Student Number

Newington College

IN FIDE SCIENTIAM

2024 **TRIAL EXAMINATION**

HSC 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 formulae sheet, data sheet and Periodic Table are provided separately
- Write your Student Number at the top of this page

Total marks: 100

Section I – 20 marks (pages 2-12)

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

Section II – 80 marks (pages 13–29)

- Attempt Questions 21-35
- 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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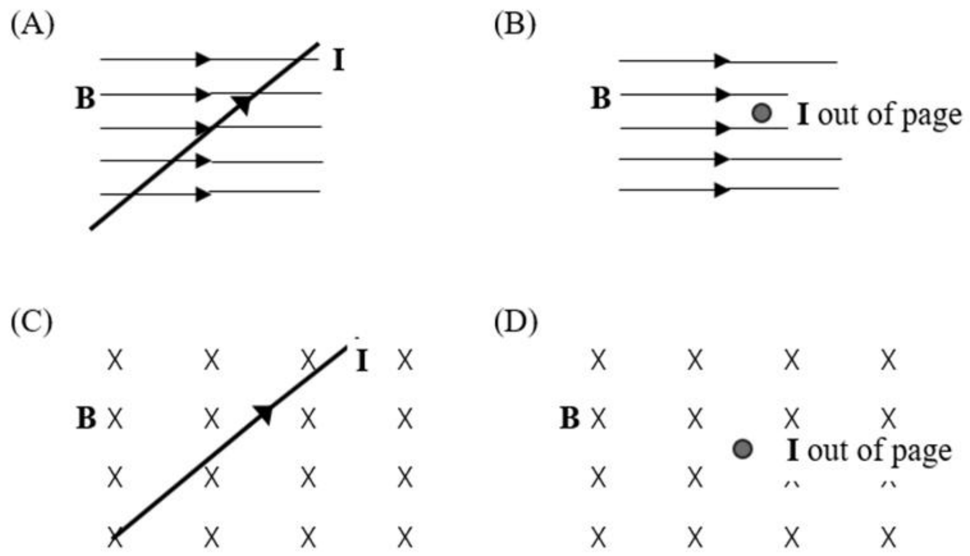
1. Under which set of conditions will **no** force be exerted on the conducting wire?



2. How can the current in the secondary coil of a transformer exceed the current in the primary coil while still obeying the law of conservation of energy?

(A) By having lower resistance in the secondary coil.

(B) By having thicker wires in the secondary coil.

(C) By having lower voltage in the secondary coil.

(D) By having no heat loss from the coils in the transformer.

3. The inclusion of magnetic braking on high-speed trains has the advantage of:

(A) not generating heat.

(B) working effectively at high speed.

(C) working even if the train is stationary.

(D) working better when the train is moving slowly.

4. Which scientist first proposed a mathematically derived value for the speed of light?

(A) Maxwell

(B) Faraday

(C) Thomson

(D) Einstein

5. The Hertzsprung-Russell diagram is a scatter plot of stars showing the relationship between which two variables?

(A) Absolute magnitude and luminosity

(B) Stellar classification and colour

(C) Time and luminosity

(D) Absolute magnitude and temperature

6 Which law can be used to predict the direction of induced current in a circuit?

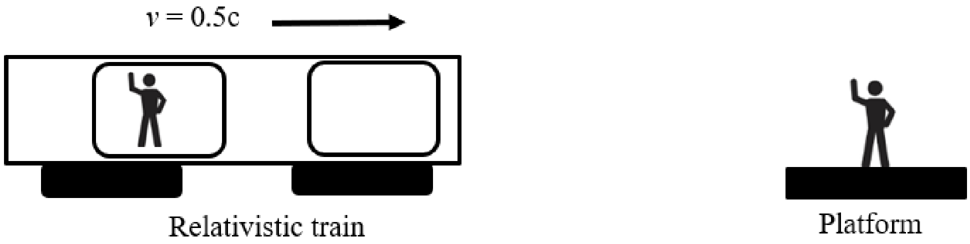
(A) Oersted's law

(B) Faraday's law

(C) Lenz's law

(D) Newton's Third law

7 A relativistic train is carrying a passenger traveling at 0.5 c. The passenger measures 10 s on her watch.



How many seconds would pass for the person on the platform who timed the same event on his watch?

(A) 8.6 s

(B) 10 s

(C) 11.6 s

(D) 14.2 s

8. One observation that supports Einstein's explanation of the photoelectric effect is that:

(A) different cathode metals have the same threshold frequency.

(B) when conditions produce photocurrent it is detected immediately.

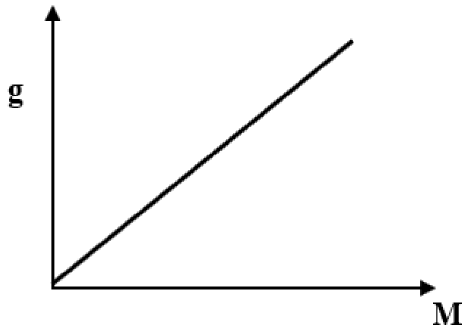
(C) less intense light requires a higher frequency for a photo current to be observed.

(D) higher frequency light gives a greater work function for a particular metal.

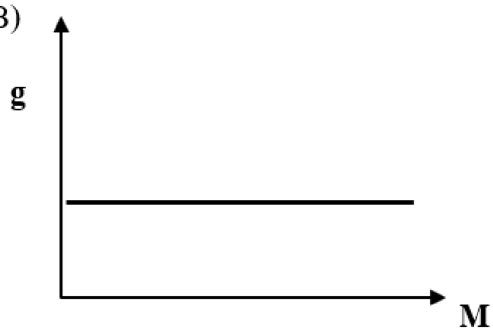
9. Several planets with identical size but different masses had their surface gravitational acceleration, **g,** plotted against their masses, **M.**

Which alternative best represents this graph?

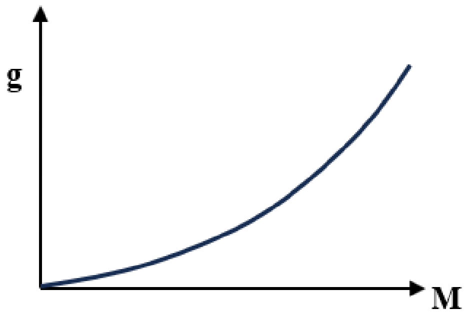
(A)



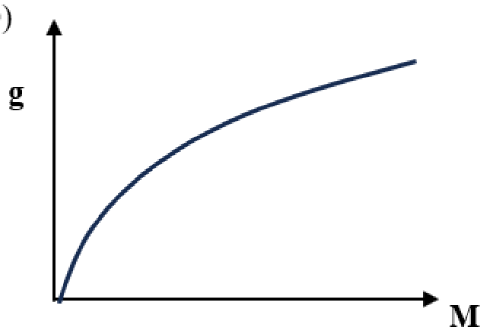
(B)



