

Marker's comments:

- 3 marks was the maximum awarded for an incomplete response.

Exemplar:

7

"The development of the model of the atom is an excellent example of the continual refining, self-correcting process that is characteristic of proper science."

Discuss this statement, referencing at least TWO examples of models of the atom that have arisen from experimental results. Your response should also include limitations of each model and how these were addressed in a subsequent model.

Thomson
plum-puddin
· cathode rai
- no densit
of Mass or
charge
Rutherfore
- Geiger/Ma
- electron or

'Proper science' usually develops models and theories based on experimental evidence. When new evidence arrives that does not support the existing model, the model must be changed. This process is clearly seen in the development of the Model of the atom in models such as J.J. Thompson's 'plum pudding' model and its successor, Ernest Rutherford's 'planetary' model.

J.J Thomson's model arose from his observation of the beam of energy produced by cathode ray tubes. The cathodes were not physically disintegrating, suggesting that Dalton's 'atoms' model was actually divisible. Thomson's model explained the behaviour of cathode rays by placing negatively charged particles randomly in a 'pudding' of positive matter. ~~I~~ When excited, the 'plums' could be ejected from the atom. 

A limitation of his model was that absence of a density of mass or positive charge, which could not explain the behaviour of alpha particle deflections seen in the Geiger-Marsden experiment.

In the Geiger-Marsden experiment, alpha-particles were fired at a thin layer of gold foil and their deflections measured. To the surprise of the physicists, approximately ~~one~~ 1 in 8000 alpha particles were deflected by more than 90°, suggesting a very dense, positively charged nucleus in the atom. This observation led to Rutherford's planetary model: , in which protons were tightly packed in the centre and electrons orbited the outside like planets to the sun. However, Rutherford's model could not explain why the electron orbits did not instantly decay and fall to the centre of the atom. This limitation was explained by Bohr's model of energy levels of orbital shells and quantised energy.

Throughout history ~~huma~~ physicists have had to constantly update and re-think models in order to explain experimental evidence. This process is clearly evident in the evolution of the model of the atom from Thomson to Rutherford and beyond.