
Student Number

Gosford High School

2022

Trial HSC Examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper
- Write your student number at the top of this page

Total marks:
100

Section I – 20 marks (pages 3–11)

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

Section II – 80 marks (pages 12–27)

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

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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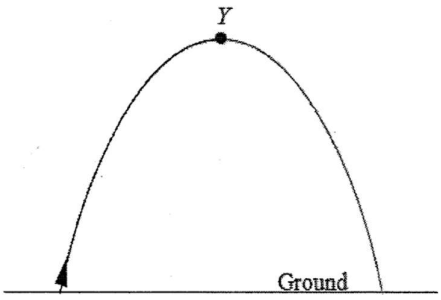
1 Which statement about an object undergoing projectile motion is correct?



A. Its kinetic energy at point Y will be zero.

B. Its potential energy at point Y is a minimum.

C. Its kinetic energy will be the same at launch as it is at impact.

D. Its kinetic energy on launch will be the same as the potential energy at point Y.

2 Which is a correct expression for the total energy of an orbiting satellite?

A. $E_{\text{total}} = \frac{E_K}{2}$

B. $E_{\text{total}} = -\frac{E_K}{2}$

C. $E_{\text{total}} = \frac{U}{2}$

D. $E_{\text{total}} = -\frac{U}{2}$

3 Two satellites are in the same Low Earth Orbit. Satellite X has four times the mass of satellite Y.

What is the ratio of their orbital speeds?

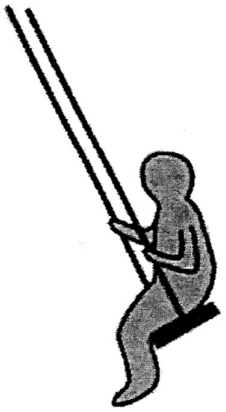
A. $X : Y = 1 : 1$

B. $X : Y = 1 : 4$

C. $X : Y = 4 : 1$

D. $X : Y = 2 : 1$

4 Students discuss the best way to increase speed when on a swing in a children's playground.



Which statement is correct and supported by physics principles?

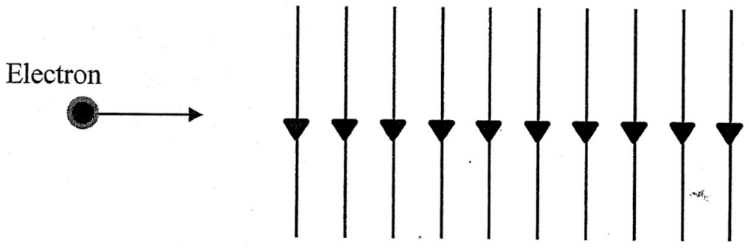
A. Straighten your legs at top of swing to increase speed, as the leg movement adds to available kinetic energy.

B. At top of swing, straighten your legs and pull on the support ropes, because both actions raise your centre of mass, adding potential energy.

C. Pull on the support ropes at top of swing to provide a torque around the pivot point where the rope is attached.

D. At top of swing, straighten your legs and pull on the support ropes, because both use force and therefore increase the centripetal acceleration.

5 The diagram shows an electron which moves with a constant velocity, entering an electric field at a right angle.



Which alternative describes the path of the electron in the electric field?

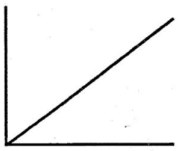
A. A parabolic path down the page

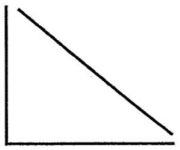
B. A circular path down the page

C. A parabolic path up the page

D. A circular path up the page

6 Which graph could show the relationship between the force between parallel current-carrying conductors and the distance between them?

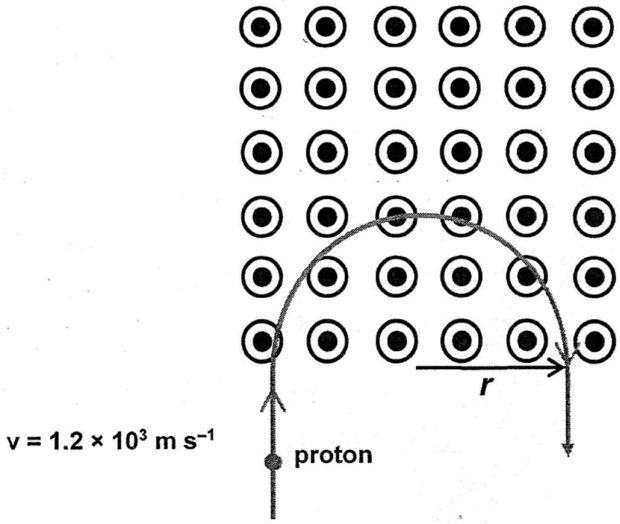
A. 

B. 

C. 

D. 

7 A proton with a velocity of 1.2×10^3 m s^{-1} is fired into a uniform magnetic field of 3.0×10^{-2} *T*, directed out of the page, as shown in the diagram below. It moves in a vacuum in a semi-circle of radius *r*.



Which choice best gives the speed of the proton as it exits the magnetic field?

A. 0.8×10^3 m s^{-1}

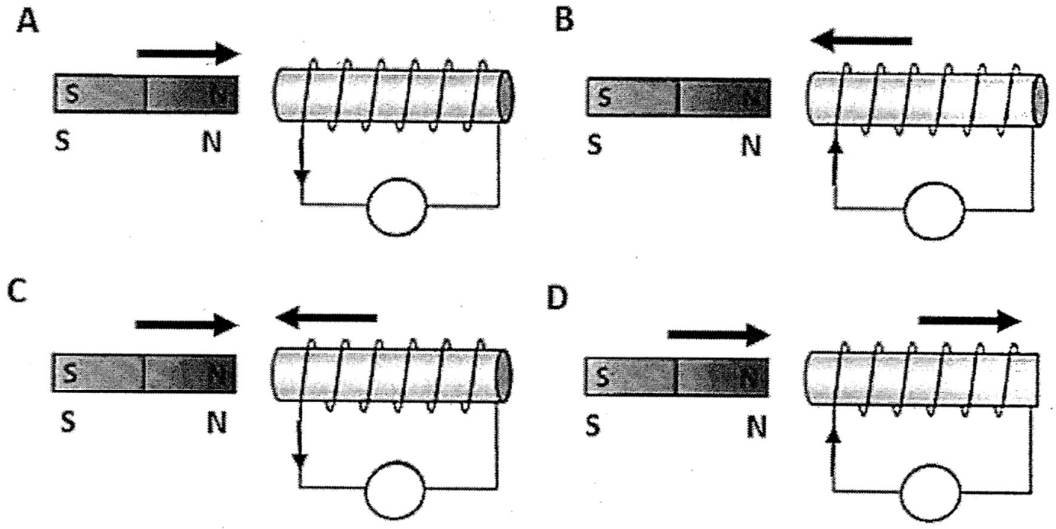
B. 1.2×10^3 m s^{-1}

C. 1.8×10^3 m s^{-1}

D. 2.4×10^3 m s^{-1}

8 The arrows in the diagrams below represent the motion direction of the magnet or the coil. The speeds are identical in each diagram.