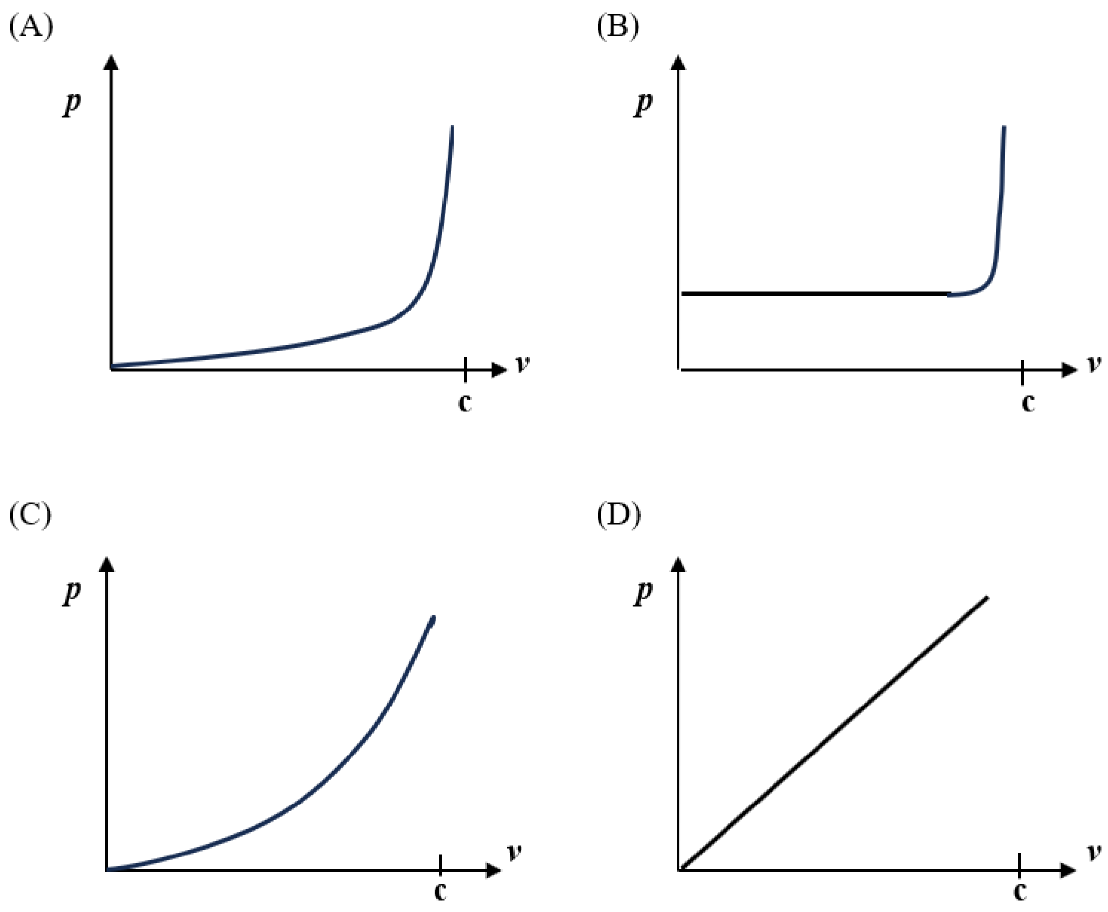
(C)



(D)



10. Which graph best represents a plot of the values of the momentum, $\boldsymbol{p}$ versus the speed**,** $\boldsymbol{v}$ of an object?



11. A person with a viral infection has their body temperature rise from 37 ºC (310 K) to 40 ºC. What is the change in the peak wavelength of electromagnetic radiation emitted?

(A) Increase by 8.96×10^{-8} m

(B) Decrease by 8.96×10^{-8} m

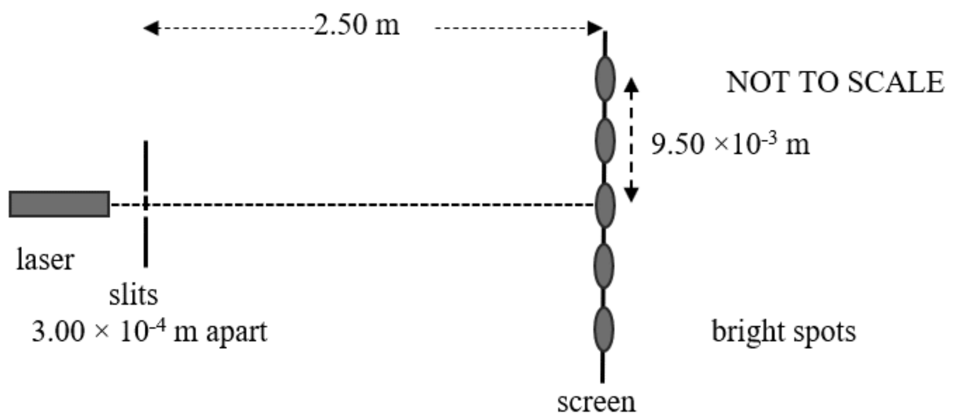
(C) Increase by 9.66×10^{-4} m

(D) Decrease by 9.66×10^{-4} m

12. Laser light of unknown wavelength was passed through a pair of slits separated by 3.00×10^{-4} m.

This produced an interference pattern on a screen 2.50 m from the slits.

The distance between the central bright spot in the interference pattern and another bright spot is 9.50×10^{-3} m as shown in the diagram below.



The laser wavelength is closest to:

(A) 1.14×10^{-6} m

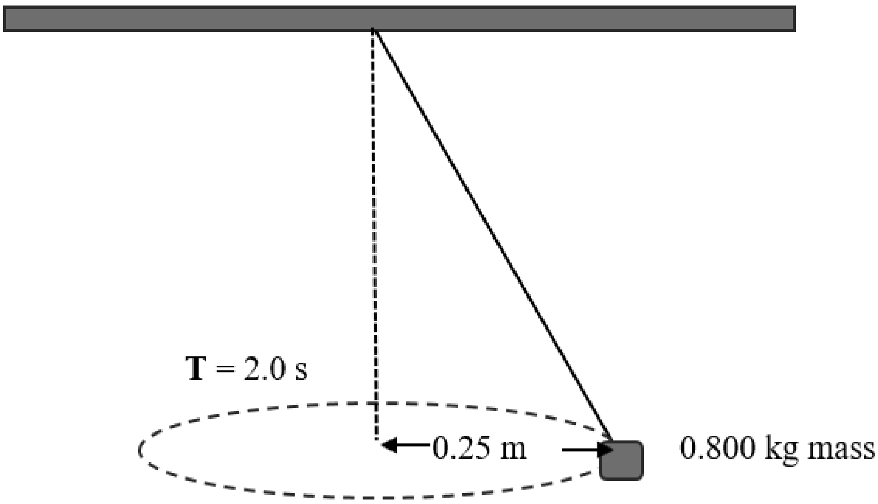
(B) 5.70×10^{-7} m

(C) 5.70×10^{-4} m

(D) 1.14×10^{-9} m

13. An 0.800 kg mass is swinging in a horizontal circle on the end of a conical pendulum as shown.

The radius of the circle **r** is 0.25 m and the period **T** is 2.0 s.

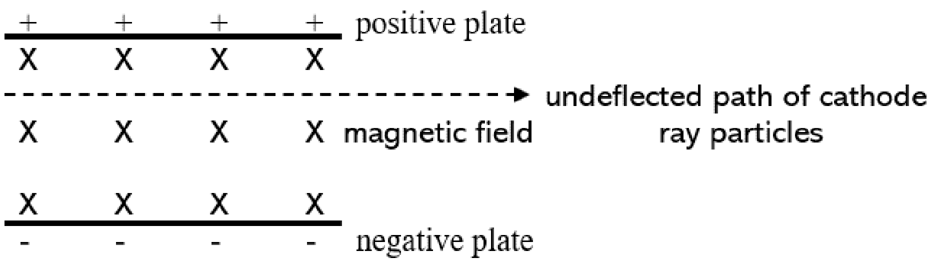


Which row of the table shows the correct kinetic energy and the correct amount of work done on the mass during one full revolution?

	Kinetic Energy (J)	**Work Done (J)**
(A)	0.79	zero
(B)	0.25	0.63
(C)	0.50	1.58
(D)	0.25	zero

14. Cathode ray particles with a speed v pass through a velocity selector undeflected.

The selector comprises crossed electric and magnetic fields, arranged as shown.



If the magnitude of the electric field in the velocity selector is doubled, cathode ray particles with what velocity will now pass through undeflected?

(A) $2v$

(B) v

(C) $\sqrt{2}\, v$

(D) ½ v

15. A ball is kicked from ground level over horizontal ground with a speed of 25.0 m s^{-1} at an angle of 30° towards goal posts. The ball travels a horizontal distance of 12.0 m before crossing the goal line.

