2023

Task 4: Trial Examination

Weighting: 30%

HSC Physics Booklet 1

Place sticker with student number in this box.

Place a sticker on any writing booklets used.

DO NOT PUT A STICKER ON EVERY PAGE.

Total marks - 100

BOOKLET 1

Section I - 20 marks

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

BOOKLET 2

Section II - PART 1 - 24 marks

- Attempt Questions 21-26
- Allow about 40 minutes for this part

BOOKLET 3

Section II - PART 2 - 32 marks

- Attempt Questions 27-32
- Allow about 60 minutes for this part

BOOKLET 4

Section II - PART 3 - 24 marks

- Attempt Questions 33-36
- Allow about 45 minutes for this part

General Instructions

- Reading time - 5 minutes
- Working time - 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided
- For questions in Section II, show all relevant working in questions involving calculations
- This paper MUST NOT be removed from the examination room.

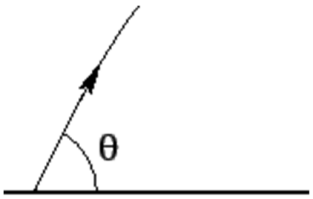
Subject Teachers:
Ms Disney
Mr Fiander
Mr Sloan
Mr Smith
Mr Solomonides

Section I
20 marks

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

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

1. A projectile is launched at a speed of 32.8 ms^{-1} at an angle of 62° above the horizontal as shown below.



Calculate the magnitude of the initial vertical and horizontal components of the velocity of the projectile.

	Horizontal velocity (ms^{-1})	Vertical velocity (ms^{-1})
A.	15.4	29.0
B.	29.0	15.4
C.	22.1	24.2
D.	24.2	22.1

2. Which combination of quarks makes up a proton?

A. uud

B. $\overline{u}\overline{u}\overline{d}$

C. $uu\overline{d}$

D. udd

3. A person on Earth is watching a spacecraft fly past Earth at a speed of 0.85c.

An event on the spacecraft takes 43 minutes to occur as measured by the person on the spacecraft.

How long does the event take for the observer on Earth?

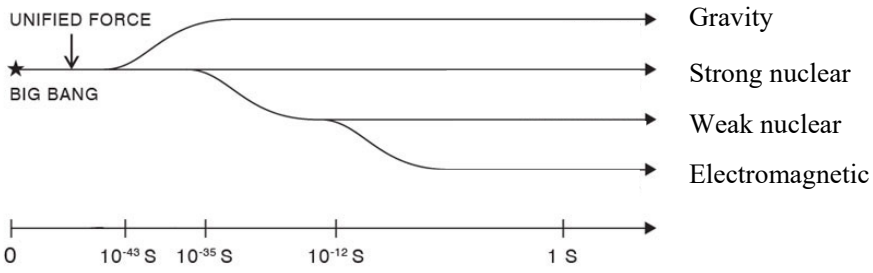
A. 23 minutes

B. 82 minutes

C. 111 minutes

D. 155 minutes

4. The diagram below shows the splitting of the four fundamental forces at the beginning of the universe.



Formation of particles, nuclei, atoms and stars could not occur until specific forces existed. Gravity causes particles to attract to each other.

Which other forces were required to form the following types of matter?

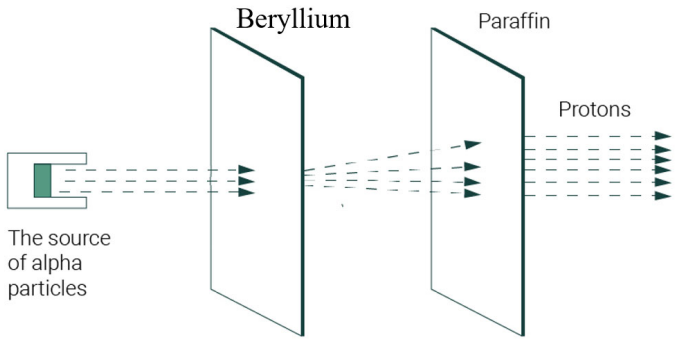
A. Atoms – strong nuclear and weak nuclear forces.