Which alternative shows the correct direction of the induced current I in the coil?



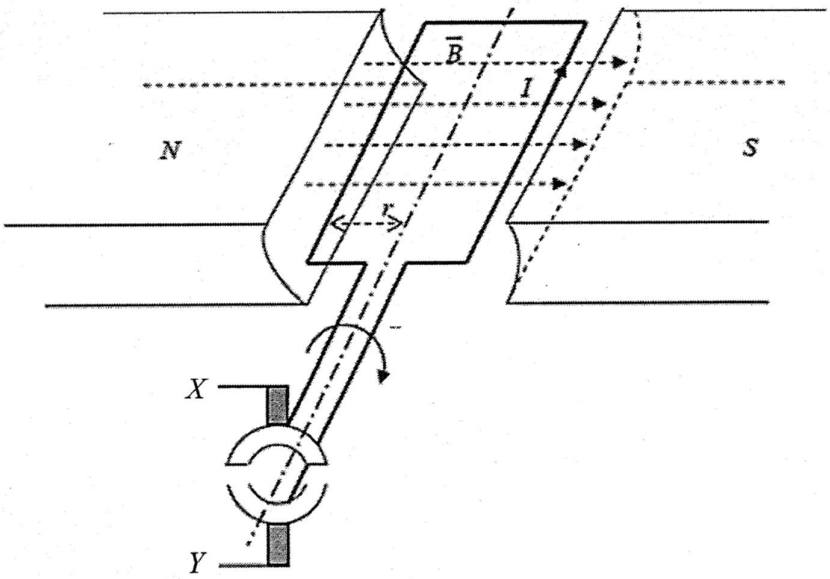
9 Which wave behaviour provided evidence for the transverse nature of light waves?

A. Polarisation
B. Diffraction
C. Interference
D. Refraction

10 Which is the best description of an electromagnetic wave?

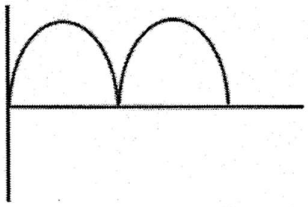
A. Perpendicular oscillating electric and magnetic fields
B. Accelerating electric and magnetic fields
C. Perpendicular constant electric and magnetic fields
D. Radiating parallel electric and magnetic fields

11 A student set up a model generator according to the diagram below and attached a galvanometer across the points X and Y.

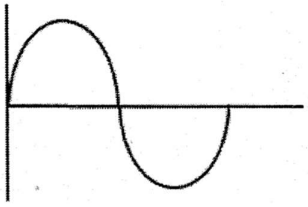


Which graph best shows how the current through the meter changes as the coil is rotated 360° from the position shown?

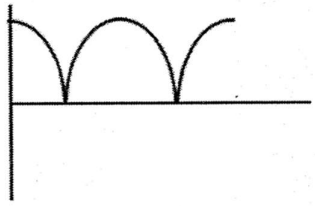
A.



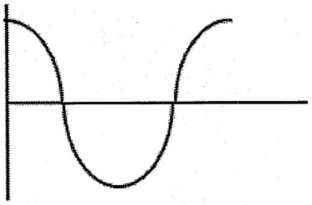
B.



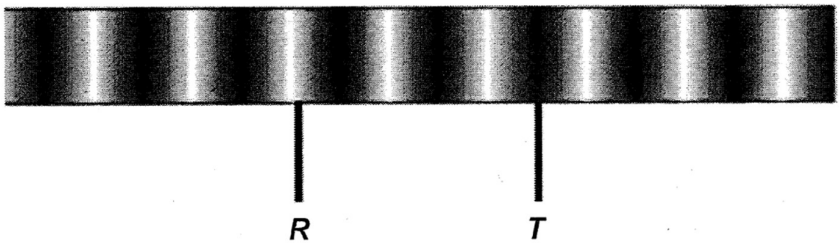
C.



D.



12 The diagram shows the regular light and dark interference pattern produced by a laser beam through two close slits 0.10 mm apart on a screen 1.6 m away from the slits. The distance between maximum at R and minimum at T on the interference pattern is 18 mm.



According to this information in the diagram, what is the wavelength of the incident light used in this experiment?

A. $1.1. \times 10^{-8}$ m

B. 2.2×10^{-7} m

C. 4.5×10^{-7} m

D. 4.5×10^{-4} m

13 Which statement about the spectra of incandescent and laser lights is correct?

A. Incandescent light has a continuous spectrum, laser light has a spectrum specific to its narrow frequency range.

B. Laser light has a continuous spectrum, incandescent light has a spectrum concentrated in the yellow region.

C. Laser light has a very wide spectrum concentrated in the infra-red, incandescent has a very narrow spectrum.

D. Both laser light and incandescent light have a very narrow spectrum.

14 Which of the following is the most accurate statement regarding limitations of special relativity?

A. It has never been tested due to shortcomings in technology

B. Its equations only apply to space travel

C. Its effects can only be measured when objects are travelling close to the speed of light

D. It only applies to inertial frames of reference

15 A rocket is heading directly towards the surface of the Earth at a constant speed of 0.75c. Physicists on Earth calculate the time that the rocket will take to reach the surface of Earth as 850 microseconds.

How long does the pilot in the rocket calculate it will take him to reach the surface of Earth?

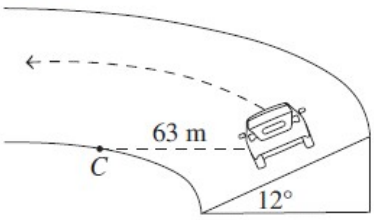
A. 562 microseconds

B. 638 microseconds

C. 1133 microseconds

D. 1235 microseconds

16 A road has a curve of radius 63 m and is banked at an angle of 12°. The diagram shows a car approaching the curve in wet, slippery conditions.



Assuming that there is no friction, calculate the maximum speed at which the car can safely make the turn.

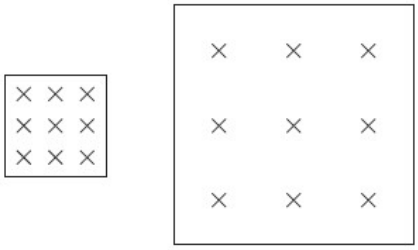
A. 6.07 km h^{-1}

B. 11.5 km h^{-1}

C. 36.5 km h^{-1}

D. 41.2 km h^{-1}

17 A Physics teacher drew two magnetic fields and asked their students to explain the difference between the magnetic flux of each field. The two magnetic fields are shown in the diagram.



Which of the following statements is correct?