At what height does the ball cross the goal line?

(A) 0.83 m

(B) 3.8 m

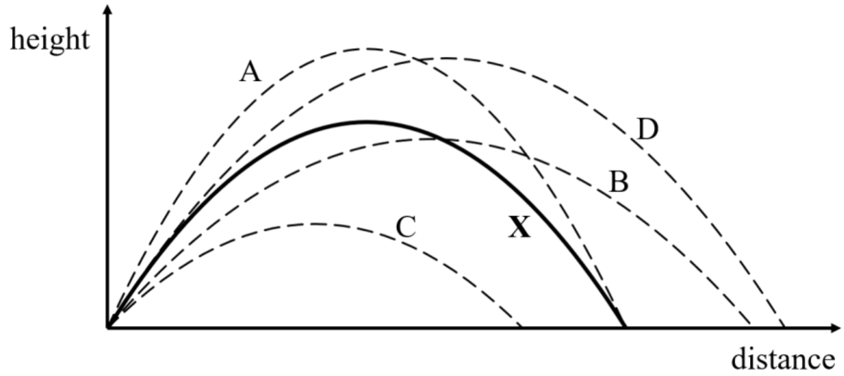
(C) 5.4 m

(D) 10.4 m

16. A projectile launched on Earth follows the trajectory labelled **X**, as shown.

Another projectile is launched with identical speed and angle, but on the surface of a planet where the gravitational acceleration is less than 9.8 m s^{-2}.

Which trajectory would this other projectile follow? Air resistance can be ignored.



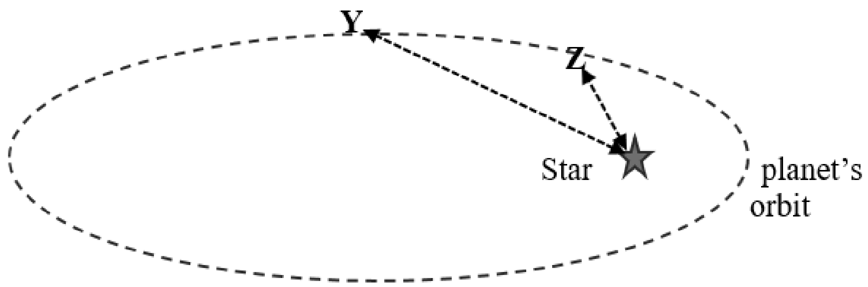
(A) A

(B) B

(C) C

(D) D

17. A planet is orbiting a star in a non-circular orbit where the distance between the planet and the star at point **Y** is twice that when the planet is at point **Z**, as shown.



If the planet's orbital speed at point **Y** is **v**, what is the planet's speed at point **Z**?

(A) $\sqrt{2}\,\mathbf{v}$

(B) 4**v**

(C) **v**

(D) 2**v**

18. What is the maximum wavelength of light that would ionise a hydrogen atom with an electron in the second lowest energy level?

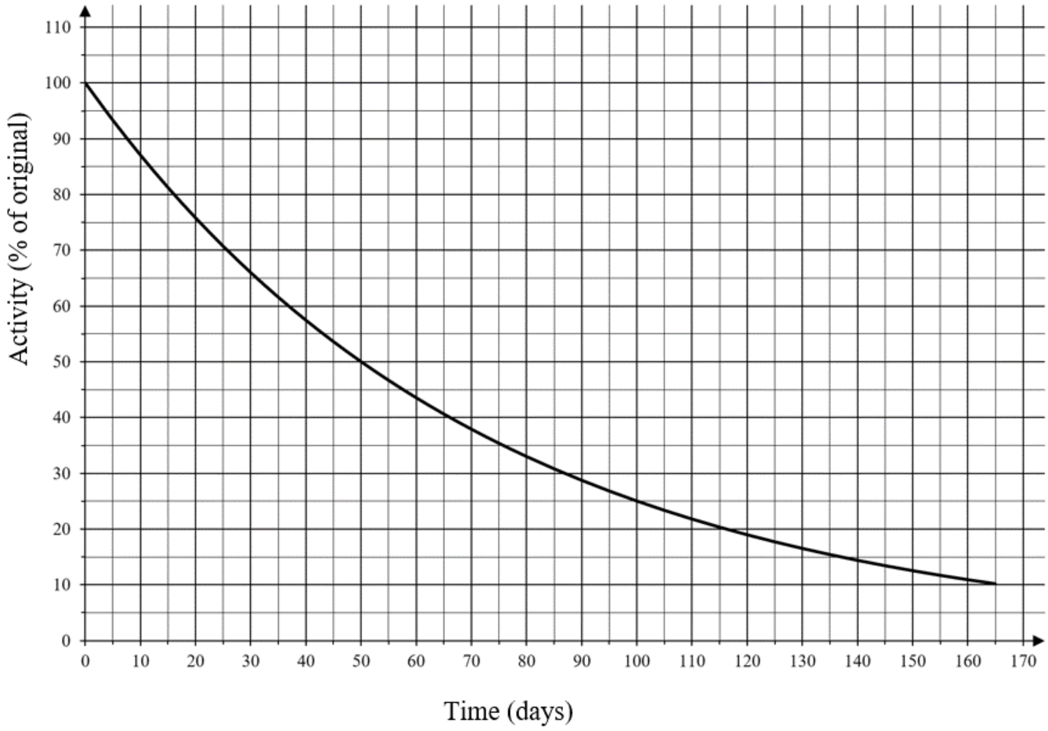
(A) 91 nm

(B) 182 nm

(C) 365 nm

(D) 730 nm

19. A radioactive sample's activity was observed to decay over time and the results plotted on the graph below.



The decay constant, λ, for this radioactive sample is closest to:

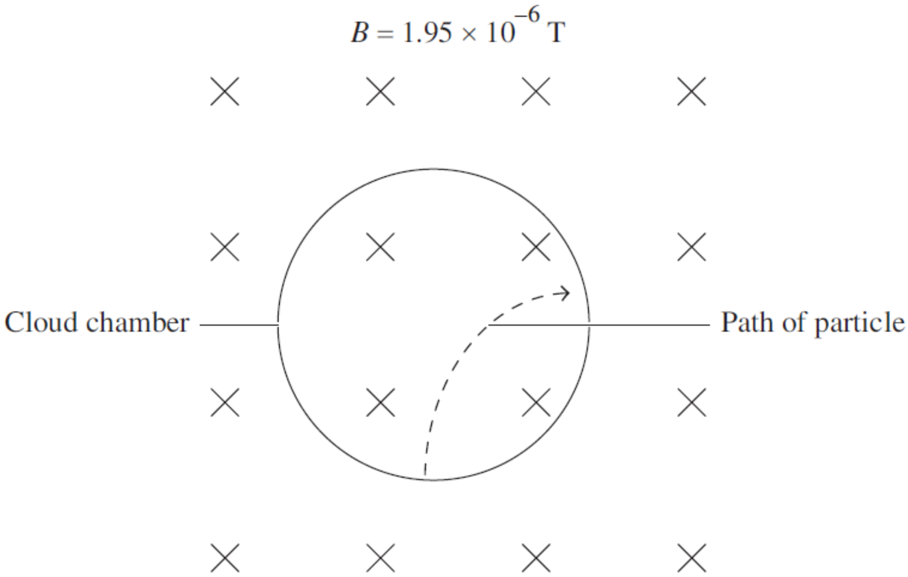
(A) $6.0 \times 10^{-3}\ s^{-1}$

(B) $9.6 \times 10^{-6}\ s^{-1}$

(C) $1.6 \times 10^{-7}\ s^{-1}$

(D) $1.6 \times 10^{-7}\ day^{-1}$

20. A particle in an accelerator reaches a velocity of 2.5×10^4 ms^{-1} before entering a Wilson cloud chamber. The cloud chamber is in a uniform magnetic field of 1.95×10^{-6} T. the path of the particle in the cloud chamber is illustrated in the diagram.