B. Nuclei – strong nuclear and electromagnetic forces.

C. Protons – strong nuclear and weak nuclear forces.

D. Atoms – strong nuclear and electromagnetic forces.

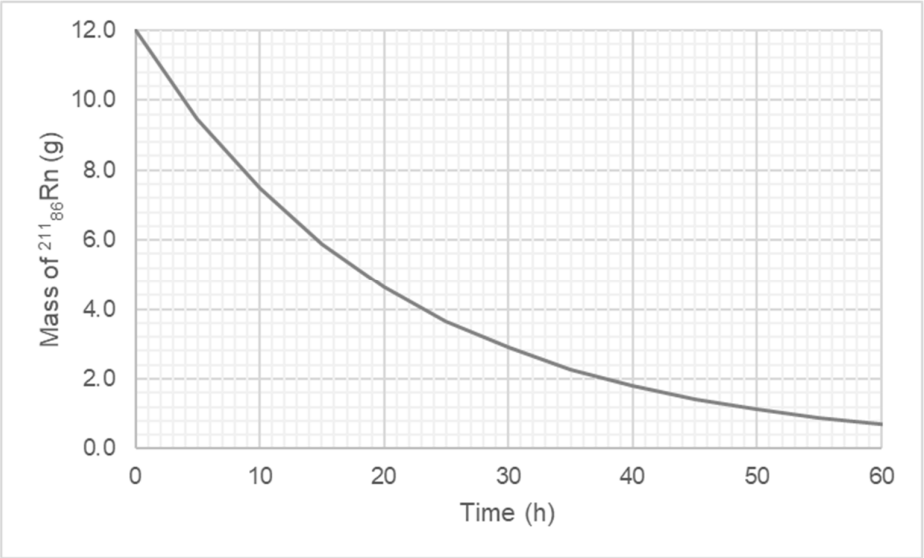
5. The following image shows an experiment that helped to understand the structure of the atom.



Who performed this experiment and what was the discovery made?

	Scientist	Discovery
A.	Rutherford	Discovery of the neutron
B.	Rutherford	Discovery of the nucleus
C.	Chadwick	Discovery of the proton
D.	Chadwick	Discovery of the neutron

6. The following graph shows how the mass of Radon-211 in a sample changes over time.



Determine the radioactive decay constant for Rn-211

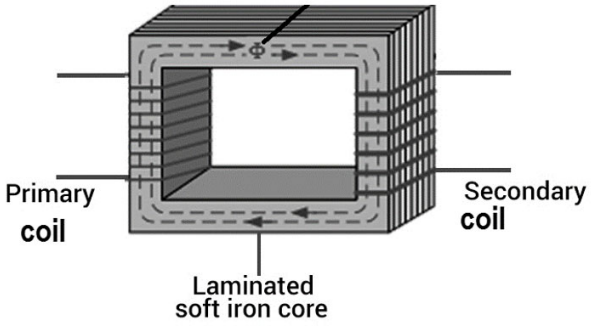
A. $6.4 \times 10^{-6}\ s^{-1}$

B. $1.3 \times 10^{-5}\ s^{-1}$

C. $0.02\ s^{-1}$

D. $0.05\ s^{-1}$

7. The diagram below shows the laminated iron core of a transformer.



What is the purpose of the laminations in the iron core?

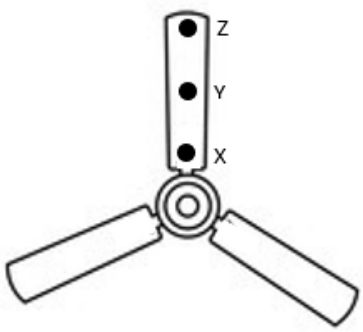
A. To make the iron core lighter.

B. To reduce power loss in the transformer.

C. To transfer the flux from the primary to the secondary coil.

D. To prevent the formation of any eddy currents in the iron core.

8. A fan has three points marked on it X, Y and Z as shown below.



As the fan blade spins, the angular speed and linear speed of points X, Y and Z are measured.