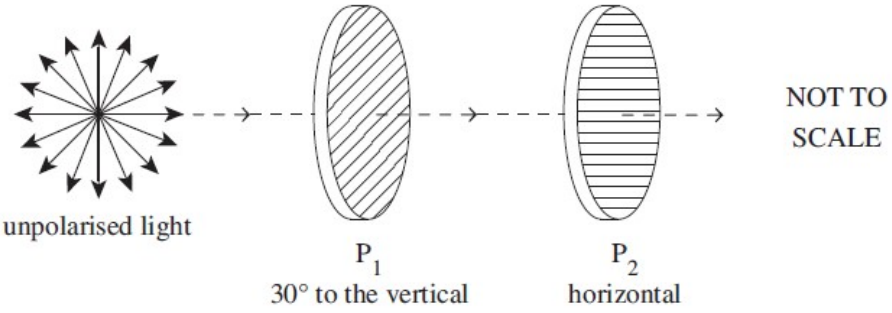
A. The two magnetic fields show the same amount of flux, and the smaller magnetic field shows less flux density.

B. The two magnetic fields show different amounts of flux, and the smaller magnetic field shows less flux density.

C. The two magnetic fields show different amounts of flux, and the smaller magnetic field shows greater flux density.

D. The two magnetic fields show the same amount of flux, and the smaller magnetic field shows greater flux density.

18 A light meter measures 150 Wm^{-2} of unpolarised light at a fixed position from a light source. A polarising sheet, P_1, is placed at this position with an axis of polarisation 30° to the vertical. A second polarising sheet, P_2, is placed so that any light that passes through P_1 also passes through the P_2. P_2 has an axis of polarisation oriented horizontally. The diagram shows the set-up.



What intensity of light is transmitted through P_2?

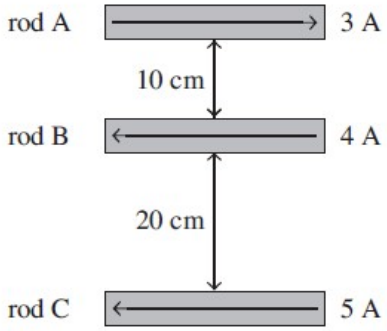
A. 9.38 Wm^{-2}

B. 18.75 Wm^{-2}

C. 37.5 Wm^{-2}

D. 75 Wm^{-2}

19 The diagram shows a set-up that uses three rods (A–C), each carrying a current in the direction indicated by the arrows.



What is the magnitude and direction of the force per unit length on rod C?

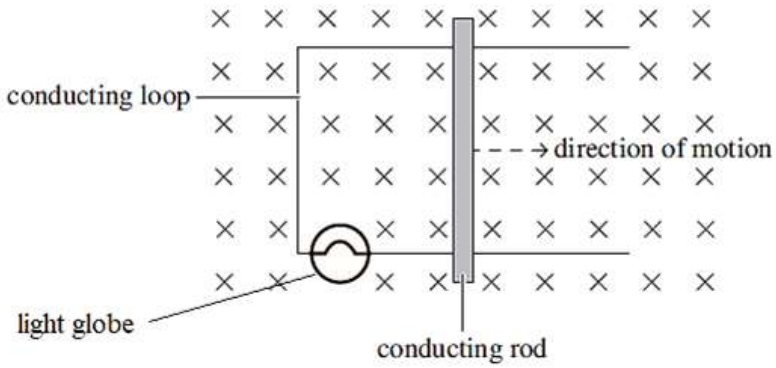
A. 1×10^{-5} N m^{-1} down

B. 1×10^{-5} N m^{-1} up

C. 3×10^{-5} N m^{-1} up

D. 3×10^{-5} N m^{-1} down

20 A conducting rod is rolling horizontally along a metal conducting loop in a magnetic field, as shown in the diagram.



Which row of the table is correct?

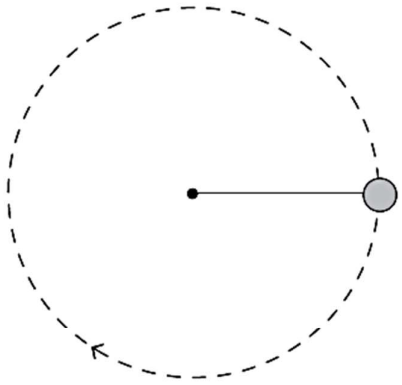
	Direction of force on the conducting rod	*Direction of current around the conducting loop*	*Brightness of Light Globe*
A.	to the left	anticlockwise	Decreasing
B.	to the left	clockwise	Constant
C.	to the right	anticlockwise	Decreasing
D.	to the right	clockwise	Constant

Section II – 80 marks

- **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 (6 marks)

The diagram shows a totem tennis set-up, as viewed from above. A tennis ball is tied to a pole with a cord so that it moves in a clockwise, circular motion around the centre pole.



(a) Label the velocity of the ball and the forces acting on it at the point shown in the diagram above. Explain your answer. **3**

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Question 21 continues on next page

(b) The ball has a mass of 60.0 g and the cord is 1.80 m long. The ball rotates around the centre pole at an angle of 45° to the pole. **1**

Calculate the radius of the ball's circular path.

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(c) Determine the magnitude of the net force acting on the ball at the point shown. **2**

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Question 22 (2 marks)

In an experiment involving an evacuated gas tube, electrons were accelerated from rest through a voltage of 2400 V, then entered a uniform magnetic field strength of 1.8×10^{-3} T at right angles to the electron beam. **2**

Calculate the speed of these electrons upon entering the magnetic field.

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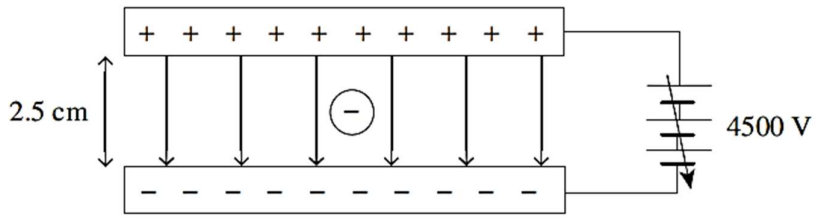
Question 23 (3 marks)

Draw a labelled diagram to show the propagation of waves according to Huygen's model of light. **3**

Question 24 (4 marks)

In science, observations lead to hypotheses and further experimentation.

Robert Millikan conducted experiments to determine the charge on an electron. One of these experiments is shown in the diagram. **4**



Explain the observations Millikan made that led to his determination of the charge of an electron.

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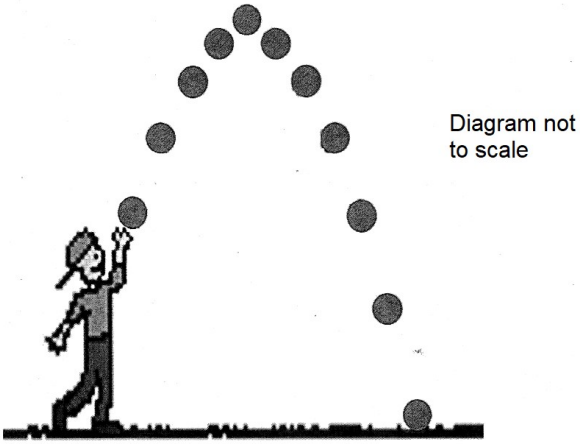
Question 25 (4 marks)

The diagram shows a strobe photo of a ball projected into the air. The camera took 7 images per second of the ball.