The radius of the particle's path is 5.0cm. What is the charge-to-mass ratio of the particle?

(A) 3.9×10^{-12} C kg^{-1}

(B) 2.6×10^{9} C kg^{-1}

(C) 1.8×10^{11} C kg^{-1}

(D) 2.6×10^{11} C kg^{-1}

Student Number

2024 TRIAL EXAMINATION

HSC Physics

Section II Answer Booklet

80 marks
Attempt Questions 21-35
Allow about 2 hours and 25 minutes for this section

Instructions

- Write your Student Number at the top of this page.
- 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.

Please turn over

Question 21 (5 marks)

High voltage power lines are responsible for distributing electricity over large distances from the point of generation.

Transformers are used to step-up the electricity to a very high voltage (220 kV) for distribution. Local streets contain power transmission lines of high voltage (11 kV), or low voltage (415 V).

a) What ratio of primary to secondary turns is required to step down from a very-high voltage to a low voltage, for transmission in Australia? **2**

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b) Explain why transformers have limitations compared to the ideal model AND justify one way to improve the efficiency of a transformer. **3**

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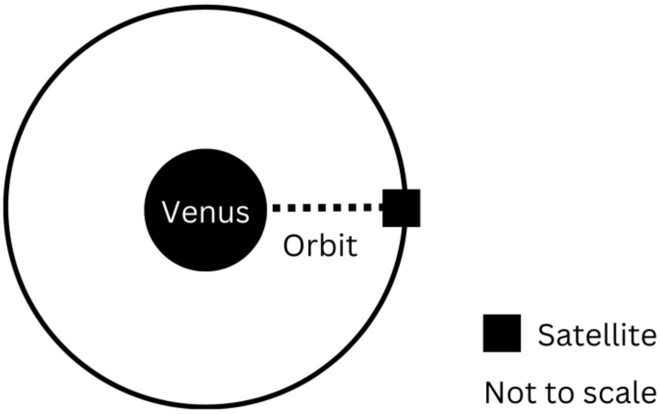
Question 22 (5 marks)

On May 4, 1989, the objective of the Magellan mission to Venus was to place a satellite in orbit to image the entire surface of the planet.



Mass of Venus is 4.867 x 10^{24} kg

Mass of satellite is 3445 kg

Orbital radius = 6.346 x 10^{6} m

a) Determine the orbital period of the satellite around Venus. Assume a circular orbit. **2**

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b) How much additional work would need to be done for the satellite to escape the planet, Venus? Use relevant equations and calculations to support your answer. **3**

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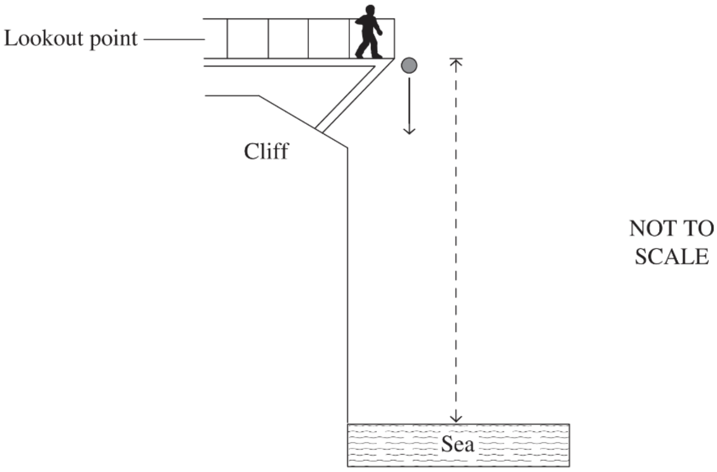
Question 23 (5 marks)

A popular tourist site has a lookout point at the top of a cliff overlooking the sea.

a) A visitor accidentally rolls a ball off the lookout point, as shown in the diagram. It takes 3.5 seconds for the ball to land in the sea below.



Calculate the vertical distance that the ball travels before it lands in the sea. **2**

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b) The tourist site also offers helicopter sightseeing tours. A passenger in one of the helicopters drops their phone while trying to take a photo of the scenery. When the phone is dropped, the helicopter is 200 m above the ground and travelling at a horizontal speed of 50.0 m s^{-1}.

Calculate the horizontal distance that the phone travels before it lands on the ground **3**

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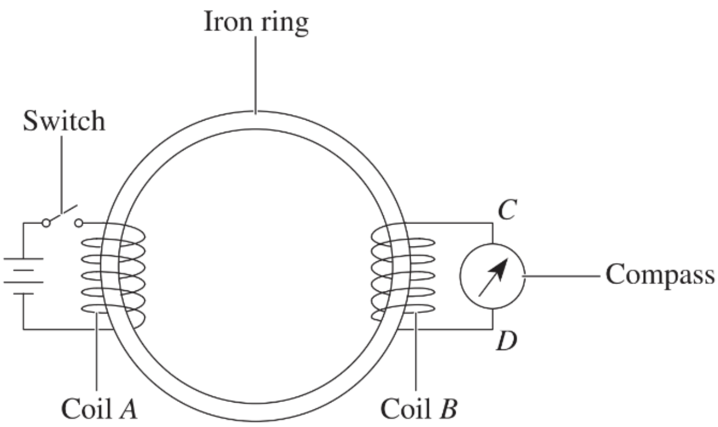
Question 24 (3 marks)

Faraday's iron ring experiment used two coils and a soft iron ring, as shown in the diagram.



A compass was placed above the wire CD to detect any changes in the magnetic field produced. Faraday observed that the compass needle did not deflect when the switch was left open or closed, but it did deflect momentarily when the switch was initially opened or closed.

Explain Faraday's observations. **3**

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End of Question 24

Question 25 (5 marks)

AC induction motors and electromagnetic braking have features in common. With reference to relevant physics concepts, explain what these are by outlining the operation of both. **5**

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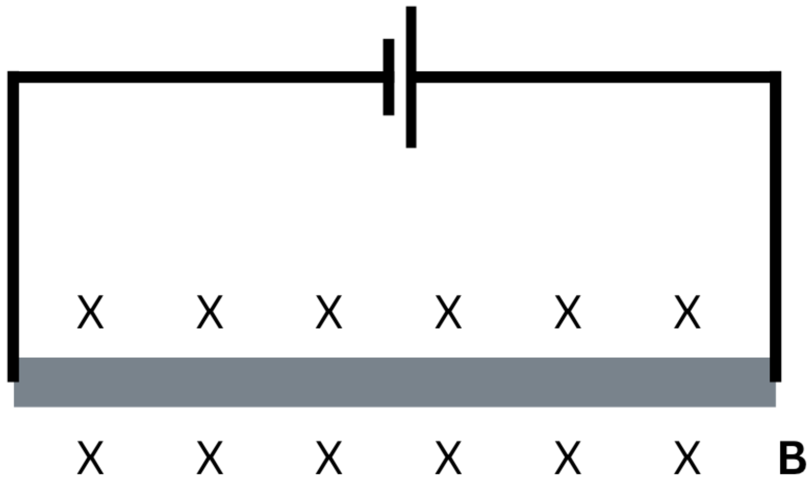
End of Question 25

Question 26 (8 marks)

A student observes the movement of a current carrying conductor in a magnetic field. A diagram of their set-up is outlined below.



