PENRITH HIGH SCHOOL

13:46

Trial HSC Exam

SCIENCE HSC PHYSICS

Task Weighting: 30%

General Instructions:

- Working time – 180 minutes
- Reading Time – 5 minutes
- Write using black or blue pen, answers written in pencil may be disqualified from review
- Draw diagrams & graphs using a dark pencil and, where appropriate, ruler
- NESA approved calculators may be used
- A HSC data sheet and Periodic Table are provided
- Marking guidelines for certain questions may be based on question deconstruction and use of a coherent and logical progression of argument
- Write your student number at the bottom of every answer page

Total Marks: 100

Section A
Pages 3 – 12

20 marks

- Core Subjects – Multiple Choice
- Attempt Questions 1–20
- Allow about 35 minutes for this part

Section B
Pages 13 – 26

64 marks

- Core Subjects – Extended Answer
- Attempt Questions 21–32
- Allow about 110 minutes for this part

Section C
Pages 27 – 30

16 marks

- Working Scientifically
- Attempt Questions 33–35
- Allow about 35 minutes for this part

Total pages this exam: 30
M/C answer sheet: 1

Student Number: ……

This page has been left blank intentionally

Section A **Core – Multiple Choice**

Answer all questions using the coloured answer-sheet provided separately

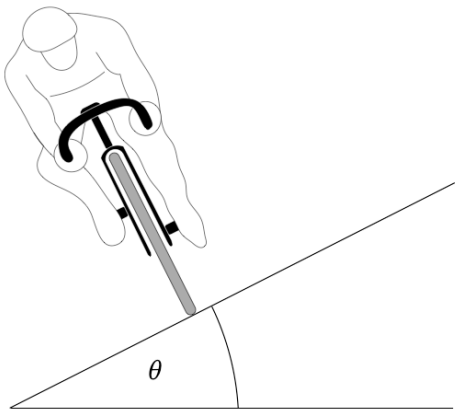
---

Question 1. Two objects are simultaneously flicked horizontally out different windows of a tall building. One is from a height of 150m and the other from 50m. The 50m object is much lighter and has triple the initial velocity of the higher one.

Ignoring air-resistance, which of the following statements about these projectiles is most correct:

A. Both objects will reach the ground at the same time
B. The first object flight-time will be 3 times the second object
C. The first object flight-time will be √3 times the second object
D. The lighter object will take much longer to reach the ground

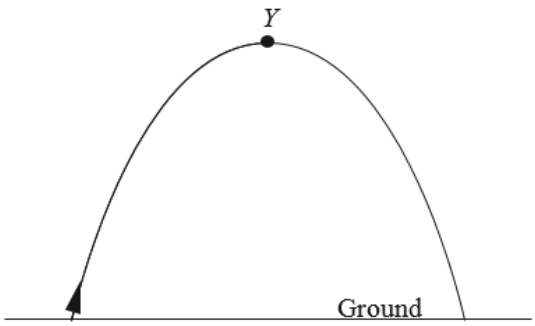
Question 2. A cyclist goes around the banked track on a race track:



Which of the following statements about this scenario is most correct:

A. The incline provides a centre directed contact force to stop the cyclist from sliding when turning in a circle
B. The track is banked so that the vertical component of the gravity force is reduced to prevent stress on the bicycle frame and cyclist
C. The track is banked to provide additional friction when turning
D. On banked tracks the torque will always remain unchanged

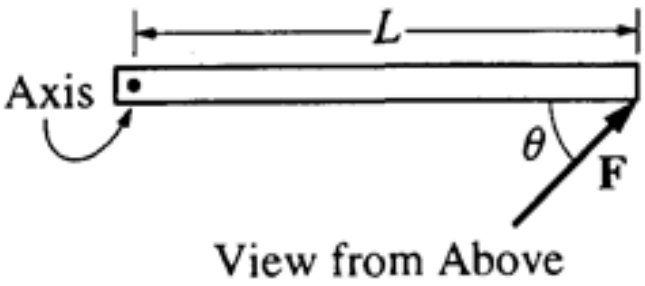
Question 3. Consider the trajectory of a projectile launched at 60°:



Ignoring air-resistance, which of the following statements about this scenario is most correct:

A. The horizontal and vertical acceleration will vary during the flight time
B. The horizontal and vertical velocity will vary during the flight time
C. At "Y" the object momentarily stops before starting to fall again
D. At "Y" the acceleration remains unchanged

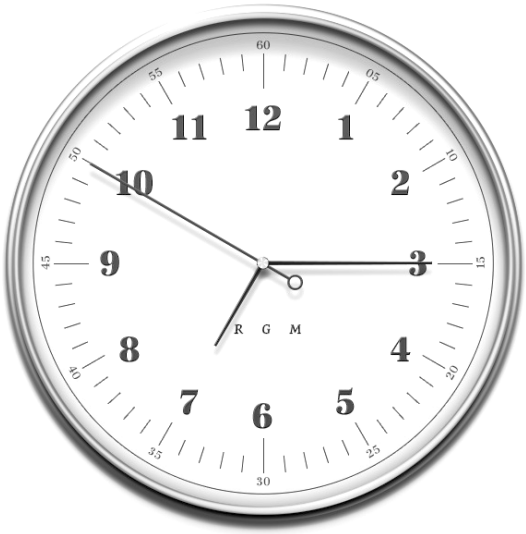
Question 4. A force is applied at an angle to a torsion bar, as shown below:



If F = 20 N, θ = 35° and L = 2 km, then the torque will be closest to:

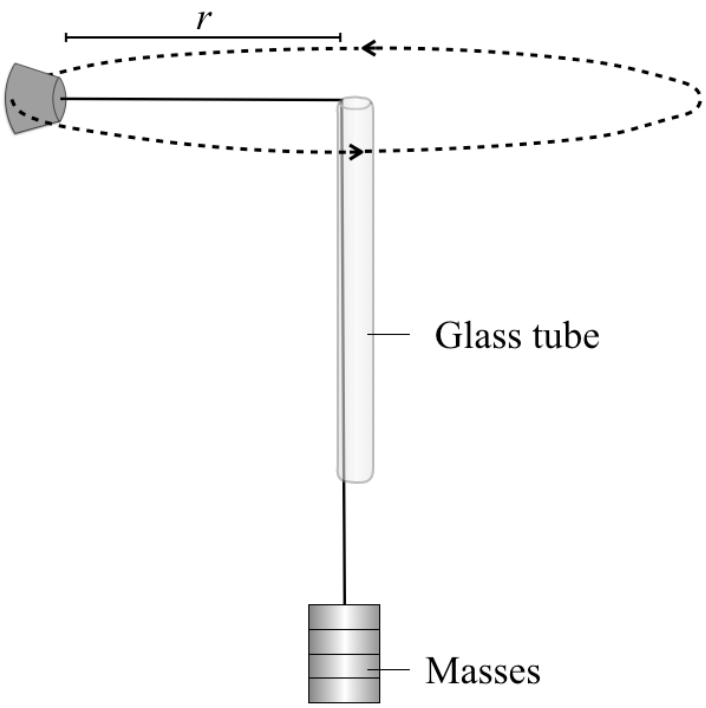
A. 10.35 Nm
B. 10.35 kNm
C. 22.94 Nm
D. 22.94 kNm

Question 5. Which of the following statements about the angular velocity of the minute-hand on an analogue clock (shown below) is most correct:



A. 1.745 milliradians per second
B. 0.105 radians per second
C. 360 degrees per second
D. 360 radians per second

The apparatus diagram below applies to both questions 6 and 7:



Question 6. The period of rotation of the stopper was measured by recording the average time for 20 revolutions. Midway through the experiment the stopwatch was changed and it

was noticed that the time for each period was, on average, 1 second longer for each trial – irrespective of who did the timing. When the original stopwatch was reinstated, then the trial times were back to their original values.

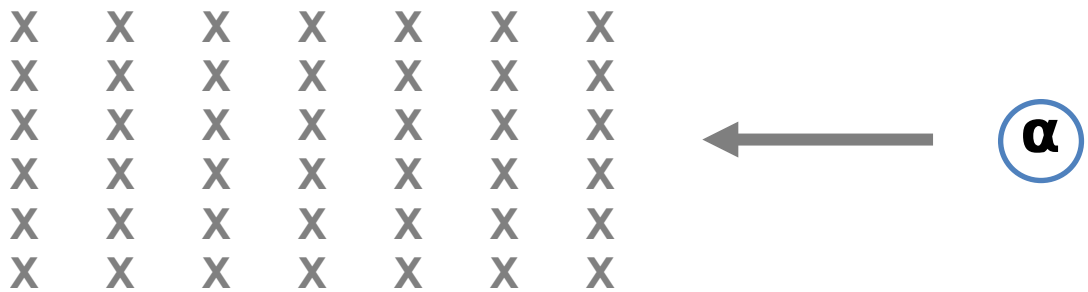
Which of the following statements best describes what happened:

A. The times were different due to random error
B. The string must have stretched to produce such a consistently different result
C. The times were different due to systematic error in the second watch
D. The times were different due to human error

Question 7. The principle which this apparatus is designed to show is most likely:

A. That "r" is always π times the value of the masses
B. That the masses will always remain stationary irrespective the rate of rotation
C. That force due to gravity will equal the force due to centripetal motion
D. That glass tubes have zero friction

Question 8. An alpha particle (a high-velocity **helium nucleus**) is fired into a uniform magnetic field in a vacuum, as show in the diagram:



Which of the following statements is most correct about what happens when the alpha particle enters the magnetic field:

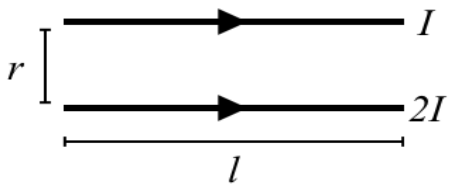
A. It will slow down and stop
B. It will continue moving in a straight line
C. It will be deflected upwards
D. It will be deflected downwards

Question 9. Which of the following statements about a charged particle moving perpendicular to the field lines in electric and magnetic fields is most correct:

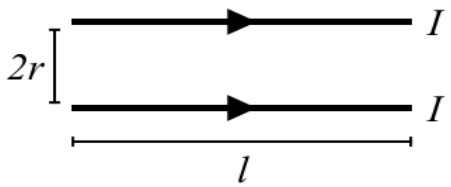
Option	Electrical Field	Magnetic Field
A	Parabolic path	Straight line
B	Circular path	Parabolic path
C	Parabolic path	Circular path
D	Straight line	Circular path

Question 10. Which of the following options will have the **second strongest** force acting between the current carrying wires?