Rank the angular and linear speed of points X to Z.

A. Angular speed and linear speed both increase from X to Z.

B. Angular speed is constant, linear speed increases from X to Z.

C. Angular speed is constant, linear speed increases from Z to X.

D. Linear speed is constant, angular speed increases from X to Z.

9. Two parallel wires of length 3.5 m carry the same magnitude of current. The two wires are fixed in place, 5.3 cm apart and have a repulsive force of 3.78×10^{-6} N between them.

Calculate the magnitude and direction of the current in the wires.

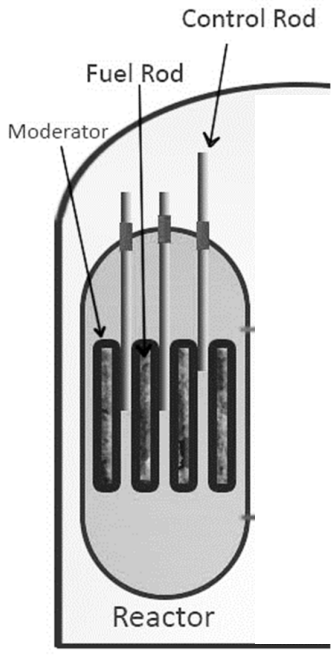
A. 0.286 A in the same direction

B. 0.286 A in the opposite direction

C. 0.535 A in the same direction.

D. 0.535 A in the opposite direction.

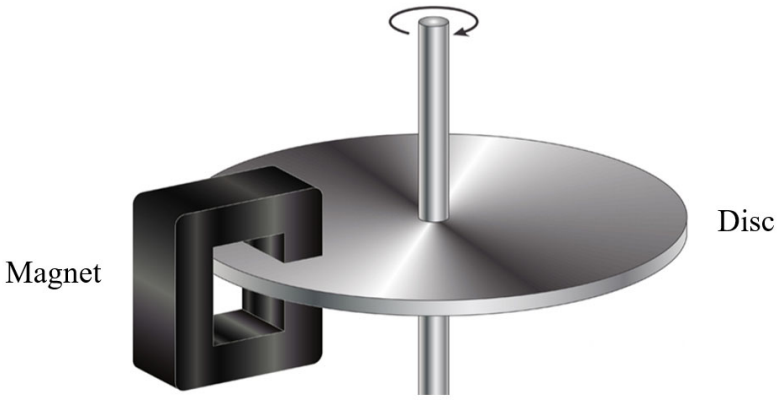
10. The diagram below shows a fission reactor.



What is the role of the moderator and control rods in a controlled nuclear fission reaction?

	Moderator	**Control rods**
A.	A substance that slows neutrons via collision	Moveable rods that absorb neutrons
B.	A substance that slows neutrons via collision	Moveable rods that slow neutrons through collision
C.	A substance that absorbs and releases neutrons	Moveable rods that absorb neutrons
D.	A substance that absorbs neutrons via collision	Moveable rods that slow neutrons through collision

11. The following diagram shows a metal disc that is free to rotate about the central pole and is not in contact with the magnet.



When the metal disc is spun and the magnet is not present, the disc spins and takes approximately 45 seconds to come to a stop.

When the metal disc is spun at the same initial rate, and the magnet is present, it slows quickly and comes to a stop in approximately 10 seconds.

What is the reason for the difference in stopping times?

A. Friction between the magnet and disc creates a resistive force that opposes the spinning motion.

B. Eddy currents form in the disc due to Lenz's law, resulting in magnetic fields that oppose the spinning motion.

C. Eddy currents form in the magnet due to Faraday's law, resulting in magnetic fields that oppose the spinning motion.

D. Eddy currents form in the disc due to Faraday's Law, resulting in magnetic fields that oppose the spinning motion.

12. Muons form in the upper atmosphere through nuclear reactions and provide evidence of special relativity.

Non-relativistic data about muons is seen in the table below.