(a) What was the maximum height of the ball above the ground? **2**

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(b) Determine the range of the projectile. **2**

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Question 26 (6 marks) **Marks**

The table shows data for three of the moons of Jupiter, the largest planet in our solar system with a diameter of approximately 143 000 km.

Moon of Jupiter	Orbital radius (km)	Orbital period ($\times 10^5$ s)	(Orbital radius)^3 ($\times 10^{26}$ m^3)	(Orbital period)^2 ($\times 10^{10}$ s^2)
Io	493 500	1.53	1.2	2.34
Europa	742 500	3.1	4.1	9.61
Ganymede	1 141 500	6.2	14.9	38.4

(a) On the axes provided, graph relevant data to verify Kepler's Law of Periods. Include a line of best fit. **3**

(b) Explain how the graph provides evidence for Kepler's law of Periods. **1**

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(c) Using your graph, determine the mass of Jupiter. **2**

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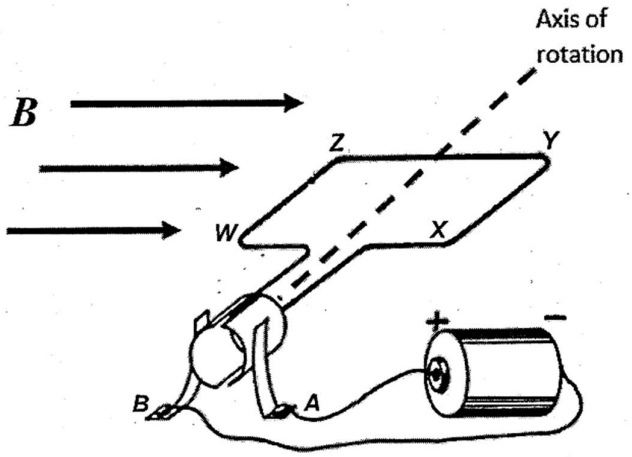
Question 27 (6 marks) **Marks**

The diagram below shows a simple electric motor. The square coil *WXYZ* has sides of 4.0 cm and lies completely in the horizontal uniform magnetic field *B* of strength 2.0 *T*. The magnetic field is perpendicular to the sides *WZ* and *XY*. The coil has 20 turns and rotates about the axis shown. The current drawn from the battery is 2.5 A.



(a) For the position of the coil in the diagram, determine the torque on the side *WZ*. **3**

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(b) Explain the continuous movement of the coil in relation to the changing torque acting on the coil. **3**

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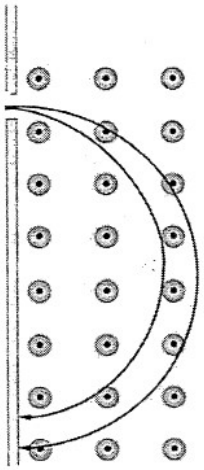
Question 28 (4 marks)

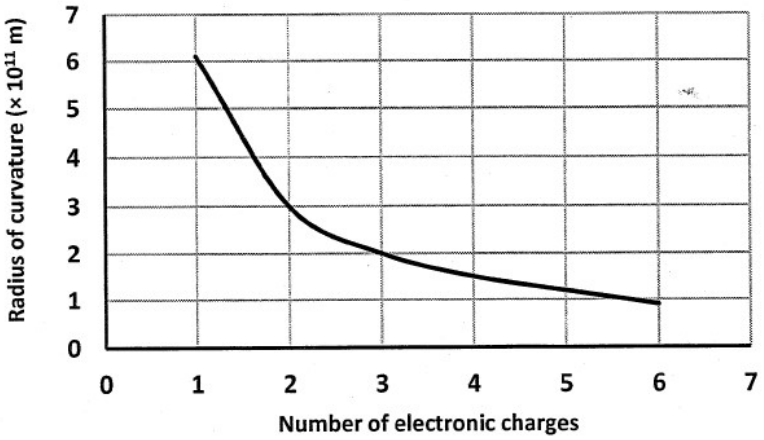
Using a mass spectrometer, some students did an experiment to determine the relationship between the charge on a particle and its radius of curvature in a magnetic field. The diagram shows the path of only two of the six charged particles observed. **4**



Their results are shown in the table.

Charge on particle (Number of electronic charges)	*Radius of curvature of path ($\times 10^{-11}$ m)*
1	6.1
2	2.9
3	2.1
4	1.5
5	1.2
6	0.9

The students plotted their results, shown on the graph below, and concluded that the radius of curvature of a charge in a magnetic field, is inversely proportional to the magnitude of the charge.



Question 28 continues on next page

Evaluate their conclusion and identify any problems with their method. 4

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Question 29 (6 marks)

Einstein used thought experiments to explain how the behaviour of light affects the concepts of time, space and matter.

(a) The rest life, or proper lifetime, of a meson is 2.5×10^{-8} s. An observer measures the distance travelled by a meson moving at 2.95×10^{8} m s^{-1} in the laboratory. **3**

Compare the expected distance travelled by the meson in the absence of time dilation with the distance that would be measured by the observer.

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(b) A spacecraft of mass 79 000 kg is moving at 0.3*c*. **3**

Compare the momentum of the spacecraft measured by the spacecraft's pilot with the momentum measured by an external observer, and explain why objects cannot accelerate to the speed of light.

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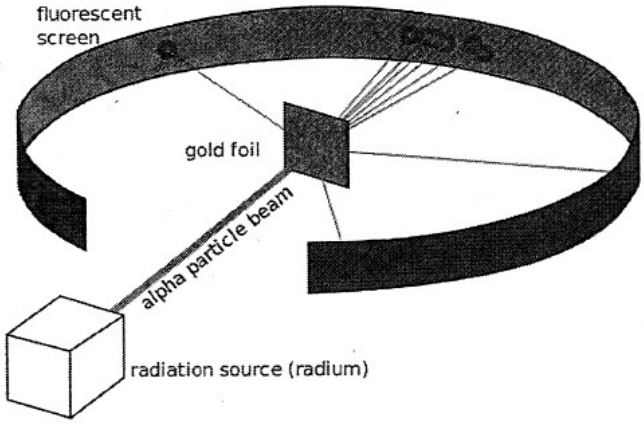
Question 30 (7 marks)

The diagram represents an important experiment done by a group of scientists in 1907. 7



Outline the background to the experiment, its results and the proposed model of the atom based on the experimental results.