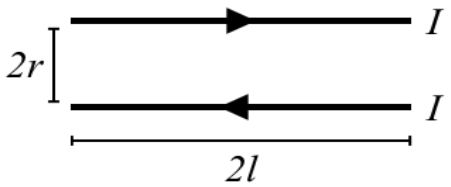
(A)



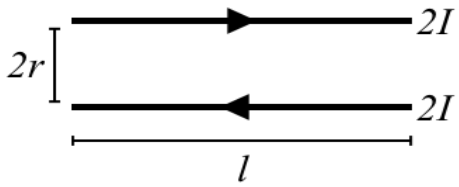
(B)



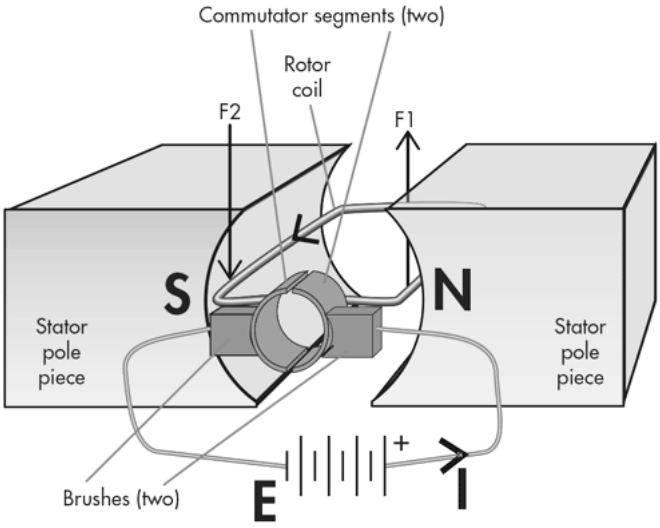
(C)



(D)



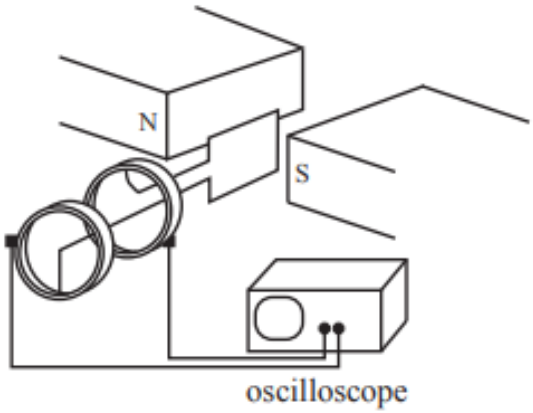
Question 11. A simple DC motor is shown below:



The torque this motor produces while operating can best be described as:

A. Constant while the loop is between the magnets
B. Constant during each full rotation
C. Varying sinusoidally
D. Will change between negative and positive values

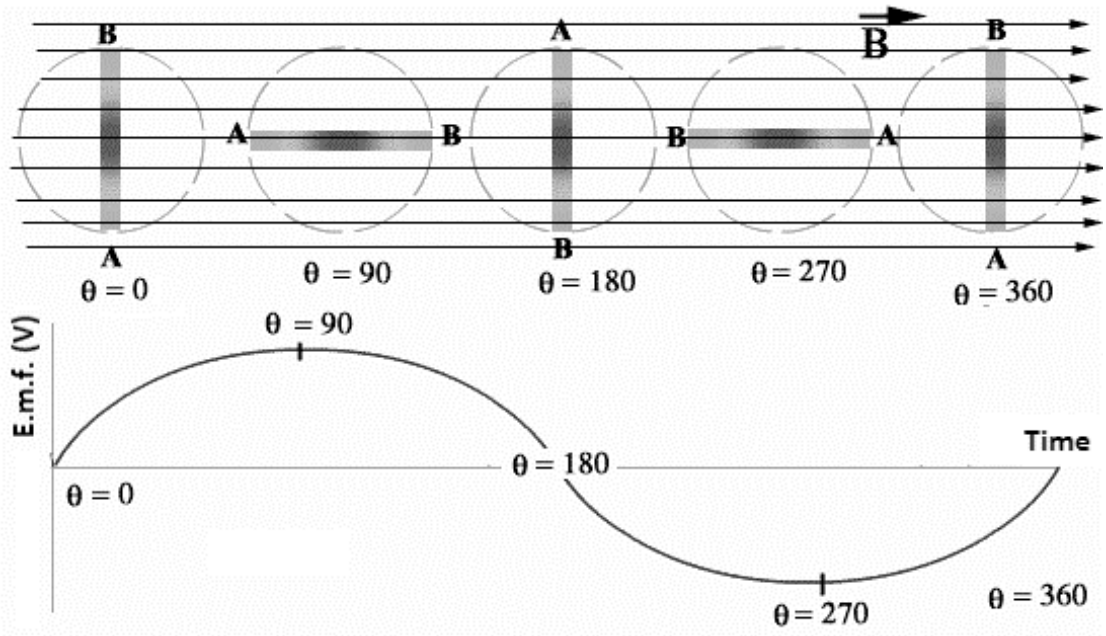
Question 12. The diagram below shows a simple generator with slip-rings:



The coil inside the magnetic field is turned and the oscilloscope is set to display *emf* versus time. While the loop is rotating the oscilloscope will most likely display:

A. A straight-line output at a constant *emf* value
B. A full-wave-rectified output where *emf* varies between 0V and a positive maximum
C. A square-wave output where *emf* is never positive
D. A sine-wave output where *emf* varies between negative and positive values

Question 13. The diagram below the emf output from a ring turning inside a magnetic field:



The ring is shown side-on, with the top and bottom labelled "A" and "B".

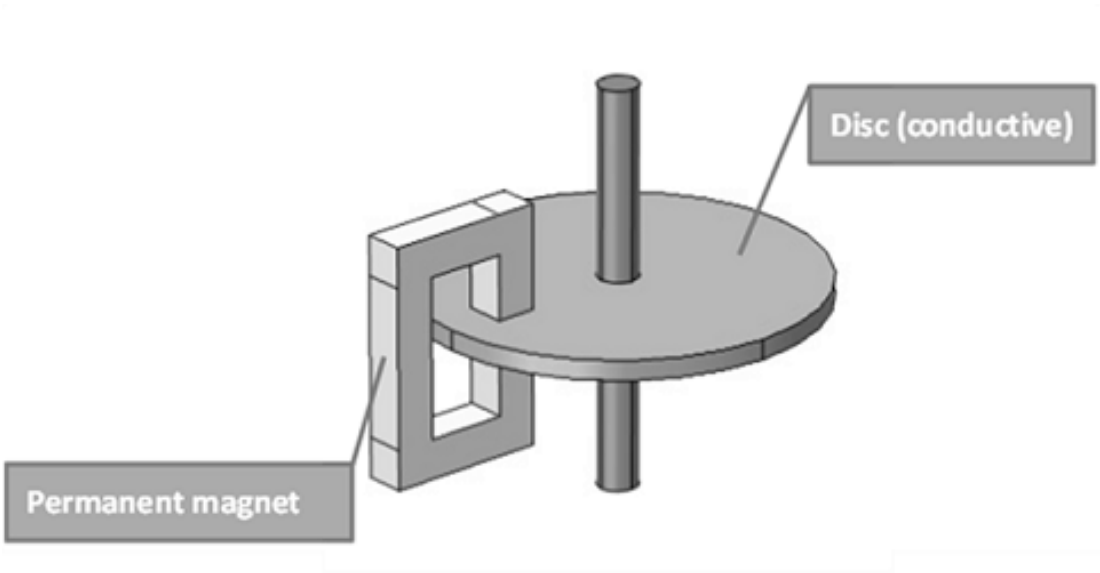
Which of the following statements about the *emf* output is most correct:

A. *emf* becomes 0V when the angular velocity is fastest
B. *emf* is maximum at 90° because the magnetic flux is highest
C. *emf* is constant because magnetic flux is constant
D. *emf* is 0V at 180° and 360° because $\Delta\phi / \Delta t = 0$

Question 14. Electrical motors are sometimes equipped with a small resistor in series with the motor coils. This is done mainly to:

A. Ensure the bushes maintain a reliable electrical connection
B. Decrease the electrical load on the motor when it is running
C. Protect the coils from burn-out due to no back-emf protection at start up
D. Smooth the torque produced

Question 15. The following shows a copper disc mounted on an axle with one edge of the disc inside the strong magnetic field supplied by a permanent magnet:



The disc was made to spin at a fast rate by connecting the axle to a motor. The motor was then disconnected while the disc was still spinning. Which of the following most accurately describes what happens next?