A current carrying conductor of length 1.5 m is placed in a uniform magnetic field of strength 0.5 T the current through the conductor is 0.6 A.

a) Determine the magnitude of the force experienced by the current carrying conductor by the magnetic field. **2**

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b) The student makes the claim – “This must be how DC electric motors work.”
Assess the validity of the statement made by the student and explain their observation as it applies to DC electric motors. **3**

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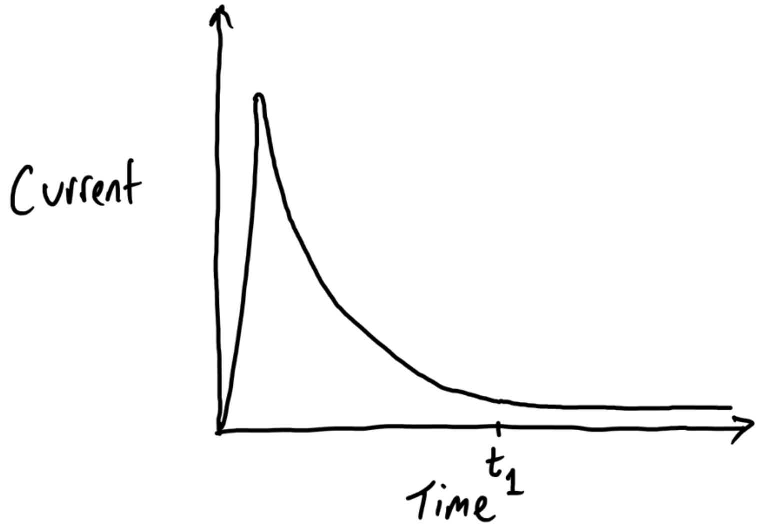
Question 26 continues on next page

The student decides to investigate a simple DC electric motor. After running for a length of time the student notices that heat is radiating from the motor.

c) The student observes the current in the motor against the time and makes the following sketch in their logbook.



Explain the nature of the curve after t_1. **3**

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End of Question 26

Question 27 (5 marks)

A new car has a maximum lateral acceleration of 0.96g, where 1 g is the equivalent to the magnitude of the acceleration due to gravity. This represents the maximum centripetal acceleration the car can withstand without spinning out on a circular track.

a) The car is travelling at 126 km/h, what is the minimum radius of the circular path the car can navigate safely? (Assume an unbanked track.) **3**

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b) The driver decides to test the limits of the new car on a banked track, with the same radius calculated in Part (a), with an angle of 15 ° to the horizontal.

What impact does this have on the maximum speed? Why? **2**

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Question 28 (7 marks)

A space organisation is planning to send an astronaut to a distant planet, P. The spacecraft will travel at a speed of 0.8c and the journey is expected to take 15 years, as measured by observers on Earth.

a) Determine the distance to P in metres, as measured by observers on Earth. **2**

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b) Use time dilation to show that the astronaut will be observed to age only 9 years while travelling. **2**

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c) The astronaut is NOT expected to experience time dilation within their frame of reference.

Explain why the astronaut will still expect to age only 9 years on the journey. Use calculations to support your answer. **3**

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Question 29 (9 marks)

A stationary uranium nucleus was observed to undergo the following radioactive decay:

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + \alpha$$

Particle	Mass (u)	Mass (kg)
U-238	238.0507785	3.954×10^{-25}
Th-234	234.043594	3.887×10^{-25}
Alpha	4.002603	6.648×10^{-27}

The kinetic energy of the Th-234 nucleus is 0.072 MeV.

a) Show that the kinetic energy of the alpha particle is 4.2 MeV. **3**

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b) Show that the velocity of the emitted alpha particle is 1.4×10^{7} ms^{-1}. **2**

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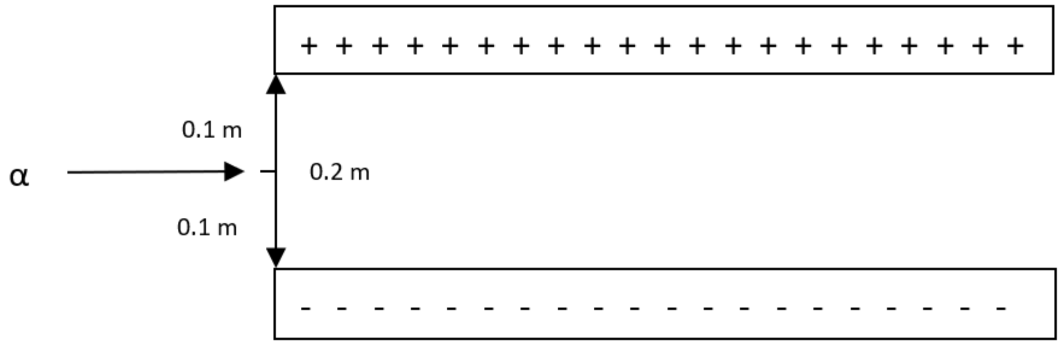
Question 29 continues on next page

c) A different alpha particle was directed horizontally with initial velocity $4.5 \times 10^5\ ms^{-1}$ at the midpoint between very long parallel electric plates as shown below.



NOT TO SCALE

The plates have a potential difference of 100 V and are separated by 0.2 m. Determine the horizontal distance the alpha particle travels before striking the bottom plate. **4**

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End of Question 29

Question 30 (5 marks)

The following spectrum is that of hydrogen observed at rest in the laboratory.

Blue Red

Explain how the movements of a distant star could change the observed spectrum to the one below. **5**

Blue Red

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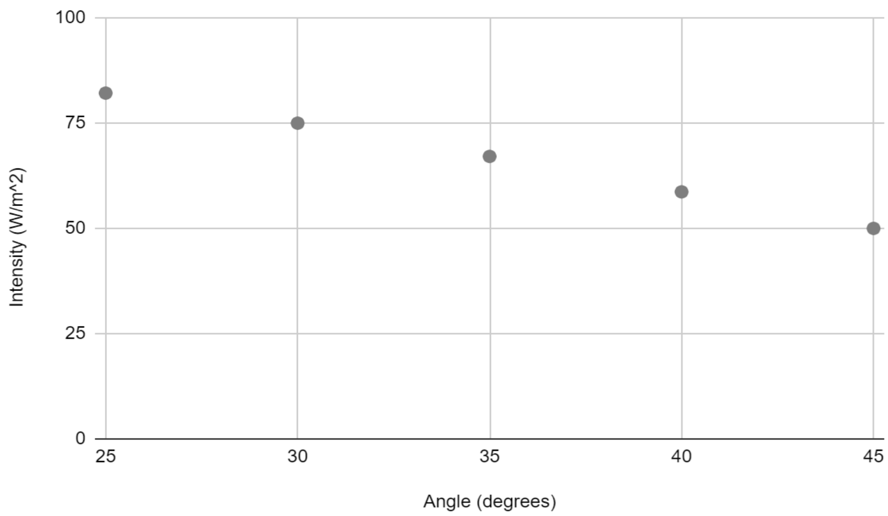
End of Question 30

Question 31 (5 marks)

During an investigation, light was passed through two successive polarised filters. One filter was rotated to change the angle and the resulting intensity of light was measured. The data is presented below.



The investigator concluded that the most appropriate model for the data is a negative, linear relationship between angle and intensity.

a) Justify the validity of this model based on the collected data. **2**

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b) Models gain support or are rejected based on the accuracy of their predictions. As more data is collected outside of the range of angles initially investigated, justify whether this model is likely to gain support or be rejected. Refer to an accepted alternative model in your answer. **3**

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Question 32 (3 marks)

Justify how ONE observation from photoelectric effect investigations was inconsistent with the wave model of light. **3**

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Question 33 (3 marks)

The Balmer series is observed when electrons in hydrogen transition to the second atomic shell (n=2). Determine the lowest frequency of light observed in the Balmer series. **3**

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Question 34 (5 marks)

Early models considered atoms to be the smallest particles. Analyse the contribution of J.J. Thomson and at least ONE other scientist in determining the existence of different subatomic particles. **5**

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End of Question 34

Question 35 (7 marks)

a) Determine the wavelength of an electron moving at $2.0 \times 10^{7} \mathrm{ms}^{-1}$. **2**

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b) How was an observation from electron scattering experiments used to support de Broglie's proposal of matter waves? **3**

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c) Explain why matter waves have not been observed for objects larger than single molecules. **2**

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End of paper

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

2024 Higher School Certificate
Trial Examination
Physics
Marking Guidelines

Section I– Multiple-Choice Answer Key

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

Section II

Question 21(a)

Criteria	Marks
• Correctly calculates the ratio of primary to secondary turns	2
• Provides some relevant information	1

Sample response/solution:

$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{220\times10^3}{415}$ =**530,** therefore the ratio of primary to secondary turns is 530.