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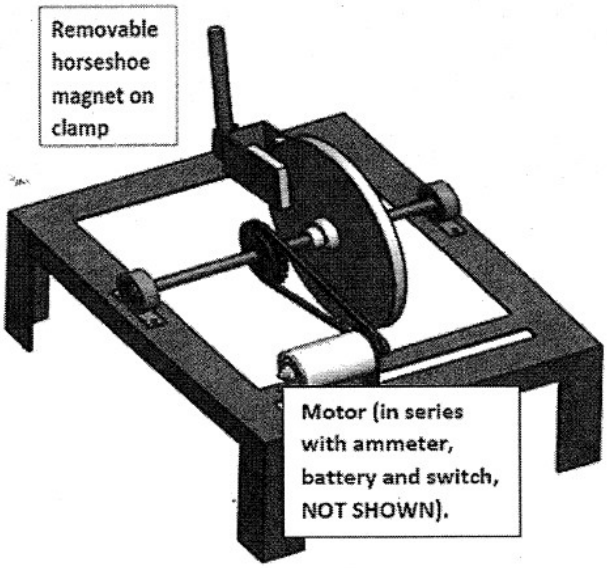
Question 31 (7 marks) **Marks**

A student sets up an aluminium disc which is able to rotate in the vertical plane. The axle of the disc has a pulley wheel turned by a motor in series with an ammeter, battery and switch. A clamp with a horseshoe magnet can be attached so that a horizontal magnetic field passes through one part of the disc. **7**



The student observes the current and the speed of disc rotation, before and after the magnet is attached with its magnetic field passing through the disc. When the magnet is in place, the current through the ammeter is more and the speed of rotation of the disc is less.

By applying Lenz's Law, explain each observation.

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Additional writing space for Question 31 is provided on next page

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Question 32 (3 marks)

For electricity to be transmitted over the large distances between generators and households, transformers are used. Two transmissions take place over the same transmission lines. **3**

- In transmission A, energy is transmitted at 28 kV AC.
- In transmission B, the same amount of energy is transmitted at 280 kV AC.

Compare the power losses that occur in transmissions A and B. Include relevant equations and calculations in your response.

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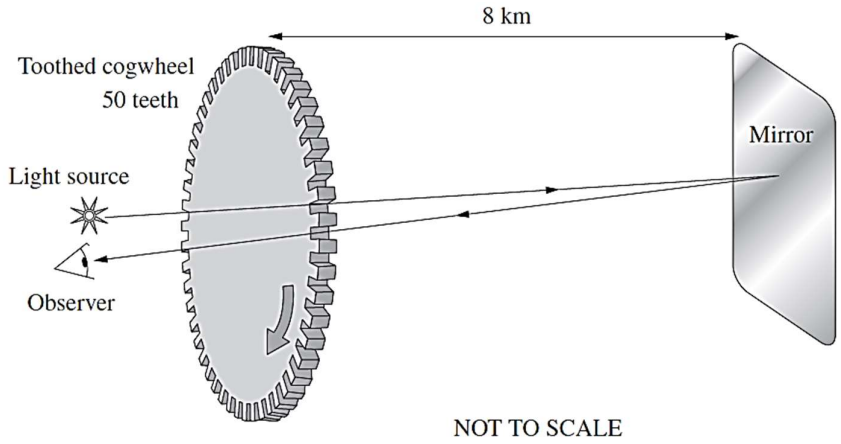
Continue on to next page

Question 33 (5 marks)

In the 1840s, French physicist, Hippolyte Fizeau performed an experiment to measure the speed of light. He shone an intense light source at a mirror 8 km away and broke up the light beam with a rotating cogwheel. He adjusted the speed of rotation of the wheel until the reflected light beam could no longer be seen returning through the gaps in the cogwheel. **5**

The diagram shows a similar experiment. The cogwheel has 50 teeth and 50 gaps of the same width.



NOT TO SCALE

Explain why specific speeds of rotation of the cogwheel will completely block the returning light. Support your answer with calculations.

Question 34 (4 marks)

A communications company launched a satellite of mass 250 kg. The satellite is in an orbit with an altitude of 27 129 km above the Earth.

Calculate the gravitational potential energy of the satellite and its escape velocity.

In your response, explain what the term 'escape velocity' means. **4**

Question 35 (7 marks)

In an experiment, students used a light source that emitted a wide range of frequencies. They used filters so that only specific frequencies could fall onto a photoelectric plate. Most of the filters produced frequencies which did not cause emission. **7**

Julie says that if the intensities of these frequencies were increased, emission will occur. They experimented with this variable and found that emission still did not occur.

Explain the student's observations and how they provide evidence for the nature of light.

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Question 36 (6 marks)

In science, there is a close link between developments in technology and developments in knowledge and understanding.

Evaluate this statement with reference to the cathode ray debate and Thomson's discovery of the electron. **6**

End of paper

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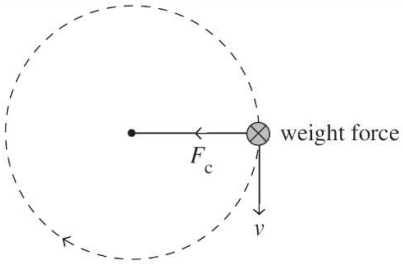
GHS Physics Trial HSC 2022 – Marking Guideline

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

21.

(a)



The ball is accelerating towards the centre of the circle. This net force is the centripetal force. Gravity is acting downwards, but the tension in the cord (the horizontal component) pulls the ball inward, keeping it moving in a circle around the pole. The velocity is a tangent to the circle in the direction of the motion of the ball.

Mod 5 Advanced Mechanics
PH12–4, 12–6, 12–12 Bands 4–5

- Labels the velocity and 2 forces.

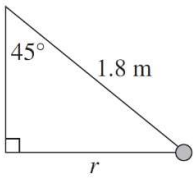
AND

- Explains the unbalanced force and the direction of velocity 3

- Any TWO of the above points 2

- Any ONE of the above points 1

(b)



$$\sin 45° = \frac{r}{1.80}$$

$$r = 1.80 \sin 45°$$

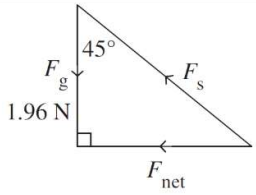
$$= 1.27 \text{ m} \quad \text{(to three significant figures)}$$

Note: A diagram is not required for the response but may be used as part of the working.

Mod 5 Advanced Mechanics
PH12–4, 12–6, 12–12 Band 4

- Provides the correct solution 1

(c)



$$F_{net} = 0.588 \tan 45°$$

$$= 0.59 \text{ N}$$

Note: A diagram is not required for the response but may be used as part of the working.