A. The disc would slow to a stop within a few seconds
B. The disc would spin for over 10 minutes until eventually slowed by friction
C. The disc would stop the instant the motor was disconnected
D. The disc would keep spinning indefinitely due to the strong magnetic field

Question 16. An electrical circuit was made where a 3A current oscillated along a platinum wire 50 metres long. It was noticed that EMR was produced while the circuit was operating, especially by the long wire.

The most likely type of EMR produced by such an apparatus would be:

A. Radio Waves
B. Microwaves
C. Infrared radiation
D. Visible light

Question 17. The four images below show interference patterns from a double-slit experiment, all recorded at the same distance from the slits. Which pattern would result from the slits with the **largest** separation?

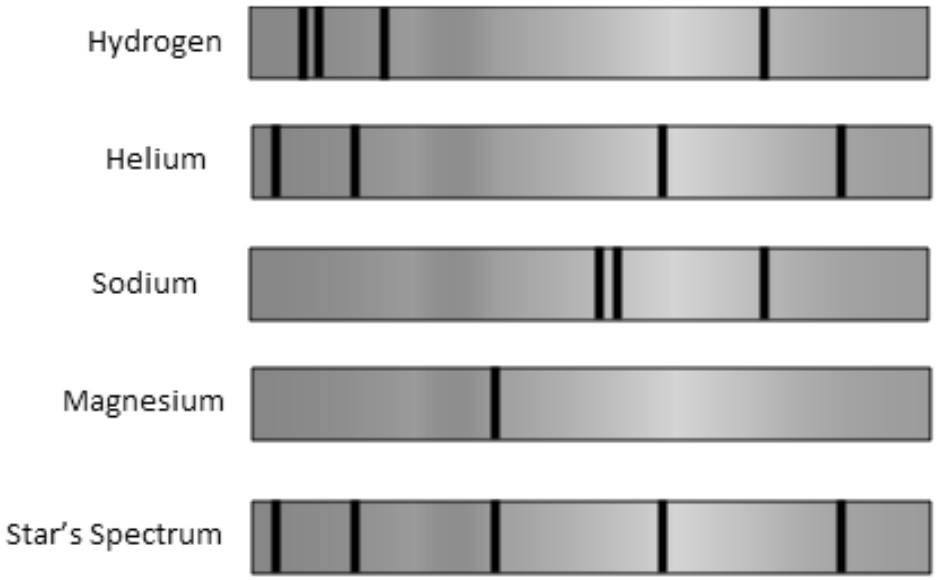
A. 

B. 

C. 

D. 

Question 18. Listed below are absorption spectra for different elements, along with the spectra from a distant star:



According to the star's spectrum, the elements present in the star are most likely:

A. H and He
B. He only
C. H, He, Na and Mg
D. He and Mg

Question 19. Two spaceships are approaching each other at a relative approach velocity of 0.7c:

A microwave beam is sent from one spaceship to the other. From the frame of the spaceship which receives the beam, the velocity of the beam would be:

A. 1.4c
B. 0.7c
C. c
D. 340 m/s

Question 20. Which of the following is NOT evidence to support the Big-Bang theory of the expanding universe?

A. Direct measurement of H_0
B. Direct observation of gravitational lensing
C. Measured abundance of H, He and Li
D. CMBR at predicted 2.73 K

End of Section A

Section B **Core Modules – Extended Response**

Answer all questions in the spaces provided on this examination paper – do not use separate examination booklets for answers to Section B

Show all relevant working in questions involving calculations

---

Question 21 (5 marks)

[Module 5.1]

A student wishes to kick a football to the top of a 12m tall vertical cliff. If the base of the cliff is 10m horizontally from the student:

(a) Calculate the minimum velocity required for the ball to reach the top of the cliff:

3

……

……

……

……

……

……

……

……

(b) The student uses the value you calculated in (a) to kick the ball. Assuming this was the correct value, why might the ball still not reach the top of the cliff?

2

……

……

……

……

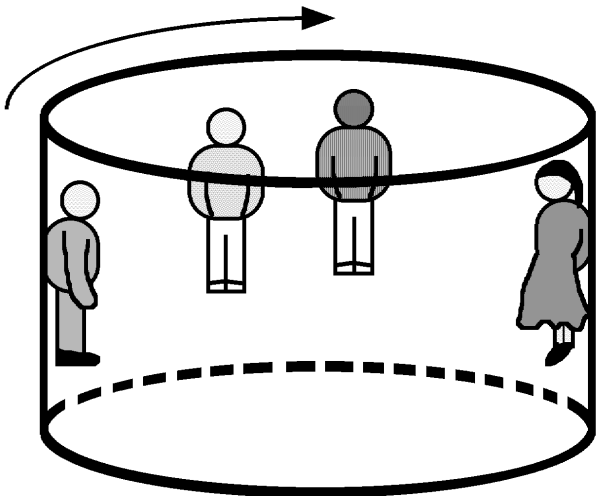
Question 22 (6 marks)

[Module 5.2]

At Luna Park in Sydney there is a ride called "The Rotor". Here patrons enter a vertically oriented cylindrical chamber which will rotate rapidly, causing them to be pinned to the vertical wall as the floor drops away.

The rotor cylinder has a diameter of 10m and rotates with a period of 2.50s.

A student of mass 65 kg is on the ride. She can be seen wearing a dress on the right hand side of the image below:



(a) In the space below, sketch a free-body force diagram for the girl: 2

(b) Identify on your diagram for part (a) any **balanced** and **unbalanced** forces: 2

Question 22 (continued…)

(c) Calculate the linear speed of the girl:

2

……

……

……

……

……

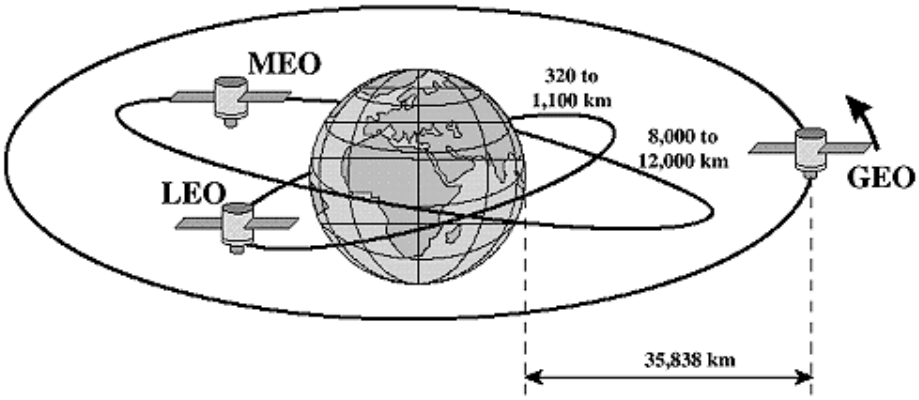
……

……

Question 23 (5 marks)

[Module 5.3]

A satellite is circling the Earth such that it takes 1 hour and 40 minutes to complete one circular orbit:



(a) Calculate the satellite's **altitude** in kilometres:

3

……

……

……

……

……

……

……

(b) Identify **two** benefits of the satellite orbiting at the altitude you calculated in (a) above:

2

……

……

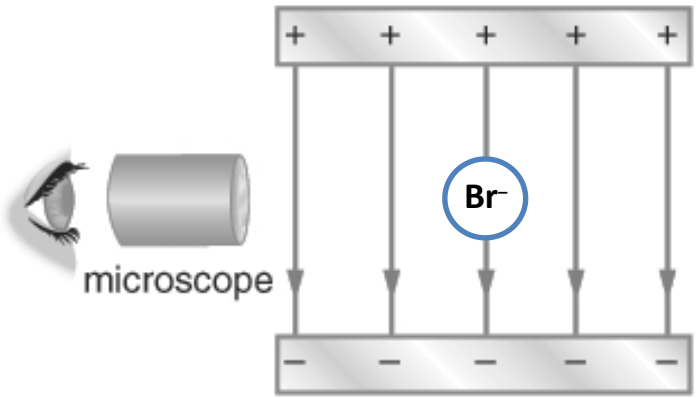
……

……

Question 24 (6 marks)

[Module 6.1]

An experiment was done where a single Bromine-79 ion (comprised of 35 protons, 44 neutrons and 36 electrons) was suspended between two charged parallel horizontal plates, as shown in the diagram below (not to scale):



If the separation between the plates was 15 μm:

(a) Calculate the voltage required to keep the Bromine ion suspended:

4

.....

.....

.....

.....

.....

.....

.....

(b) Why must the positive and negative plates be arranged as shown in the diagram for this experiment to work?

2

.....

.....

.....

.....

Question 25 (6 marks)

Two thin straight parallel wires are separated by a distance "d". The wires are 20 cm long and each carry 1A of current in the same direction. The force between the wires is 25 mN.