Marker's comment:

Many students did not simplify the final ratio, or left it with a decimal place. Any ratio should be simplified and turns in a coil are integers!

Question 21(b)

Criteria	
• Explains the limitations of transformers AND justifies one way to improve the efficiency	3
• Explains the limitations of transformers	2
• Provides some relevant information	1

Sample response/solution:

Energy loss due to heat and Eddy currents so not all the energy input is transformed into the output. Laminated core instead of a large block of iron reduces the size and impact of the Eddy currents, so the efficiency of the transformer can be improved.

Marker's comment:

In explaining limitations, responses needed more than just identifying sources of energy loss. Note the difference between asked to 'explain' (provide a cause – eddy currents, and effect – resistive heat loss) vs 'identify'.

Question 22(a)

Criteria	Marks
• Correctly calculates the force of gravity between the satellite and Venus	2
• Provides some relevant information	1

Sample response/solution:

$$\boldsymbol{T^2 = \frac{4\pi^2 r^3}{GM} = \frac{4\pi^2(6.346 \times 10^6)^3}{6.67 \times 10^{-11} \times 4.867 \times 10^{24}}}$$
$$\boldsymbol{T = 5574.89\ s}$$

Therefore, the orbital period around Venus s 92.9 minutes.

Question 22(b)

Criteria	Marks
• Explains the energy changes as the satellite manoeuvres with relevant calculations	3
• Describes the energy changes as the satellite manoeuvres AND/OR includes relevant calculations	2
• Provides some relevant information	1

Sample response/solution:

For a satellite to escape to infinity, the total mechanical energy of the satellite must be zero.

$$U + K = -\frac{GMm}{2r} = -\frac{6.67 \times 10^{-11} \times 4.867 \times 10^{24} \times 3445}{2 \times 6.346 \times 10^6} = -8.81 \times 10^{10}\text{J}$$

Therefore, the amount of required work done by the rocket boosters attached the satellite would equal to 8.81 x 10^{13} J to increase the total energy to zero.

Marker's comment:

Very few students addressed this question properly. It asked for an explanation of the changes <u>supported by calculations</u>, not just a calculation. Read over the sample response carefully and note the difference.

There were several ways of doing this calculation, students should re-familiarise themselves with satellites and work. A common error was to calculate the work needed to move the satellite from it's current point in space out to infinity, ignoring that it already had additional energy from being in orbit (i.e. forgetting about E_k)

Question 23

(a) $u = 0$

$a = 9.8 \text{ m s}^{-2}$

$t = 3.5 \text{ s}$

$s = ?$

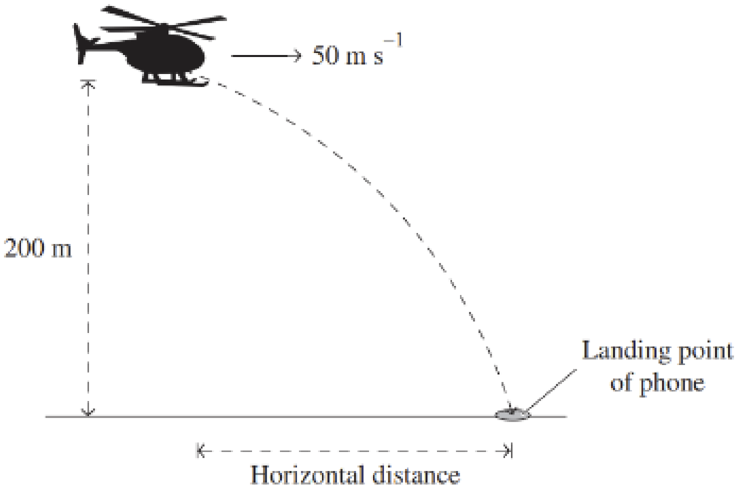
$$s = ut + \frac{1}{2}at^2$$

$$= 0 + \frac{1}{2} \times 9.8 \times 3.5^2$$

$$= 60 \text{ m}$$

Mod 5 Advanced Mechanics (PH12–6, 12–12)	Bands 2–3
• Provides the correct solution using the required variables AND the correct formula.	2
• Provides some relevant working	1

(b) The scenario can be illustrated as follows.



$a_y = 9.8 \text{ m s}^{-2}$

$a_x = 0 \text{ m s}^{-1}$

$u = 50 \text{ m}^{-1}$

The angle of projection is 0° because the phone was dropped from the helicopter. Therefore:

$$u_x = u\cos\theta$$

$$= 50\cos(0)$$

$$= 50 \text{ m s}^{-1}$$

$$u_y = u\sin\theta$$

$$= 50\sin(0)$$

$$= 0 \text{ m s}^{-1}$$

(continues on next page)

(continued)

Calculating the phone's time of flight gives:

$$s_y = u_y t + \frac{1}{2} a_y t^2$$

$$-200 = 0 + \frac{1}{2}(-9.8) \times t^2$$

$$t^2 = \frac{-200}{-4.9}$$

$$t = \sqrt{40.81\ldots}$$

$$= 6.38 \ldots \text{ seconds}$$

Therefore, calculating the horizontal distance that the phone travels gives:

$$s_x = u_x t$$

$$= 50.0 \times 6.38 \ldots$$

$$= 319 \text{ m}$$

Note: Responses are not required to include diagrams to obtain full marks.

Mod 5 Advanced Mechanics (PH12–6, 12–12)	Bands 3–4
• Provides the correct solution.	3
• Calculates the phone's time of flight	2
• Provides some relevant working	1

Question 24

For example:

Faraday's law states that a change in magnetic flux will induce an electromotive force (emf), which will in turn induce a current.

When the switch is left open, there is no magnetic field; when it is left closed, there is a constant magnetic field. Therefore, coil *B* does not experience a change in flux, so the compass needle does not deflect.

When the switch is initially opened or closed, the magnetic field produced by coil *A* rapidly changes, causing coil *B* to experience a change in magnetic flux. This induces a current in coil *B*, which in turn causes the compass needle to deflect.

Mod 6 Electromagnetism (PH12–4, 12–5, 12–7, 12–13) Working Scientifically Skills (PH12–6)	Bands 5–6
• Explains what happens in coil *B* when the switch is initially opened or closed. AND • Explains why the needle deflects when the switch is initially opened or closed. AND • Explains what happens in coil *B* when the switch is left open or closed	3
• Outlines what happens in coil *B* when the switch is initially opened or closed. AND • Outlines what happens in coil *B* when the switch is left open or closed.	2
• Provides some relevant information	1

Question 25

Marking Criteria	Marks
• Common features of both are outlined • Operation of both EM braking and AC induction motors outlined clearly and thoroughly • Any relevant physics concepts addressed	**5**
• As above with an omission	**4**
• A common feature of both identified • Operation of both EM braking and AC induction motors outlined • Some relevant physics concepts addressed	**3**
• Several relevant aspects of the question are addressed including at least one physics concept	**2**
• Relevant aspect of the question is addressed	**1**

AC induction motors are based on having the rotor constructed in the form of a "squirrel" cage with two rings at each end connected by conducting rods. The cage will rotate surrounded by a stator producing a rotating magnetic field, with no electrical connection between the rotor and the stator. Due to Lenz's law, the current induced in the bars of the rotor themselves generate a magnetic field that opposes that produced by the stator, producing a force and a torque, causing the rotor to rotate.

In a somewhat similar fashion, electromagnetic braking occurs when there is relative motion between the source of a magnetic field and a conductor, e.g. a rail, sheet of metal or rotating disk. As a region of the conducting material approaches the magnetic field, the flux increases, inducing eddy currents which themselves produce a magnetic field that opposes the external magnetic field thus producing a force that opposes the relative motion. Again, no electrical conduct is made between the source of the magnetic field and the moving part.