Property	Non-relativistic observation
Distance from formation to Earth surface	10 km
Half-life of muon	2.2 μs
Number of muons reaching Earth	0

What is the reason that relativistic data measured about muons differs from the non-relativistic data in the table above?

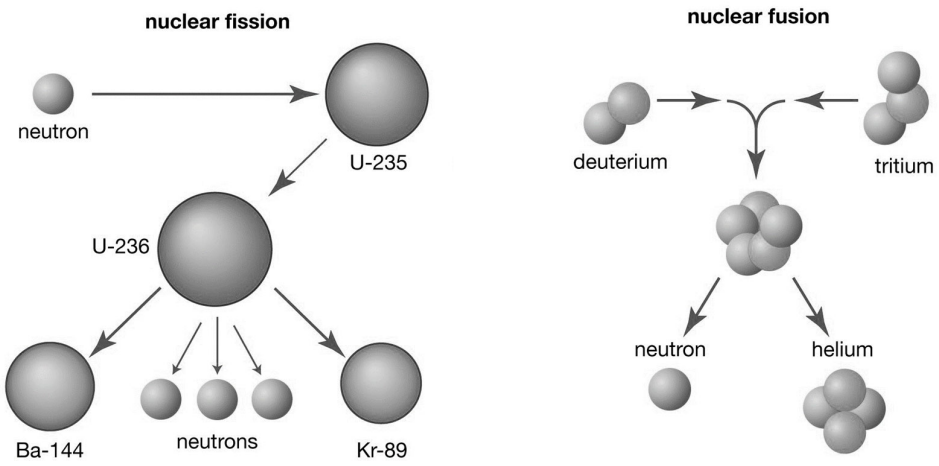
A. The muons experience a longer half life due to time dilation. Humans observe muons travelling a shorter distance to the Earth's surface.

B. Humans observe muons having a longer half life due to time dilation. The muons experience length contraction of the distance to Earth's surface.

C. The muons experience a longer half life due to time dilation. The muons experience length contraction of the distance to the Earth's surface.

D. Humans observe muons having a longer half life due to time dilation. Humans observe muons experiencing length contraction of the distance to Earth's surface.

13. Examples of fission and fusion reactions are shown below.



Which of the following is true when comparing the two reactions shown above?

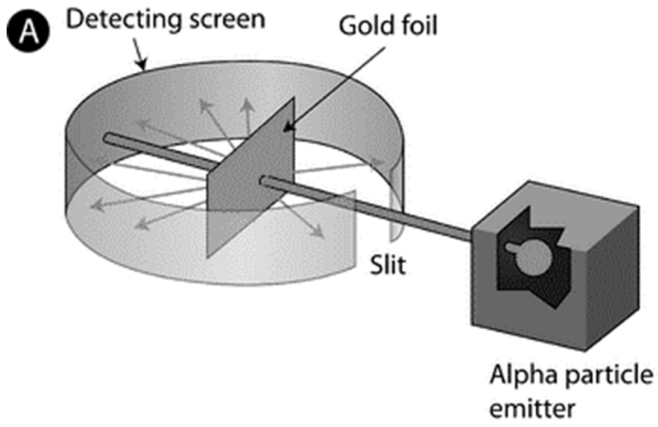
A. Only fusion reactions require energy to start the reaction.

B. Both fission and fusion reactions have a net release of energy.

C. Fission reactions have a net release of energy, fusion reactions have a net absorption of energy.

D. In fission the products have greater mass than reactants, in fusion the reactants have greater mass than the products.