(a) Calculate the distance "d" separating in the wires:

3

……

……

……

……

……

(a) Ignoring any effects due to Special Relativity, explain why there is a force between the wires when the currents are operating. Use an appropriate sketch as part of your answer:

3

……

……

……

……

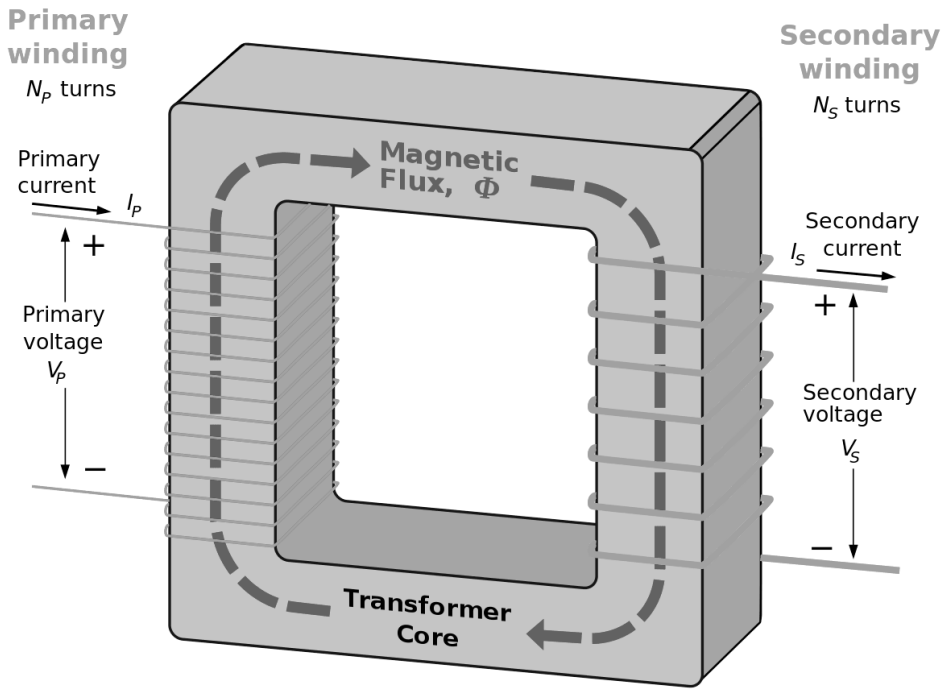
……

……

Question 26 (4 marks)

[Module 6.3]

The following diagram shows a transformer:



Justify **two** modifications to this apparatus to significantly improve transformer efficiency:

4

……

……

……

……

……

……

……

……

Question 27 (5 marks)

[Module 6.4]

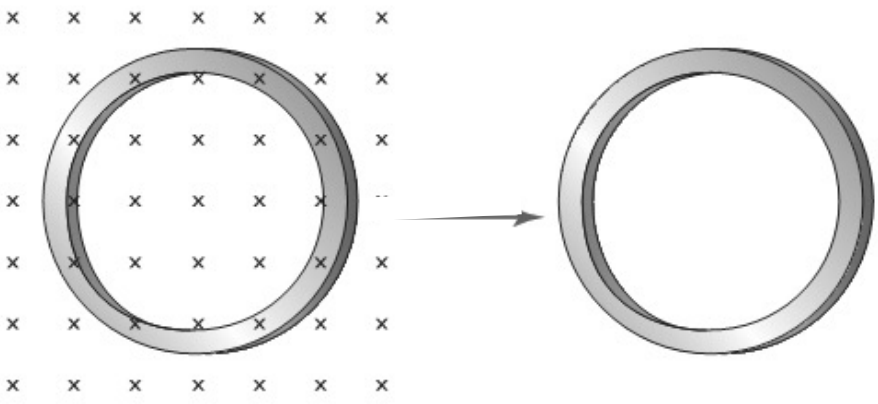
(a) State Lenz's Law:

1

……

……

(b) A stationary copper ring is inside a magnetic field when the field is suddenly turned off:



Apply Lenz's Law to explain why a large clockwise current is momentarily induced in the ring:

4

……

……

……

……

……

……

……

……

……

……

Question 28 (6 marks)

[Module 7.1, PH12-7]

Assess J.C. Maxwell's contribution to electromagnetic theory:

Question 29 (6 marks)

[Module 7.2]

(a) Young's double-slit experiment is usually done in a modern laboratory using a laser light source. Explain why only a single laser light source is typically used:

4

……

……

……

……

……

……

……

……

……

……

(b) A double slit apparatus using a laser was assembled and the interference pattern projected onto a wall 6m away. The slit separation was 200 µm and the distance to the first maxima was measured to be 6.25mm. What was the wavelength of the laser light in nanometres?

2

……

……

……

……

……

……

Question 30 (8 marks)

[Module 7.3]

A photoelectric experiment was conducted to determine the work function and threshold frequency of Silver and an unknown metal. The following results were obtained:

Metal	Work function (eV)	Threshold Frequency (THz)
Silver	4.73	1143.62
"Unknown"	2.28	–

(Reference: https://www.sps186.org/downloads/basic/163614/PhotoelectricEffectNOTES.pdf)

N.B. Planck's Constant can be represented as $h = 4.136 \times 10^{-15}$ eV.s

(a) Use the grid on the following page to **graphically** determine the threshold frequency of the unknown metal. Ensure you:

* Label your graph axes and provide appropriate units
* Indicate on your graph which metal is Silver and which is "unknown"
* Write the threshold frequency for the unknown metal in the space below

4

……

(b) Justify whether the unknown metal will generate electrons with a higher maximum kinetic energy than silver when exposed to yellow light of wavelength 500nm:

4

……

……

……

……

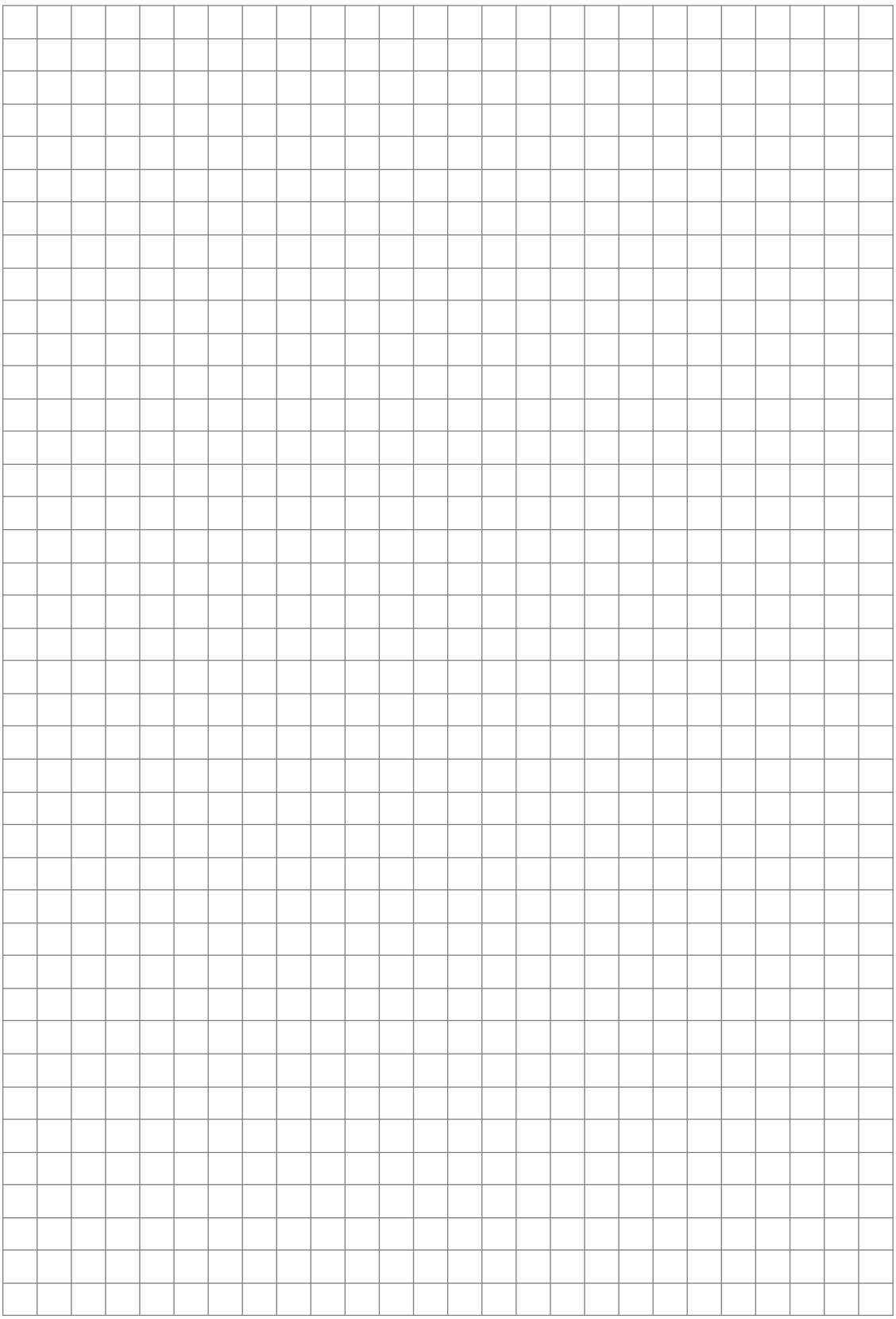
……

……

……

……

(Graph grid for Question 30)



Question 31 (4 marks)

In the 1953 science fiction novel "Childhoods End" by Arthur C. Clarke… "*Jan stows away on an Overlord supply ship and travels 40 light years to their home planet. Due to the time dilation of special relativity at near-light-speeds, the elapsed time on the ship is only [two] weeks, and he has arranged to endure it in drug-induced hibernation*".