Question 26 (a)

Criteria	Marks
• Correctly determines the force experienced by the conductor	2
• Provides some relevant information	1

Sample response/solution:

$$F = BIL = 0.5 \times 0.6 \times 1.5 = 0.45 \text{ N}$$

Question 26 (b)

Criteria	Marks
• Assesses the claim made by the student AND explains the observations with reference to the motor effect	3
• Assesses the claim made by the student OR explains the observations with reference to the motor effect	2
• Provides some relevant information	1

Sample response/solution:

The claim is valid as it is a demonstration of the motor effect. The force experienced by a current carrying conductor in a magnetic field. In a DC motor, two antiparallel conductors spin on an axis due to the presence of the magnetic field. That is, the force experienced by the current carrying conductors with antiparallel current in a coil result in the spinning motion in a DC motor.

Question 26 (c)

Criteria	Marks
● Explains the nature of the curve in terms of the back emf produced in the circuit ● Justifies why the line doesn’t touch the x-axis (non-zero due to heat loss from resistance)	3
● Explains the nature of the curve in terms of the back emf produced in the circuit	2
● Provides some relevant information	1

Sample response/solution:

After time t_1 the current is almost at zero due to the back emf produced in the DC motor because of Lenz’s Law. In an ideal situation the result current in the circuit would be zero due to the production of the back emf, and therefore a straight and flat line. However, as the circuit is not 100 % efficient and heat is produced, this results in the current in the motor being non-zero. The back emf is in a steady state as the induced magnetic field opposes the changing magnetic field of the supplied current.

Question 27 (a)

Criteria	Marks
● All calculations correct	3
● Correct answer provided AND some mistakes in calculations	2
● Provides some relevant information OR an attempt at appropriate calculations	1

Sample response/solution:
$a_c = 0.96g = 0.96 \times 9.8 = 9.408\ ms^{-2}$
$a_c = v^2/r$, $r = v^2/a_c = 35^2/9.408 = 130.20833 = 130$ m (Note: 126 km/h = 35 m/s)
Therefore, the maximum radius for the track is 130 m (2 sig. fig.)

Question 27 (b)

Criteria	Marks
● States the impact on the maximum speed AND provides a reason why	2
● Provides some relevant information	1

Sample response/solution:
Banked tracks allow the car to navigate the bend at an increased speed, because the car does not have to rely on the friction between the road and the tires to move around the curve as gravity provides some of the opposing force.

Marker's comment:
Calculation of design speed didn't help here, unless you factored in the car's ability to resist 0.96g of lateral acceleration. The common design speed equation that students have memorised is for a track & velocity that would produce <u>no</u> lateral forces.

Question 28 (a)

Criteria	Marks
● Correctly calculates distance to P	2
● Provides some relevant information	1

Sample response/solution:
d = v x t = 0.8 x 15 = 12 light years
$12 \times 3 \times 10^8 \times 365 \times 24 \times 60 \times 60 = 1.14 \times 10^{17}$ m

Question 28 (b)

Criteria	Marks
● Correctly calculates t_0	2
● Provides some relevant information	1

Sample response/solution:

$$t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t_0 = 15 \times 0.6 = 9\ years$$

Question 28 (c)

Criteria	Marks
• Correctly explains aging of astronaut within their frame AND uses correct calculations to support answer	3
• Correctly explains aging of astronaut within their frame AND attempts calculations to support answer OR • Performs correct calculations	2
• Provides some relevant information	1

Sample response/solution:
In the astronaut's frame of reference, the distance to P is contracted:

$$l = l_0\sqrt{1-\frac{v^2}{c^2}} = 12 \times 0.6 = 7.2\ ly$$

Based on this distance, the journey time measured by the astronaut is:

$$t = \frac{d}{v} = \frac{7.2}{0.8} = 9\ years$$

Marker's comment:
This question was not answered well, by the majority of students. Responses that repeated calculations from (b) and (a) did not earn marks, as the question states the astronaut does not experience time dilation. Similarly, making broad statements about the rules of relativity did not earn marks (i.e. "intertial frames of reference are equivalent").

The answer, as above, is that from the astronaut's perspective they have a shorter distance to travel – so this is a matter of length contraction and should be supported with a speed=distance/time calculation to show a travel time of 9 years.

Question 29 (a)

Criteria	Marks
• Correctly calculates kinetic energy including full working	3
• Shows some working to determine kinetic energy	2
• Provides some relevant information	1

Sample response/solution:
Mass difference: 238.0507785-(234.043594+4.002603) = 4.5815x10^{-3}u
Energy equivalence: 4.5815x10^{-3} x 931.5 = 4.26766725 MeV
Subtract Th-234 KE: 4.26766725 – 0.072 = 4.19566725 = 4.2 MeV

**Question says 'show that', which means you must show full working **

Question 29 (b)

Criteria	Marks
• Correctly calculates velocity	2
• Calculation shown with minor error	1

Sample response/solution:

4.2 MeV = $4.2 \times 10^{6} \times 1.602 \times 10^{-19} = 6.7284 \times 10^{-13}$ J

$$KE = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2 \times 6.7284 \times 10^{-13}}{6.648 \times 10^{-27}}} = 1.4 \times 10^{7}\ ms^{-1}$$

**** Many students putting mass in amu directly into E = mc^2 (should be in kg).**

Many students, didn't recognise M in MeV, or convert to Joules **

Question 29 (c)

Criteria	Marks
• Correctly determines the horizontal distance travelled	4
• Correctly calculates time to fall	3
• Correctly calculates acceleration on particle	2
• Provides some relevant information	1

Sample response/solution:

$$F = qE = q\frac{V}{d} = 2 \times 1.602 \times 10^{-19} \times \frac{100}{0.2} = 1.602 \times 10^{-16}\ \text{N}$$

$$a_y = \frac{F}{m} = \frac{1.602 \times 10^{-16}}{6.648\ \times 10^{-27}} = 2.4097 \ldots \times 10^{10} = 2.4 \times 10^{10}\ ms^{-2}$$

$$s_y = \frac{1}{2}a_y t^2$$

$$t = \sqrt{\frac{2\times 0.1}{2.4\times 10^{10}}} = 2.8809 \ldots \times 10^{-6} = 2.9 \times 10^{-6}\ \text{s}$$

$$s_x = u_x t = 4.5 \times 10^{5} \times 2.9 \times 10^{-6} = 1.2964 \ldots = 1.3\ \text{m}$$

***** Many students did not recognise that an alpha particle has 2 protons, therefore need to multiply charge on proton by 2, to find total charge ****

Question 30

Criteria	Marks
• Explains in detail how relative velocity could give observed spectrum using appropriate physics terminology	5
• Explains doppler shift • Connects to both changes in observed spectrum	4
• Explains doppler shift correctly and clearly and outlines 1 observation OR • Identifies shifting right indicates movement away AND thicker lines indicates rotation	3
• Identifies shifting right indicates movement away OR • Identifies thicker lines indicates rotation	2
• Provides some relevant information	1

Sample response/solution:

The observed frequency of a light wave changes due to relative motion. Motion towards causes wavefronts to bunch together, increasing frequency, known as blueshift. The opposite effect, redshift, occurs when relative motion is away.

The observed spectrum is shifted toward lower frequencies, indicating the star is moving away. The lines are also thicker, indicating the star is rotating; one side is blueshifted as it moves towards the observer and the other is redshifted as it moves away.

Answers could include:

An appropriate diagram.