14. The gold foil experiment is shown below.



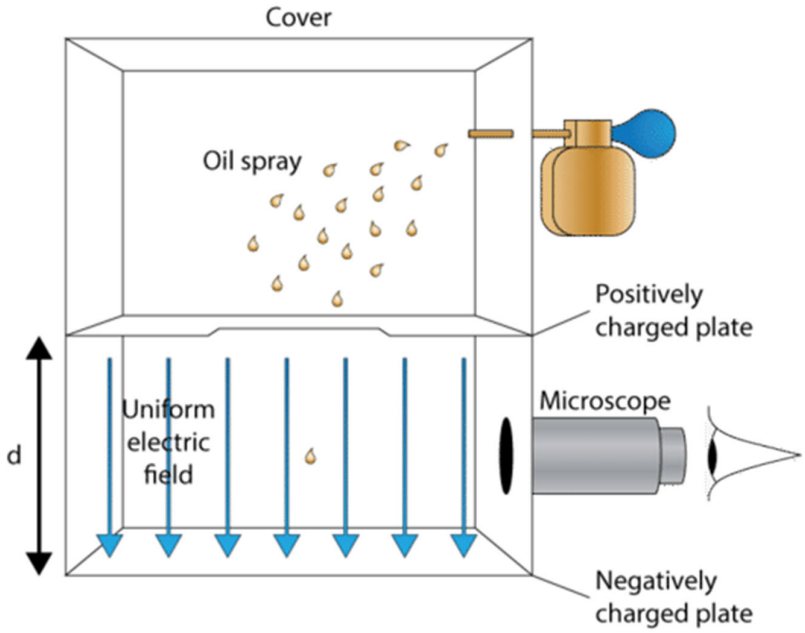
In experiments like this, specific observations are used to make a conclusion about the structure.

Which of the following observations matches the conclusion?

	Observation	Conclusion
A.	The majority of alpha particles passed through undeflected	The nucleus was in the centre of the atom
B.	A small proportion of particles were deflected or reflected	The atom is mostly empty space
C.	A small proportion of alpha particles changed course and were deflected	The nucleus had a positive charge causing deflection of alpha particles
D.	A small proportion of particles were deflected or refracted	The nucleus had a positive charge causing deflection of alpha particles

15. The diagram below shows Millikan's oil drop experiment where negatively charged oil droplets fall into a uniform electric field directed downwards, as shown below.

The oil droplets in the electric field are accelerating downwards.



Which of the following is the correct equation to find the charge on an oil drop that is accelerating downwards?

A. $q < \frac{dmg}{V}$

B. $q < \frac{mg}{v}$

C. $q = \frac{dmg}{V}$

D. $q = \frac{qvB}{E}$

16. For an object to leave the Earth's gravitational field it must be projected at escape velocity.

Which of the following is NOT a consideration in the definition of escape velocity?

A. The object reaches an infinite distance from Earth.

B. The Earth's gravitational force stops acting on the object.

C. The acceleration of the object equals the gravitational acceleration of the Earth.

D. The initial gravitational potential energy and kinetic energy of the object are equal in magnitude.

17. All motors have a constant top speed that will be reached some time after beginning to rotate.

What is the reason for the maximum top speed?

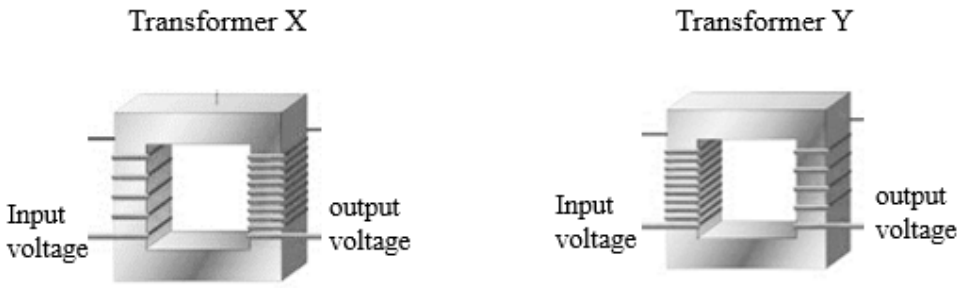
A. The back emf eventually equals the supply emf, resulting in a constant net voltage.

B. The supply emf gradually decreases as the back emf increases, resulting in a constant voltage in the motor.

C. As the motor increases in speed, the back emf increases to a maximum, resulting in a constant net voltage.

D. The starting resistance gradually decreases, resulting in a constant resistance that determines the maximum speed of the motor.

18. Two transformers, X and Y, are shown below.



Which of the following shows a change made to both transformers, and the resulting correct change to the output voltage?