(Reference: https://en.wikipedia.org/wiki/Childhood%27s_End)

(a) Assuming 45 years elapsed on Earth during the journey, calculate the average speed of the Overlord spaceship and express your answer in terms of "c":

3

……

……

……

……

……

……

……

……

(b) Identify why the spaceship and Earth elapsed times must be completely different :

1

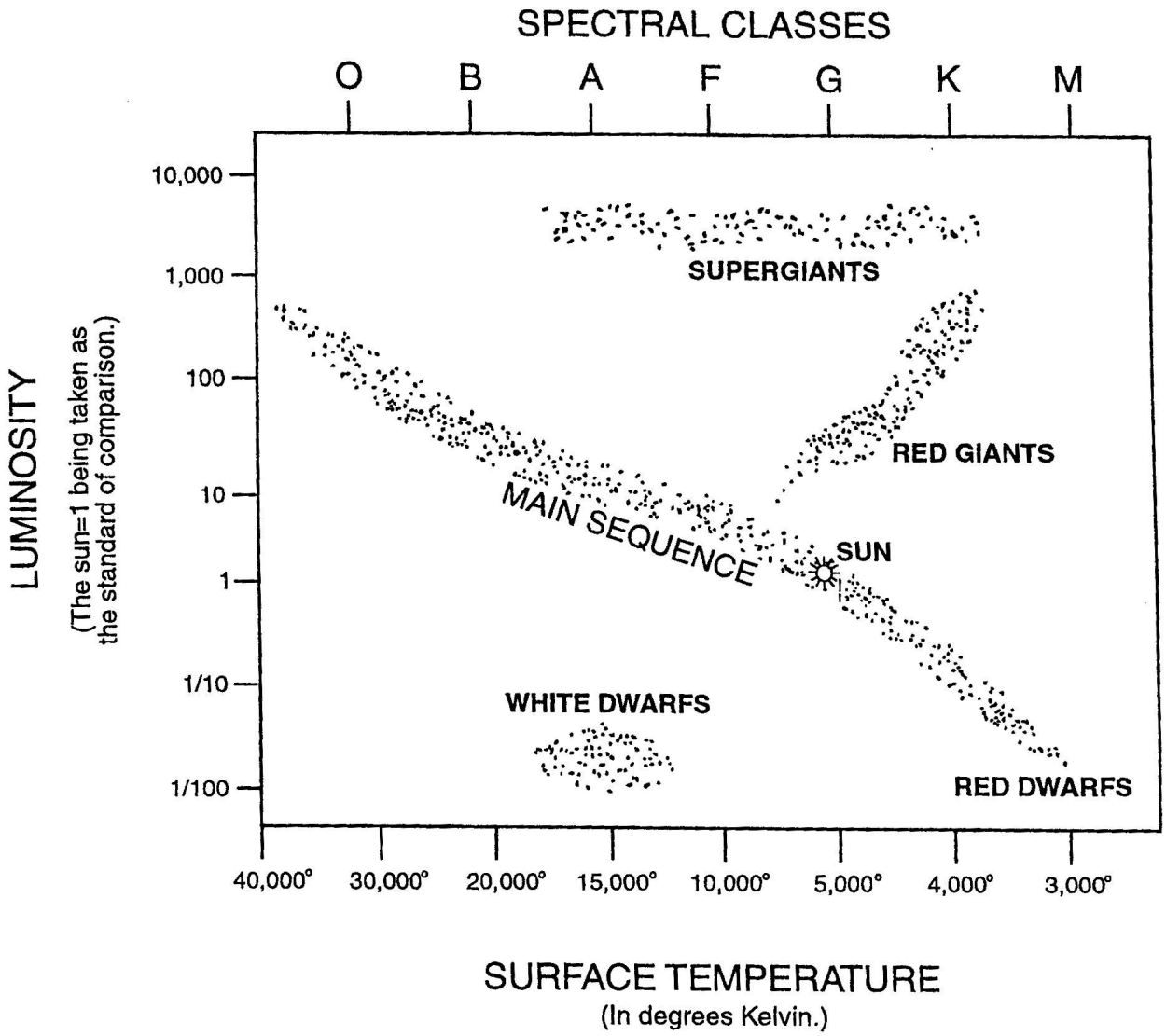
……

……

Question 32 (3 marks)

[Module 8.1]

Refer to the following Hertzsprung Russell diagram:



LABEL ON THE DIAGRAM to indicate the positions of our **Sun**:

"X" – 500 million years before it joined the main sequence

"Y" – 100 thousand years after it has left the main sequence

"Z" – 500 million years after it has completely exhausted its nuclear fuel

End of Section B

Section C **Working Scientifically – Extended Response**

Answer all questions in the spaces provided on this examination paper – do not use separate examination booklets for answers to Section C.

Take care to plan & structure your response to ensure a coherent & logical progression of argument

---

Question 33 (3 marks)

[Module 7.1, PH12-1]

The element Ytterbium is used as a doping agent in lasers. A quantitative first-hand investigation is to be done to examine the effect of temperature on the emission spectrum of Ytterbium. Write a valid hypothesis for this proposed investigation:

3

……

……

……

……

……

……

Question 34 (4 marks)

[PH12-4, 5 & 7]

During your Preliminary and HSC Depth Studies, you made use of secondary sources for articles and data. Explain how you ensured these sources were reliable.

4

……

……

……

……

Question 34 (*continued…*)

……

……

……

……

……

……

Question 35 (9 marks)

[PH12-1, 2, 4, 5 & 7]

Referring to a specific investigation you conducted in HSC Physics, justify and evaluate the use of variables and experimental controls to ensure a valid method was used for the reliable collection of data:

9

……

……

……

……

……

……

……

……

……

……

……

……

Question 35 (*continued…*)

End of Section C

END OF EXAM

13:46 TRIAL HSC EXAMINATION Multiple Choice – Answer Sheet

Student Number……

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

See overleaf for instructions…

Instructions for answering multiple-choice questions in Section 1

- Complete your answer in either blue or black pen
- Multiple choice

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

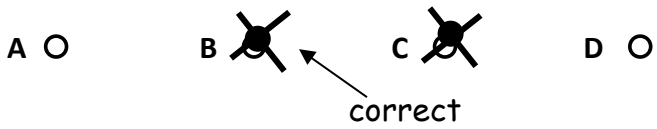
Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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 the correct answer by writing the word ***correct*** and drawing an arrow as follows.



7/30/2020 HSC PHYSICS

YEAR 12 – HSC Trial

Reporting Outcomes &

Assessment Marking Guide

***Please note**: The following is a marking guideline only. The mark you receive for any particular question ultimately depends upon the professional judgement of the teacher marking that question, along with that of the faculty head-teacher.*

Reporting Outcomes

- **PH12-6** – Solves scientific problems using primary and secondary data, critical thinking skills and scientific processes (M/C, Q31, Q32 = 27/ 100)
- **PH12-7** – Communicates scientific understanding using suitable language and terminology for a specific audience or purpose (Q27, Q28, Q33-Q35 = 27/ 100)
- **PH12-12** – Describes and analyses projectile, circular motion and motion in a gravitational field (Q21-Q24 = 22/ 100)
- **PH12-13** – Explains and analyses the electric and magnetic interactions due to charged particles and currents (Q25, Q26, Q29, Q30 = 24/ 100)

Criteria	***Outcome***
Demonstrates an extensive knowledge and understanding of the concepts of the physics course content including context, prescribed focus areas and domain. Displays an outstanding ability to describe and explain physics concepts, including abstract ideas, clearly and accurately, and to apply the concepts to unfamiliar situations. Applies a high level of critical thinking skills in developing appropriate solutions to problems involving a long sequence of related tasks. Analyses, evaluates and extrapolates data effectively, identifies complex relationships, quantifies explanations and descriptions, and synthesises information to draw conclusions. Communicates succinctly, logically and sequentially using a variety of scientific formats. Demonstrates a high-level ability to design an experimental procedure.	*O*
Demonstrates a thorough knowledge and understanding of the concepts of the physics course content including context, prescribed focus areas and domain. Effectively communicates a detailed understanding of physics concepts using appropriate physics terminology and some illustrative examples, and applies the concepts to unfamiliar situations. Analyses information given in written, tabular, graphical and diagrammatic forms and relates this to other relevant information. Displays competence in manipulating equations to solve problems involving a number of steps. Demonstrates a thorough knowledge of the use of appropriate experimental procedures.	*H*
Demonstrates a sound knowledge and understanding of the concepts of the physics course content including context, prescribed focus areas and domain. Describes concepts and information clearly in written and graphical forms and applies these concepts in familiar situations. Demonstrates a broad ability to carry out calculations and/or substitute into equations and to use relevant symbols and units when manipulating data. Displays proficiency in selecting relevant data from information given in written, tabular, graphical and diagrammatic forms. Describes correct apparatus for a particular physical measurement and has an adequate understanding of experimental methodology.	*S*
Demonstrates a basic knowledge and understanding of the concepts of the physics course content including context, prescribed focus areas and domain. Uses simple physics definitions and terms to communicate understanding of physics concepts. Substitutes data from information given in written, tabular, graphical and diagrammatic forms. Draws simple diagrams and graphs to describe phenomena in physics.	*B*