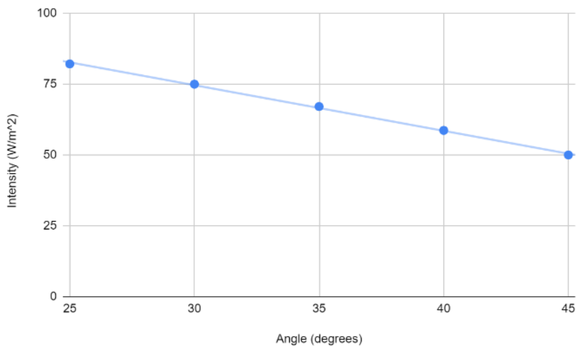
**** For full marks, need more detail than just referring to 'doppler' ****

**** For 4 or more marks, need some detail on how broadening occurs ****

Question 31 (a)

Criteria	Marks
• Justifies validity of model, including reference to data	2
• Provides some relevant information	1

Sample response/solution:



The model is valid as the trendline is straight and slopes down.

**** for 1 mark, needs to be more than just 'is valid' , 'is not valid' ****
**** Many students just repeated words from the question 'negative linear', you needed to justify the negative linear model.**
**** Many students received zero for part a, and full marks for part b. as they answered part b in part z ****

Question 31 (b)

Criteria	Marks
• Refer's to Malus' Law to show trend outside given range will not continue • Uses inaccurate prediction of linear model to justify its rejection	3
• Refers to Malus' Law to predict trend outside given range OR • Predicts given model will not be accurate outside range and will therefore be rejected with some justification	2
• Provides some relevant information	1

Sample response/solution:

The accepted model, Malus' Law, states intensity is proportional to $\cos^2\theta$. Therefore, the prediction of a linear relationship between intensity and angle will become inaccurate as data is collected outside the initial range. The inaccurate linear model will therefore be rejected.

Question 32

Criteria	Marks
• Justifies how an observation from photoelectric effect investigations was inconsistent with the wave model of light	3
• Identifies a relevant investigation and a relevant observation	2
• Provides some relevant information	1

Sample response/solution:

In some investigations, light of different intensities was directed at metals to eject photoelectrons. The wave model predicts that, since more intense light had more total energy, it would create higher maximum kinetic energy electrons. However, intensity of light had no effect on the maximum kinetic energy.

*** There are other observations that can be referenced **

Question 33

Criteria	Marks
• Correctly calculates lowest observed frequency	3
• Calculates wavelength	2
• Provides some relevant information	1

Sample response/solution:

Lowest frequency will occur with lowest change in energy, therefore:

$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ with $n_i=3$

$\lambda = 6.56 \times 10^{-7}$ m

$f = \frac{c}{\lambda} = \frac{3\times10^8}{6.56\times10^{-7}} = 4.57 \times 10^{14}$ Hz

** for 1 mark, need more than just Rydberg equation, for example some substitution into equation would suffice **

Question 34

Criteria	Marks
• Analyses contributions of Thomson AND one other scientist in determining existence of different subatomic particles • Response is clear and coherent and uses correct physics terminology	5
• Analyses contributions of Thomson AND one other scientist in determining existence of a subatomic particle	4
• Correctly analyses the relevant work of Thomson OR one other scientist	3
• Identifies relevant contributions	2
• Provides some relevant information	1

Sample response/solution:
Thomson used electric and magnetic fields to manipulate beams in cathode ray tubes. He was able to determine that the charge to mass ratio of the beams was always a constant. He was therefore able to conclude that the beams were composed of very small negatively charged particles, later known as electrons, that were a constituent particle of atoms.

Chadwick used polonium to direct emitted alpha particles at a beryllium target. The resulting 'unknown radiation' was then directed at paraffin wax to displace protons. The resulting protons could be detected and, using conservation laws, the mass of the unknown radiation was shown to be consistent with predictions of the neutron.

Question 35 (a)

Criteria	Marks
• Correctly determines wavelength	2
• Provides some relevant information	1

Sample response/solution:
$\lambda = \frac{h}{mv} = \frac{6.626\times10^{-34}}{9.109\times10^{-31}\times2\times10^{7}} = 3.6 \times 10^{-11}$ m

Question 35 (b)

Criteria	Marks
• **Justifies** how an observation from electron scattering experiments was used to support the proposal of matter waves	3
• Identifies a relevant investigation and a relevant observation	2
• Provides some relevant information	1

Sample response/solution:
Davisson and Germer scattered electrons from the surface of a nickel crystal, creating a diffraction pattern. Since diffraction was known to be a wave phenomenon, this observation demonstrated the wave nature of particles.

*** Many students received zero for this question – you need to revise Davisson and Germer experiment **

Question 35 (c)

Criteria	Marks
• Explains why matter waves have not been observed for larger objects	2
• Provides some relevant information	1

Sample response/solution:
Since wavelength is inversely proportional to mass, a larger mass quickly reduces wavelength to values that are undetectable or meaningless.

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Section II

Question	Marks	Content	Syllabus Outcomes
21 (a)	2	Mod 6: Electromagnetic induction	PH12-13, PH11/12-5, PH11/12-6
21(b)	3	Mod 6: Electromagnetic induction	PH12-13, PH11/12-7
22 (a)	2	Mod 5: Motion in Gravitational fields	PH12-12, PH11/12-6
22 (b)	3	Mod 5: Motion in Gravitational fields	PH12-12, PH11/12-6 PH11/12-7
23 (a)	3	Mod 5: Projectile motion	PH12-12, PH11/12-4
23 (b)	1	Mod 5: Projectile motion	PH12-12, PH11/12-5
23 ©	2	Mod 5: Projectile motion	PH12-12, PH11/12-6 PH11/12-7
24	3	Mod 6: Electromagnetic induction	PH12-13, PH11/12-2, PH11/12-7
25	5	Mod 6: Charged particles, Conductors and Electric and Magnetic Fields	PH12-13, PH11/12-7
26 (a)	2	Mod 6: The Motor effect	PH12-13, PH11/12-6
26 (b)	3	Mod 6: Applications of the Motor effect	PH12-13, PH11/12-7
26 (c)	2	Mod 6: Applications of the Motor effect	PH12-13, PH11/12-5 PH11/12-7
27 (a)	3	Mod 5: Circular motion	PH12-12, PH11/12-6, PH11/12-7
27 (b)	2	Mod 5 Circular motion	PH12-12, PH11/12-6, PH11/12-5, PH11/12-7
28 (a)	2	Mod 7: Light and Special Relativity	PH12-14, PH11/12-4, PH11/12-6
28 (b)	2	Mod 7: Light and Special Relativity	PH12-14, PH11/12-4, PH11/12-7
28 (c)	3	Mod 7: Light and Special Relativity	PH12-14, PH11/12-4, PH11/12-7
29 (a)	3	Mod 8: Properties of the Nucleus	PH12-15, PH11/12-4, PH11/12-7
29 (b)	2	Mod 8: Properties of the Nucleus	PH12-15, PH11/12-4, PH11/12-7
29 (c)	4	Mod 5: Projectile Motion Mod 6: Charged Particles, Conductors and Electric and Magnetic Fields	PH12-12, PH12-13, PH11/12-4, PH11/12-6
30	5	Mod 7: Electromagnetic Spectrum	PH12-14, PH11/12-7
31 (a)	2	Mod 7: Light: Wave Model	PH12-14, PH11/12-5, PH11/12-6
31 (b)	3	Mod 7: Light: Wave Model	PH12-14, PH11/12-5, PH11/12-6
32	3	Mod 7: Light: Quantum Model	PH12-14, PH11/12-7
33	3	Mod 8: Quantum Mechanical Nature of the Atom	PH12-15, PH11/12-4, PH11/12-6

34	5	Mod 8: Structure of the Atom	PH12-15, PH11/12-7
35 (a)	2	Mod 8: Quantum Mechanical Nature of the Atom	PH12-15, PH11/12-4, PH11/12-6
35 (b)	3	Mod 8: Quantum Mechanical Nature of the Atom	PH12-15, PH11/12-7
35 (c)	2	Mod 8: Quantum Mechanical Nature of the Atom	PH12-15, PH11/12-7