Mod 5 Advanced Mechanics
PH12–4, 12–6, 12–12 Band 4

- Calculates the magnitude of the net force using appropriate units 2

- Calculates the magnitude of the net force without using appropriate units. 1

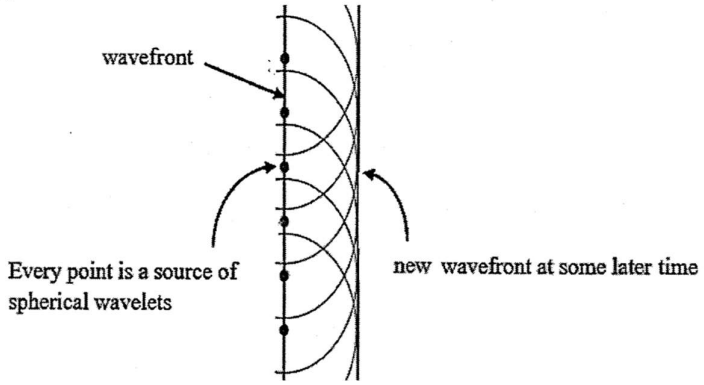
22.

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
$eV = \frac{1}{2}mv^2$ $1.6\times10^{-19}\times2400 = \frac{1}{2}\times9.1\times10^{-31}\times v^2$ $v^2 = \frac{1.6\times10^{-19}\times2400}{\frac{1}{2}\times9.1\times10^{-31}}$ $v = 2.9\times10^{7}\ \text{m s}^{-1}$	Mod 8 From the Universe to the Atom PH12–6, 12–15 Bands 4–5 • Identifies the appropriate formula to use. AND • Provides the correct solution using appropriate units. . . . . 2 • Any ONE of the above points 1

23.

Criteria	Marks
• Draws a diagram with wavefront tangential to spherical wavelets and with THREE of the labels shown below	3
• Draws a diagram with wavefront formed by spherical wavelets and with ONE of the labels shown below	2
• Draws a diagram of a wavefront with spherical wavelets	1

Sample answer:



24.

• Millikan observed the oil drops that fell through the small gap between the plates. When the electric force was equal to the opposing gravitational force, the drop remained in static equilibrium. Therefore, $Mg = qE$, where $E = \frac{V}{d}$. • He observed the charge on the oil droplet was always a multiple of 1.6×10^{-19} C, which is the charge on an electron.	Mod 8 From the Universe to the Atom PH12–7, 12–15 Bands 5–6 • Provides a concise description of 2 observations. AND • Links 2 observations to the charge always being a multiple of 1.6×10^{-19} C . . . . . 4 • Any ONE of the above points 1

25.

Criteria	Marks
• Correctly calculates the maximum height	2
• Calculates maximum height with one error	1

Sample answer:
Time to fall from highest point where vertical velocity is zero = 6 × 1/7 s
$s = ut + \frac{1}{2}at^2$
$= 0 + 4.9 \times (6 \times 1/7)^2$
Maximum height = 3.6 m

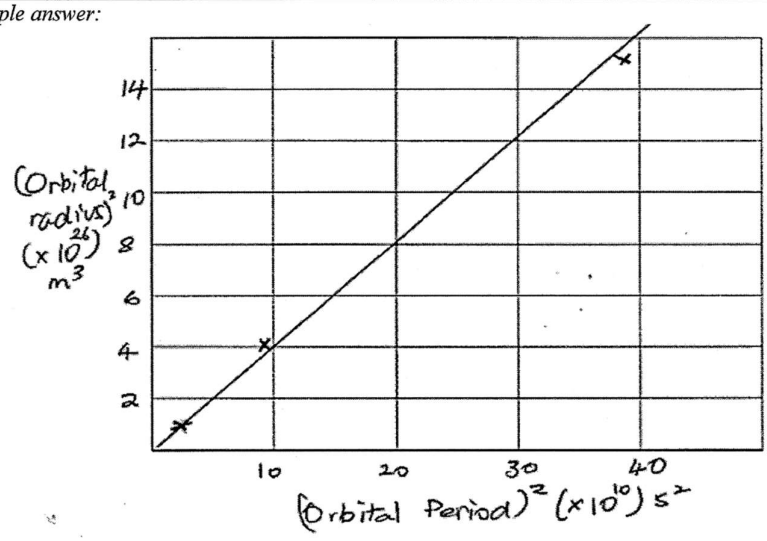
Criteria	Marks
• Correctly calculates the range using part(a) answer	2
• Calculates range with one measurement error	1

Sample answer:
Distance from ground to bottom of ball at highest point = 9.8 cm
Range of ball = 7.2 cm
9.8 cm represents 3.6 m
Therefore, 1 cm represents 3.6/9.8
Hence, range is 7.2 × 3.6/9.8 = 2.6 m

26.

Criteria	Marks
• Provides a ruled straight line graph of radius cubed against period squared with suitably labelled axes	3
• Provides graph without correct labels or graph not ruled	2
• Provides graph without correct labels and graph not ruled	1

Sample answer:



Question 26(b)

Criteria	Marks
• Relates constant gradient to Kepler's law	1

Sample answer: From the Kepler's law equation, $\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$ = constant = gradient for the graph.
Since the graph has a constant gradient, it shows that Kepler's Law of Periods holds for these three moons of Jupiter.

Question 26(c)

Criteria	Marks
• Calculates mass of Jupiter correctly using point on their graph	2
• Correctly derives equation for mass based on gradient	1

Sample answer: $\frac{GM}{4\pi^2}$ = gradient

Mass of Jupiter = $\frac{4\pi^2}{G}$ × gradient
$= (4 \times 3.1415^2/6.67 \times 10^{-11}) \times (8 \times 10^{26}/20 \times 10^{10}) = 2.4 \times 10^{27}$ kg

27.

Criteria	Marks
• Provides correct answer with units and direction	3
• Provides correct answer without units or without direction	2
• Provides incorrect answer with units and direction	1

Sample answer:
Force on WZ = nBIl = $20 \times 2.0 \times 2.5 \times 4 \times 10^{-2} = 4.0$ N
Current direction through side WZ is towards W. Using Right Hand Push Rule, the force on WZ is upwards.
Torque = F × distance from axis = $4.0 \times 2 \times 10^{-2} = 8.0 \times 10^{-2}$ Nm vertically upwards

Question 27(b)

Criteria	Marks
• Shows a clear understanding of the operation of the motor	3
• Provides some details of zero torque, momentum effect, change of current in coil sides	2
• Provides some details of TWO of the following: zero torque, momentum effect, change of current in coil sides	1

Sample answer: As the coil rotates, the torque on sides WZ and XY reduce to zero, as the perpendicular distance of the force direction to the axis of rotation reduces to zero. The momentum of the coil moves it past the vertical position. In the vertical position, the commutator setup (AB) changes the direction of the current in the coil, and hence, the direction of the torque acting on WZ and XY is changed every 180°, resulting in continuous rotation.

Markers comments
a. Many students did not take into account the distance from point of rotation point. Torque is defined by the force and distance from pivot point.
b. Many students did not address the 'verb' explain. Cause and effect / how and why. It is not enough to say that the torque changes due to angle but rather how and why.

28.