Marking Guidelines

Multiple Choice (1—20)

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

Justification for M/C Answers

(1) "C" because

(2) "A" because

(3) "D" because

(4) "D" because

(5) "A" because

(6) "C" due to

(7) "C" due to

(8) "D" because

(9) "C" due to

(10) "C" due to the other options being completely nonsensical

(11) "A" because

(12) "D" due to

(13) "D" because

(14) "C" due to

(15) "A" due to

(16) "A" due to

(17) "D" due to

(18) "D" due to

(19) “C” because

(20) “B” due to

Question 21 (a) *[3 marks – AZN]*

Suggested Answer

Vertical height = 12m *Horizontal distance = 10m* *Time to height = time to fall from height* *$S = ut + ½at^2$* *$12 = 0 + ½ \times 9.8 \times t^2$* *$t = \sqrt{(2 \times 12 / 9.8)}$* *= 1.56492 sec* *Calculate $V_{vertical}$* *V = u + at* *= 0 + 9.8 x 1.56492* *= 15.33623 m/s* *Calculate $V_{horizontal}$* *V = s / t* *= 10 / 1.56492* *= 6.39010 m/s*	*Resultant velocity* *$A^2 = B^2 + C^2$* *$A = \sqrt{(15.33623^2 + 6.39010^2)}$* *= 16.614251 m/s* *Apply sig.fig = 16.6 m/s* *Calculate elevation angle:* *$Tan \Theta = O / H$* *$\Theta = Tan^{-1} (15.33623 / 6.39010)$* *= 67.38012* *Apply sig.fig = 67.4°* *∴ Minimum velocity is:* ***> 16.6 m/s at elevation 67.4°***

Criteria	**Marks**
• Correctly calculates value with appropriate units: ○ Uses relevant equations ○ Does not round off excessively during mid-calculation ○ Sets out calculation logically and sequentially	3
• Employs mostly correct methodology, but has simple error(s)	2
• Makes a reasonable and relevant attempt to answer question	1

Q21(a) Marker's Feedback

- blah
- blah

Question 21 (b) [2 marks – AZN]

Suggested Answer

*The ball would experience **air resistance**, either directly in front of it, or else maybe a crosswind which would blow it sideways. Either way these forces have not been allowed for and would cause the ball to travel less further than expected.*

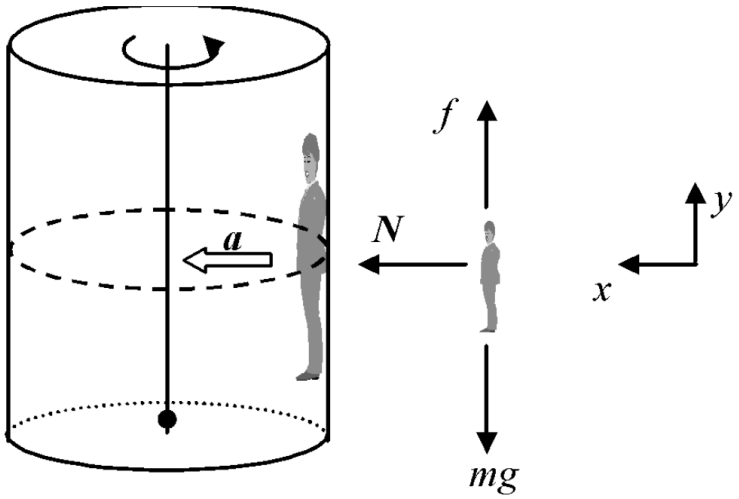
Criteria	Marks
• Correctly identifies air-resistance • Logically connects effect of air-resistance to ball falling short	2
• Makes a reasonable and relevant attempt to answer question	1

Marker's Feedback

- blah
- blah

Question 22 (a) ***[2 marks – AZN]***

Suggested Answer



Criteria	Marks
Student: • Draws a conventional force diagram • Force-diagram shows Centripetal, Gravitational and Friction components • Diagram does NOT include any reference to "Centrifugal force"	2
• Makes a reasonable and relevant attempt to answer question	1

Marker's Feedback

- blah
- blah

Question 22 (b) [2 marks – AZN]

Criteria	Marks
• The **friction and weight** forces are clearly labelled as BALANCED • The **centripetal** force is clearly labelled as UNBALANCED	2
• Makes a reasonable and relevant attempt to answer question	1

Marker's Feedback

- blah
- blah

Question 22 (c) *[2 marks – AZN]*

Suggested Answer

r = 5m; *T = 2.5 s*

v = 2 π r / T

∴ v = 2 x π x 5 / 2.5

= 12.5663706144 m/

Apply sig. fig. = ***12.6 m/s*** *(only asked for speed, so no direction)*

Criteria	Marks
• Correctly calculates value with appropriate units: ○ Uses relevant equations ○ Sets out calculation logically and sequentially	2
• Makes a reasonable and relevant attempt to answer question	1

Marker's Feedback

- blah
- blah

Question 23 (a) *[3 marks – AZN]*

Suggested Answer

T = 1 hr 40 min = 6000 sec *M = Mass of Earth = 6.0 x10^{24} kg*

G = 6.67 x10^{-11} Nm^2/kg^2 *r_{earth} = 6.371 x10^6 m*

r = 7 146 169.00247687 m

Need "altitude" so must subtract r_{earth}

∴ Altitude = 7 146 169.00247687 – 6.371 x10^6

= 775 169.002 m

Applying sig. fig. = ***7.75 x 10^5 m*** *(approx. 775 km)*

Criteria	Marks
• Correctly calculates value with appropriate units: ○ Uses relevant equations ○ Does not round off excessively during mid-calculation ○ Sets out calculation logically and sequentially	3
• Employs mostly correct methodology, but has simple error(s)	2
• Makes a reasonable and relevant attempt to answer question	1

Q23(a) Marker's Feedback

- blah
- blah

Question 23 (b) [2 marks – AZN]

Suggested Answer

Low Earth Orbit here, which is relatively close to the Earth's surface. Benefits:

*(1) Close enough to obtain **high res. images** for environmental monitoring/ weather*
*(2) Due to short distance, only **requires low power radio** for communication, so can use small antennae as well as low-power (+ compact) transponders*

Criteria	Marks
• Identifies 2 different benefits • Benefits are directly related to satellite being in LEO	2
• Makes a reasonable and relevant attempt to answer question	1

Marker's Feedback

- Other benefits: below Van Allen radiation belts, less energy to get satellite into lower orbit
- blah

Question 24 (a) *[4 marks – AZN]*

Suggested Answer

Given data: *d = 15 µm = 15 x10^{-6} m* *q = "–1" = –1.602 x10^{-19} C* *m = 35x p + 44x n + 36x e* *= 35 x 1.673 x10^{-27}* *+ 44 x 1.675 x10^{-27}* *+ 36 x 9.109 x10^{-31}* *= 5.8555E-26 + 7.37E-26* *+ 3.27924E-29* *= 1.322878 x10^{-25} kg* *Relevant equations:* *F = qE E = V/ d F = mg*	*V = 1.322878 x10^{-25} x 9.8 x 15 x10^{-6}* *–1.602 x10^{-19}* *= – 1.213877 x10^{-10} V* *Applying sig.fig = 1.2 x10^{-10} V* *Since polarity doesn't matter here (as plates are arranged appropriately):* *∴ Voltage required:* ***1.2 x10^{-10} V***

Criteria	**Marks**
• Correctly calculates value with appropriate units: ○ Uses relevant equations and inserts appropriate values ○ Calculates the correct mass (either with or without electron masses) ○ Does not round off excessively during mid-calculation ○ Sets out calculation logically and sequentially without cutting steps	4
• Employs mostly correct methodology, but has simple error(s)	3
• Significant errors in answer	2
• Makes a reasonable and relevant attempt to answer question	1

Q24(a) Marker's Feedback

- This question was worth 4 marks because there were many sequential steps required to reach the answer. Many of these steps required inputting scientific numbers into calculators accurately and quickly.
- Most students …

Question 24 (b) [2 marks – AZN]

Suggested Answer

*The upper plate must be +ve to provide an **upward attractive force** (via an electric field) on the ion. This attractive force **balances** the downward force on the ion due to gravity, causing the ion to levitate.*

Criteria	Marks
• Identifies there is **attractive** force from upward +ve plate (or repulsive force from lower –ve plate) • Gravitational force is **balanced** by electrostatic force, causing ion to levitate	2
• Makes a reasonable and relevant attempt to answer quest	1

Marker's Feedback

- blah
- blah

Question 25 (a) *[3 marks – AZN]*

Suggested Answer

Given data: *l = 20 cm = 0.2 m* *F = 25 mN = 25 x 10^{-3} N* *$I_1 = I_2 = 1A$* *$\mu_0 = 4\pi$ x 10^{-7} N/A^2* *Relevant equations:*	*$r = \frac{4\pi \times 10^{-7} \times 1 \times 1 \times 0.2}{2\pi \times 25 \times 10^{-3}}$* *= 1.6 x 10^{-6} m* *Applying sig.fig = 1.6 x 10^{-6} m* *∴ Distance between wires:* *<u>1.6 µm</u>*