Criteria	Marks
• Provides reasons for invalid conclusion based on lack of identified controlled variable and derived relationship between radius and charge based on a curve	3–4
• Provides reasons for invalid conclusion based on lack of controlled variables	2
• Provides shape of graph as reason for invalid relationship	1

Sample answer: Conclusion is invalid. A conclusion cannot be made because the graph is not a straight line. Their conclusion can only be based on a straight line graph plotting the inverse of charge or radius against the other variable. Also, the experiment description does not have the necessary controlled variables stated. The mass and velocity of the charged particle will affect the radius of curvature, as well as the charge.

Centripetal force, $mv^2/r = Bqv$ Therefore, $r = (mv/B) \times 1/q$

This shows that radius is inversely proportional to charge, only if mass and velocity are constant, as well as magnetic field.

Markers comments.
Address the verb 'evaluate' meaning to demonstrate to your marker if the conclusion was valid or not.

29.

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 30	
(a) $t = \dfrac{t_0}{\sqrt{\left(1-\dfrac{v^2}{c^2}\right)}}$ $= \dfrac{2.5\times10^{-8}}{\sqrt{1-\dfrac{(2.95\times10^8)^2}{(3.0\times10^8)^2}}}$ $= 1.37\times10^{-7}$ s In this time, travelling at 2.95×10^8 m s^{-1}, the observer would measure the meson travelling at: $s = vt$ $= 2.95\times10^8 \times 1.37\times10^{-7}$ $= 40.4$ m (with time dilation) If time dilation did not exist, the meson would travel for 2.5×10^{-8} s. Therefore, the expected distance it would travel is: $s = vt$ $= 2.95\times10^8 \times 2.5\times10^{-8}$ $= 7.38$ m (without time dilation)	Mod 7 The Nature of Light PH12–4, 12–14 Bands 5–6 • Calculates the distance travelled in the observer's timeframe. AND • Calculates the distance travelled in the meson's timeframe. AND • Provides the correct significant figures for each solution . . . . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points 1
(b) The pilot is inside the spacecraft, so they would assume their momentum to be 0 kg m s^{-1}. Calculating the mass measured by an observer gives: $p_v = \dfrac{m_0 v}{\sqrt{\left(1-\dfrac{v^2}{c^2}\right)}}$ $= \dfrac{7.9\times10^4 \times 0.3c}{\sqrt{1-0.3^2}}$ $= 7.45 \times 10^{12}$ kg m s^{-1} $= 7 \times 10^{12}$ kg m s^{-1} the momentum (or mass) approaches infinity as the velocity approaches the speed of light. Hence, an object with mass cannot accelerate to the speed of light	Mod 7 The Nature of Light PH12–4, 12–14 Band 5 • Identifies the mass for pilot AND observer. AND • Calculates the mass. AND • Explains why objects cannot exceed the speed of light . . . . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points 1

Markers comments

a. Many students did not use correct sig figs
b. The question asks you to compare therefore you must acknowledge the pilots observed momentum in your answer.

30.

Criteria	Marks
• Outlines clearly the background to the experiment including Thomson's model • Provides details of results and Rutherford's model of the atom • Explains how the model relates to the results	6–7
• Outlines the background to the experiment, provides some details of results and model of the atom and explains how the model relates to the results	4–5
• Provides TWO of the following: the background to the experiment, the results, the new model of the atom	2–3
• Provides ONE of the following: the background to the experiment, the results, the new model of the atom	1

Sample answer: This experiment, eventually known as the Rutherford alpha particle scattering experiment, was done by two of Rutherford's postgraduate students – Geiger and Marsden. It had been shown that alpha particles were deflected when passing through very thin gold foil, and it was not understood how this occurred based on Thomson's the plum pudding model of the atom, a random arrangement of positive and negative charge. Rutherford expected that the alpha particles would pass through the gold foil with very small deflections from their path. Most of the alpha particles were observed to pass straight through the foil or to be scattered only one or two degrees by the foil. The surprising result was that a few alpha particles were observed to be scattered at larger angles and a very few were reflected almost straight back.

Rutherford proposed that the force causing the large deflections and repulsion of the positively charged alpha particles, could only be caused by a positively charged small object with concentrated mass in the centre of the gold atoms. He also proposed that this centre, called the nucleus, was surrounded by a much larger region of mainly empty space and circling electrons, too small to cause the occasional deflections of alpha particles. Rutherford's new model of the atom was able to explain the experimental results of the alpha particle scattering experiments.

31.

Marked holistically with a typical 7 mark answer including the following:

- Defined and correctly related Lenz's law (1)
- Identifies induced eddy currents in disk (1)
- Explains the formation of these eddy currents by the change in magnetic flux in the disk as it rotates within the external magnetic field, inducing an EMF in accordance with Faraday's law and a current flow. (1)
- Relates the induced current's magnetic field (cause) to the slowing of the disk's rotation (effect) in accordance with Lenz's law. (1)
- Defines Back EMF as the induced EMF in a DC motor due to the change in magnetic flux within its rotating coil. (1)
- Explains that the back EMF decreases when the disk's rotation slows. (1)
- Relates a smaller back EMF to a larger net EMF across the motor and therefore a larger current in the motor and ammeter. Equation Net EMF = Supply EMF – Back EMF would be helpful here. (1)

Criteria	Marks
• Clearly explains the cause of a back emf in motor and the eddy currents in the disc based on Lenz's law and why the eddy currents change the ammeter reading	6–7
• Outlines the cause of a back emf in motor and the eddy currents in the disc based on Lenz's law and why the eddy currents change the ammeter reading	4–5
• Outlines the cause of a back emf in motor and identifies eddy currents OR • Outlines why the eddy currents are set up and identifies the occurrence of a back emf in the motor	2–3
• Identifies eddy currents in the disc OR • Identifies back emf in motor	1

Sample answer: When a motor is switched on, the motion of the motor's rotating coil in its magnetic field will induce a back emf in the coil according to Faraday's law of induction. The direction of this emf must be such that it opposes the motion of the coil (Lenz's Law) and therefore, does not contravene the law of conservation of energy. The net voltage decreases, and therefore, the current flow decreases. The magnitude of the back emf is proportional to the rotational speed of the motor coil.

When the horseshoe magnet surrounds part of the aluminium disc, eddy currents are set up in the disc because the disc is a conductor moving in a magnetic field. By Lenz's Law, the direction of the currents will be such as to oppose the magnetic field and oppose the motion of the disc. This is known as the braking effect, reducing the rotational speed of the disc and the motor coil. Consequently, the back emf is also less, resulting in the greater current.

32.

Includes equation $P_{loss} = I^2R$ (or $P = VI$ used with $V = IR$). (1)
States that power loss in A is greater than in B (or vice versa). (1)
Calculates power loss in A to be 100x larger than power loss in B (or, stated differently, power loss in B is 1/100th as large as the power loss in A). (1)

Given that voltage is equal to *IR*, power can equal *VI*.

If power remains constant, an increase in voltage must result in a decreased current to uphold the Law of Conservation of Energy. This reduced current results in a reduced overall transformation of electrical energy into heat energy. This means that the transmission lines will retain more of the original electrical energy, resulting in an overall decrease in the percentage of energy lost. Therefore, the power loss in each system can be significantly less when transferring energy at a much higher voltage. Both voltages travel along the same line; hence, *R* is constant.

Voltage in transmission A: 28×10^3 kV

Voltage in transmission B: 280×10^3 kV

The voltage in transmission B is 10 times greater than in transmission A. The current in transmission A must be a tenth of the system in transmission B.

$$P_{loss} = I^2R$$
$$= \left(\frac{1}{10}\right)^2 \times R$$

As the P_{loss} of transmission B is 1 : 100, it loses 100 times less energy than transmission A.

Note: An explanation of the difference in the transmissions is not required but may be included to develop the response.

Mod 6 Electromagnetism
PH12–5, 12–13 Band 5

- Compares the energy losses mathematically.

AND

- Includes $P = VI$ and $P = I^2R$.

AND

- Provides an overall comparison about energy and power loss in each transmission 3

- Any TWO of the above points. 2

- Any ONE of the above points 1

33.

- Explains that to block the light the cog must move the width of a gap in the time it takes light to travel to the mirror and return. (1)
- Calculates this time correctly as 5.33 x10^{-5} s. (1)
- Explains that the cogwheel must rotate 1/100th in this time for light to be blocked (wheel consists of 50 cogs + 50 gaps) (1).
- Includes a calculation to determine the angular velocity to be 1x10^{3} rad s^{-1} such as using the working out shown below (1)
- Identifies that any odd multiple of this angular velocity will also result in the light being blocked (3x, 5x, 7x, etc). (1)

Marking guidelines:

Criteria	Marks
• Explains why specific speeds will completely block the light • Supports answer with calculations	5
• Explains why a specific speed will block the light with relevant calculations	4
• Provides some relevant calculations AND/OR • Outlines how movements of the wheel can cause a tooth to completely block the light	2–3
• Provides some relevant information	1

Sample answer:

Light travels at 3.00×10^8 m s^{-1}, so for an 8 km journey to the mirror and 8 km back, the time taken will be:

$$t = \frac{s}{v}$$

$$\frac{2 \times 8000}{3.00 \times 10^8} = 5.33 \times 10^{-5} \text{ seconds.}$$

If the wheel is stationary, the light travelling through a gap will return completely through the gap, but if the wheel is rotating, a cog (tooth) will begin to block the returning light. If a tooth moves exactly the width of a gap in the time it takes the light to return, it will completely block the light.

It takes 5.33×10^{-5} seconds for the light to travel to the mirror and back. To completely block the light, the tooth will have moved into the path of a gap in this time. Since there are 50 teeth and 50 gaps, the wheel will have rotated 1/100th of a rotation in this time. This is equal to $2\pi/100$ radians.

The rotational speed of the wheel is given by $\omega = \triangle\theta / t$.

$$\omega = \frac{\frac{2\pi}{100}}{5.33 \times 10^{-5}} = 1180 \text{ rad } s^{-1}$$

Spinning the cogwheel at 3, 5 and 7 times this rate (or any odd multiple) would also completely block the returning light, as the light will be blocked by subsequent teeth.

34.

Correct gravitational potential energy value (1) with units (1).

Correct escape velocity (1) with correct definition of escape velocity (1).

Calculating the gravitational potential energy gives: $U = -\frac{GMm}{r}$ $= \frac{-6.67\times10^{-11}\times6.0\times10^{24}\times250}{3.35\times10^{7}}$ ← r = altitude + radius of Earth $= -2.99\times10^{9}$ J Calculating the escape velocity gives: $-\frac{1}{2}mv^2 = \lvert E_p \rvert$ $= -2.99\times10^{9}$ J $v = \sqrt{\frac{2GM}{r}}$ $= 4888$ m s^{-1} The escape velocity is the minimum speed that the satellite requires to escape Earth's gravitational field; this occurs when the satellite's kinetic energy is equal to magnitude of the gravitational potential energy.	Mod 5 Advanced Mechanics PH12–6, 12–7, 12–12 Band 5 • Calculates the gravitational potential energy using appropriate units. AND • Calculates the escape velocity using appropriate units. AND • Explains escape velocity . . . . . 4 • Calculates the gravitational potential energy using appropriate units. AND • Calculates the escape velocity using appropriate units. AND • Outlines escape velocity . . . . . 3 • Any TWO of the above points. OR • Provides the correct solution with no explanation of escape velocity . . . . . 2 • Any ONE of the above points 1

35.

Marked holistically but a typical 7 mark response required 7 of the following points and at least one equation supporting your answer.

- Photoelectric effect stated and described
- Particle (photon) model of light described
- Work function stated, explained and related to question.
- Threshold frequency stated, explained and related to the question
- E = hf equation stated to explain that energy of photon is proportional to frequency rather than intensity
- Role of intensity in particle model explained, where intensity corresponds to the concentration of photons but not the energy of each photon
- Interaction of photon to electron described as one photon only every able to impart energy to one electron
- K = hf – ϕ equation used to support explanation

Criteria	Marks
• Provides a well-reasoned explanation of how photons explain the result and how a simple wave nature for light does not • Identifies dual nature of light	6–7
• Outlines how photons explain the result and how a simple wave nature for light does not	4–5
• Outlines how photons explain the result	2–3
• Provides a relevant statement	1

Sample answer: This result can only be explained if light waves are made up of particles, packets of wave energy called photons. The term "intensity", when applied to electromagnetic radiations, therefore, refers to the number of photons in a beam – it does not refer to an increase in the energy of each photon, that is, increasing intensity means more photons, but each has the same energy.

For the photoelectric emission of electrons, the electrons must receive an amount of energy known as the work function of the material, to enable the electron to be emitted. One photon has to have greater energy than the work function for emission to occur. This would explain why increasing the intensity did not result in emission, which Julie predicted.

If the light photons were waves, then the electrons of the emitter would be subjected to a continuous supply of energy and eventually, if the intensity is increased, enough would be absorbed to cause emission at any frequency.

The fact that this does not happen means that these observations provide evidence for the particle nature of the light. Experiments show that light does exhibit wave behaviour and is described as having a dual nature.

36.

Criteria
6 marks

- Provides a well-organised and succinct response
- Addresses the 'evaluate' verb (e) by providing a well-supported judgement about the link between technology and the development of knowledge
- Describes at least TWO technologies (t x2) used in modified cathode ray which includes at least one example from the cathode ray debate tubes and one example from Thomson's experiment
- Explain the link (l) between how each technology described plays an important role in enhancing knowledge (k x2) and understanding about the nature of the electron.

Examples of technologies might include the following:

- Oppositely charged electric plates to produce an electric field
- Electromagnets to produce magnetic field
- Fluorescent screen to observe the trajectory of the electrons
- High voltage power supply (e.g. induction coil) connected to cathode and anode
- Vacuum tube
- Any of the specific modification of Crooke's tubes such as Maltese cross, paddlewheel, thin gold foil, etc.

Note that 5 marks came from past papers (NESA sample paper) was for q. 33.