Criteria	**Marks**
• Correctly calculates answer value with appropriate units: ○ Uses relevant equations ○ Does not round off excessively during mid-calculation ○ Sets out calculation logically and sequentially	3
• Employs mostly correct methodology, but has simple error(s)	2
• Makes a reasonable and relevant attempt to answer question	1

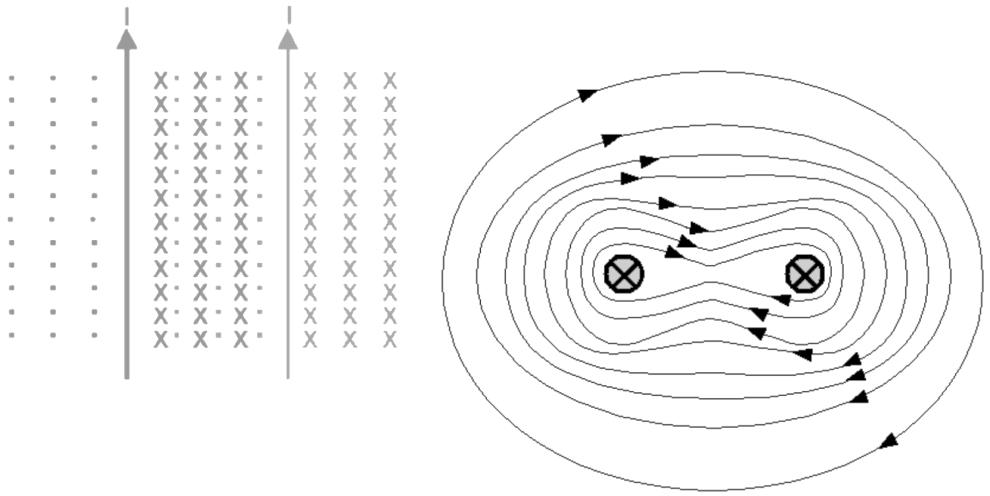
Marker's Feedback

- blah
- blah

Question 25 (b) *[3 marks – AZN]*

Suggested Answer

- *By Ampere's Law a straight wire carrying an electrical current will be surrounded by a cylindrical magnetic field (B). The direction of this field can be determined by the right-hand-grip-rule*
- *2 parallel wires, both carrying current in the same direction, will thus set up a Bs which circle the conductors in the same direction – see diagrams below*
- *WRT the region between the conductors, the RHS wire would have a B field coming out the page (•) , while the LHS wire would have the B field going into the page (X)*
- *Since these B fields oppose each other, their interaction will express itself as an attraction force between the wires, pulling them together*



Criteria	Marks
• Student provides an explanation: ○ Which is structured and logically sequential ○ Mentions the interaction of B-fields with opposite directions between the wires ○ Includes a relevant and correct diagram	3
• Answer is mostly correct, but has simple error(s)	2
• Makes a reasonable and relevant attempt to answer question	1

Q25(b) Marker's Feedback

- blah
- blah

Question 26 [4 marks – AZN]

Suggested Answer

- ***Efficiency –*** *The % of output when compared to input. 100% max and 0% minimum. To get maximum efficiency, have to reduce any energy losses as much as possible*
- ***Modification – Laminate the transformer core (perpendicular to the windings)***
  The 1° winding produces an oscillating magnetic flux, which causes eddy currents in the core which heats up due to Joule heating. Laminations (or a ferrite core) physically prevent these eddy currents from being very large, preventing energy wasted which would be better used by the 2° winding to produce electrical current
- ***Modification – Use very high conductivity wire for the windings***
  This will reduce losses due to resistive heating in the wire turnings. Ideally you could use a superconductor with 0 Ω resistance and thus have no resistive heating losses at all!
- ***Modification – Use large values for N_P and N_S***
  Will need to keep the $N_P : N_S$ ratio the same. This will increase the magnetic flux transferred between the 1° and 2° windings, reducing the relative impact of any losses due to eddy currents and/or resistive heating in the wire turnings

Criteria	Marks
• Student justifies 2 modifications: ○ Which are structured, succinct and logically sequential ○ Includes a definition of what is meant by "efficiency"	4
• Answer is mostly correct, but has simple error(s)	3
• Answer has significant errors/ omissions	2
• Makes a reasonable and relevant attempt to answer question	1

Q26 Marker's Feedback

- blah
- blah

Question 27(a) [1 mark – AZN]

Suggested Answer

The EMF induced in a conductor by a changing magnetic flux, will create a current so as to oppose the original change in flux

Criteria	Marks
• States Lenz's Law using words to the effect of the above	1

Marker's Feedback

- blah
- blah

Question 27(b) [4 marks – AZN]

Suggested Answer

- ***Relevant Equation – Faraday's Law of Induction (with Lenz's Correction)***

- ***While the field is operating***
  No change in magnetic flux ($\Delta\phi / \Delta t = 0$), so emf ("$\varepsilon$") is 0 & no induced current
- ***At the moment the field is turned off***
  ϕ suddenly drops to 0, so have a large $\Delta\phi / \Delta t$ and thus emf > 0 and current will now flow in the ring
- ***Lenz's Law***
  Determines the direction of the current. It must oppose the external change (the "–" sign in the equation above). Induced current will thus try to maintain the ϕ which has been removed. By the right-hand-rule for solenoids, to get an inward ϕ you need a clockwise current
- ***After the field has been off for a while***
  *Once more $\Delta\phi / \Delta t = 0$, so there is no emf & no current. Hence the **momentary** induction of clockwise current when the B field is suddenly turned off.*

Criteria	Marks
• Student provides an explanation: ○ Which is structured and logically sequential ○ Explicitly applies Lenz's law (in words or equation form) ○ Addresses why the induced current is clockwise and only momentary	4
• Answer is mostly correct, but has simple error(s)	3
• Answer has significant errors/ omissions	2
• Makes a reasonable and relevant attempt to answer question	1

Marker's Feedback

- blah
- blah

Question 28 [6 marks – AZN]

Suggested Answer

An ideal answer would address the following points:

- *Answer structured into an easy-to-read format: where appropriate uses subheadings, paragraphs, short sentences, bullet-points etc.*
- *Briefly identifies who J.C. Maxwell was and gives a brief overview of what he did*
- *Includes a definition for "electromagnetism"*
- *Includes description of Maxwell's 4 equations and what they do*
- *Impact of the work of Faraday, Gauss and Ampere upon the equations*
- *Unification of Electrical and Magnetic fields into "Electromagnetism"*
- *EMR is made up of interacting Electrical and Magnetic fields*
- *Maxwell's equations used to predict the speed of light, which was confirmed by experimental observation*
- *Inference that EMR is not limited to visible light (later confirmed by Hertz)*
- *Assumption that EMR requires 'Luminiferous Æther" as a medium for transmission (later shown to be incorrect)*

Criteria	Marks
• Student provides an assessment: ○ Which is succinct, structured and logically sequential ○ Which addresses, in detail, the points outlined above ○ Displays a superior understanding of J.C. Maxwell's contribution ○ Answer contains NO errors	6-5
• Answer is mostly correct, but has simple errors/ omissions	4-3
• Answer has significant errors/ omissions	2
• Makes a reasonable and relevant attempt to answer question	1

Marker's Feedback

- blah

- blah

Question 29 [6 marks – LH]

(a)

Criteria	Marks
• Student provides an explanation: ○ Which is succinct, structured and logically sequential ○ Which demonstrates knowledge of the features of Young's experiment including the relevant formula ○ Identifies that a laser provides a coherent single wavelength of light ○ Relates the role of wavelength to the interference pattern ○ Answer contains NO errors	4
• Answer is mostly correct, but has simple errors/ omissions	2-3
• Answer has significant errors/ omissions OR • Provides some relevant information	1

Sample Answer

This experiment demonstrates the production of interference bands produces when light is incident on a pair of slits. The equation $dSin\Theta = m\lambda$ describes the production of these. If the λ is constant as in a laser and the distance from the screen is also constant then the effects of separation of the slit can be investigated. If the λ is not provided by a laser then several λ's can be produced leading to a less valid experiment. Alternatively, if the light is produced by an incoherent source a second screen must be used in front of the double slit to provide a point source to produce the coherent light for diffraction.

(b)

Criteria	Marks
Student correctly	2

• identifies the formula to use • identifies the relevant variable to substitute • manipulates the formula using algebra to make λ the subject • calculates λ • writes λ in nanometeres 208 nm.	
• Student makes a suitable and relevant attempt to answer the question but makes a simple mistake in interpretation of the data or in converting to nm.	1

Question 30 [8 marks – LH]

(a)

Criteria	Marks
Students construct a graph with: • Kinetic energy in eV on the y-axis • Frequency on the x-axis • A suitable scale that covers the axes • Lines drawn as solid lines in the + y direction and dotted lines in the -y direction • Dotted lines intersect the y – axis at the indicated value for the work function of each metal • Line intersects the x – axis at the threshold frequency for silver • Line for the unknown is drawn parallel – no convergence evident at all – to the silver line • Value for the threshold frequency is graphically determined.	4
• Answer is mostly correct, but has simple errors/ omissions	2-3
• Answer has significant errors/ omissions OR • Provides some relevant information	1

Markers Feedback

Some students clearly have a very good knowledge and understanding of the photoelectric effect and the mathematical modelling around it. Most students did not however achieve full marks in this question with many making simple mistakes and omissions.

Answers to this question demonstrate very poor knowledge and understanding of the photoelectric effect. Many students had no idea of the standard way to construct these

graphs providing reversed axes, poor scales, dotted lines, no dotted lines, converging lines, lines going in the incorrect direction.

Students are strongly encouraged to revise the photoelectric effect and attempt many questions to test their understanding of the material.

(b)

Criteria	Marks
Students use the information gathered in part a or the predicted values of the threshold frequency of the unknown to answer this question. Students relate the frequency of the yellow light to the work function of the metal through calculation. Students correctly identify that the threshold frequency of silver is greater than the frequency of the incident light so no electrons will be emitted from silver however the frequency of the incident light is greater than the threshold frequency of the unknown so it will emit electrons.	4
• Answer is mostly correct, but has simple errors/ omissions	2-3
• Answer has significant errors/ omissions OR • Provides some relevant information	1

Sample answer

Using the information from part (a) the threshold frequency of the unknown is 500 THz. The frequency of the incident light is calculated using

$C = f\lambda$ leading to f of light = 600 THz

Since the frequency of the incident light is greater than the threshold frequency of the unknown and less than that of the silver metal, electrons will only be emitted from the unknown and not from the silver. Thus, the unknown will have photoelectrons with a higher E_k than the silver.

Marker's feedback

Some students have excellent understanding of the relationship between the concepts in this part of the question providing ideal answers. However many students did not know where to begin.

Question 31 [4 marks – LH]

(a)

Criteria	Marks

Students correctly:
• Identify
  • t_0 as 2 weeks
  • and t_v as 45 years
• Convert 2 weeks and 45 years to relevant comparable time units
• Use algebra to correctly make v the subject of the time dilation formula
• Correctly substitute time values in to the time dilation formula
• Correctly calculate v as a multiple of "c"
	3

• One small error	2
• Substantial error, miscalculation, assumption.	1

Marker's feedback

Students mostly completed this question very well. Some errors in judgement were made such as saying 2 weeks is equal to 1/26 years which is somewhat less accurate than converting years to days and weeks to days similarly.

Some students found a value for v which was greater than c and did not comment on this which was cause for concern.

(b)

Criteria	Marks
• Students relate the difference in time to time dilation	1

Marker's feedback

Some students made some unusual and incorrect comments about the variation of c in different frames of reference or attributed the time dilation to Newton.

Question 32 [3 marks – LH]

Criteria	Marks
One mark for each reasonably correct position of each star.	3

Marker's feedback

In this diagram I primarily looked for "X" to be placed to the right of the sun and not on the main sequence, "Y" above the sun but not as far as the supergiants or toward the blue and "Z" down with the white dwarfs as these are the main identifiable stages for a sun like star. Some students were quite confused about where to place each.

Question 33 [3 marks - LH]

Criteria	Marks
Students provide one clear measurable independent variable and one clear measurable dependent variable in a logically written statement without excessive extra detail.	3
Student provides on clear measurable independent and dependent variable but adds too much extraneous information or the answer is unclear.	2
Student provides on clear measurable independent or dependent variable.	1

Sample Answer

A null hypothesis could be:

The temperature of Ytterbium will not alter the peak wavelength produced in the Ytterbium emission spectrum.

Or a predictive hypothesis could be:

As the temperature of Ytterbium is increased, the peak wavelength produced in the emission spectrum of Ytterbium will decrease.

Anything that is quantitative, explicit and succinct.

Marker's feedback

Students appear to have found this question most difficult. Most were very vague about what they were going to change the temperature of. Most wrote something like, "As the temperature is increased .." leaving it very open - do they mean of the Ytterbium, laser, the

room? Others wrote reasonable independent and dependent variables that were not quantitative or wrote so much that their work was just not a hypothesis.

Question 34 [4 marks – LH]

Criteria	Marks
Student provides: • Clear definition of reliability • Clear and correct method to find reliability that includes comparison to other valid sources with favourable comparisons leading to increased reliability.	4
Student provides: • Clear and correct method to find reliability • May include definition of reliability • Some confusion with validity	3
Student references comparing	2
Student provides some useful and relevant information	1

Marker's feedback

Students appear to have also found this question most difficult. Most were very vague about what type of sources they would compare their secondary sources to and/or that favourable comparisons improved the reliability of their source material. Many students are still confusing reliability and validity with many constructing long answers about validity instead of reliability.

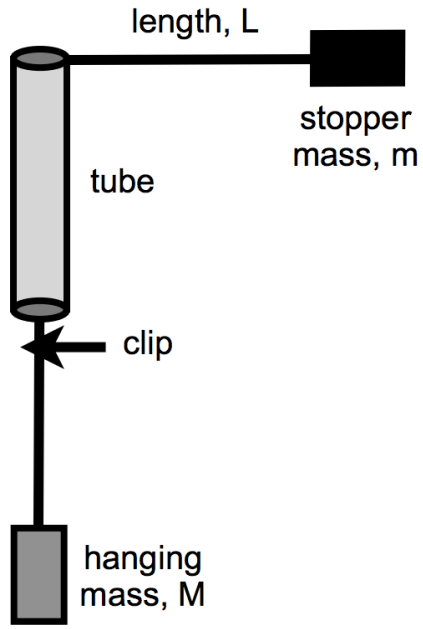
Question 35 [9 marks – LH]

Criteria	Marks
• Shows a comprehensive understanding of the need to use variables and experimental controls to ensure that a valid procedure was developed • Shows a comprehensive understanding of how to collect reliable data • Makes a clear justification in supporting their argument or conclusion • Makes a clear evaluation of validity AND reliability by making a judgement based on criteria	9
• Shows a comprehensive understanding of the need to use variables and experimental controls to ensure that a valid procedure was developed • Shows a comprehensive understanding of how to collect reliable data • Makes a justification in supporting their argument or conclusion • Makes a clear evaluation of validity OR reliability by making a judgement	7-8

based on criteria	
• Outlines how to use variables and experimental controls to ensure that a valid procedure was developed • Outlines how to collect reliable data • Justifies and/or evaluates their procedure	5-6
• Outlines some use of variables and experimental controls and/or a procedure that allowed for the collection of data	3-4
• Provides some relevant information	1-2

Sample Answer:

During our studies we investigated centripetal force and how the radius of the circular path affects the time period of rotation. To achieve this, we spun a rubber stopper on the end of a string using a glass tube, with a counter-weight at the other end of the string (see diagram). The centripetal force F_c was provided by the weight Mg. Accordingly, the following equations emerge:



$Mg = F_c$

$Mg = mv^2/r \qquad v = 2\pi r/T \qquad r = L$

$Mg = m(2\pi r/T)^2/L$

$g = 4\pi^2 L/T^2$

$T^2 = 4\pi^2 L/g$

Thus, we can say the time period squared, T^2, the dependent variable, is directly proportional to the radius of the circle, L, the independent variable; providing the other variables are constant: the controlled variables i.e. m, the mass of the stopper; M, the mass of the hanger; and g, the acceleration due to gravity. By only varying one variable, L, and keeping the controlled variables constant, we ensured that it was a fair test i.e. a valid scientific method. To achieve this, we:

1. Measured the mass of the bung, m

2. Set the length of the string above the tube at 30cm by pulling it out then clipping it at the bottom of the tube with a clip
3. Used 150 g for the hanging mass, M
4. Twirled the bung until the clip moved up to the bottom of the tube.
5. At this point, we measured the time required for the stopper to travel a total of 20 cycles around the tube
6. This was repeated twice more to obtain an average time for that length
7. Steps 4-6 were repeated for increasing lengths performing a circle of radius 40, 50, 60, 70, 80cm

However, the validity of the experiment was somewhat tempered by friction between both the string and tube at the top of the tube, and the clip and tube at the bottom of the tube, as these frictional forces were not accounted for in the equations used as a basis for our experimental procedure. To minimise the impact of such frictions, and thus to increase the validity, we used olive oil at the top of the tube, while practised twirling the stopper such that the clip just missed scratching against the bottom of the tube, reducing friction in both cases.

Overall, this was a valid experiment as we minimised the systematic errors from the sources of friction.

To ensure a reliable collection of data, the stopper was firstly twirled 20 times rather than once thus minimising percentage error in the measurement, plus this was repeated twice more for each length (step 6), to obtain an average for each length. Collecting data at 6 lengths allowed us to plot a T^2 v L graph with good range to obtain a straight line of best fit, thereby demonstrating the linear relationship between T^2 and L, as predicted by the equation. Overall, this was a reliable experiment as there was a low spread in time values for each length plus our average values lay very close the straight line of best fit.

Marker's Feedback

This question was clearly a surprise to most students. It is a robust task requiring approximately 16 – 17 minutes of examination time and thus must be planned. The majority of answers were poorly planned and did not answer the whole question.

In the context of evaluating the validity of an experiment you conducted you have to outline the experiment itself to provide sufficient information about how the variables were controlled such that there was only on independent and one dependent variable. You need to provide the method used to ensure the data was reliable – how did the experimenter remove random error. How was the reliability evaluated? Was it compared to a mathematical model? Which one? Was a graph used? How did the data fit the graph?

There were very many low marks for this question where students provided "some relevant information". Students are strongly encouraged to re attempt this question, starting with a scaffold of the sections to produce a better response.

Marking Guide – End