	Change made to both transformers	Result
A.	Increase frequency of input AC	Increased voltage output in both transformers
B.	Input voltage decreased	Output voltage on X will increase, but decrease on Y
C.	Input voltage increased	Output voltage on both transformers will increase
D.	Input voltage increased	Output voltage on X will increase, but decrease on Y

19. The following nuclear equation shows the formation of a daughter nucleus and an unknown particle.

$$ {}^{A}_{Z}X + {}^{1}_{0}n \rightarrow {}^{A-1}_{Z-2}Y + ? $$

What is the other type of particle produced?

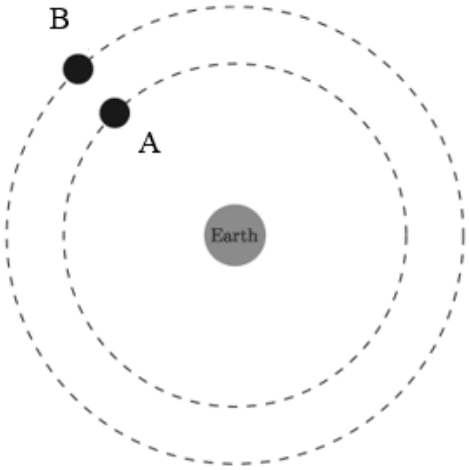
A. ${}^{2}_{2}H$

B. ${}^{4}_{2}He$

C. ${}^{3}_{2}He$

D. ${}^{1}_{1}p$

20. Two satellites, A and B are orbiting Earth at different altitudes as shown in the diagram and table below.



Satellite	Altitude (km)
A	629
B	7 629

Determine the ratio of T_A:T_B.

A. 0.0237

B. 0.125

C. 0.354

D. 2.828

END OF BOOKLET 1

Place sticker with student number in this box.

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DO NOT PUT A STICKER ON EVERY PAGE.

2023

Task 4: Trial Examination

HSC Physics
Booklet 2

BOOKLET 2

Section II - PART 1 - 24 marks

- Attempt Questions 21-26
- Allow about 40 minutes for this part

Instructions:
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Extra writing booklets are available upon request. If you use a booklet, clearly indicate which question you are answering and indicate in this paper that a booklet has been used. Use a new booklet for each question.

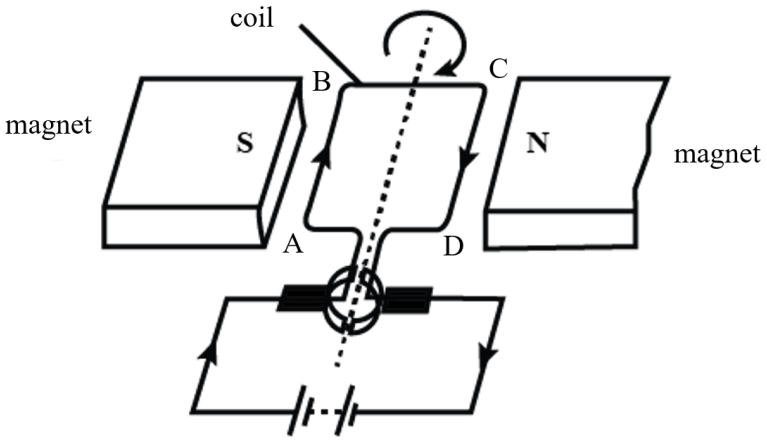
EXTRA BOOKLETS USED: **(please circle)** YES / NO

IF EXTRA BOOKLETS USED - HOW MANY BOOKLETS USED? (please circle)

1 2 3 4 5 or write number here.....

Question 21 (4 marks)

The diagram shows a simple DC motor with a single rectangular coil of wire in a uniform magnetic field of strength 4.52 T. The length of side AB is 0.13 m and the length of side BC is 0.057 m.



(a) If the current flowing in the coil is 0.48 A, calculate the magnitude of the maximum torque produced by the motor. **2**

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(b) Justify one change to the motor that would increase the maximum torque. **2**

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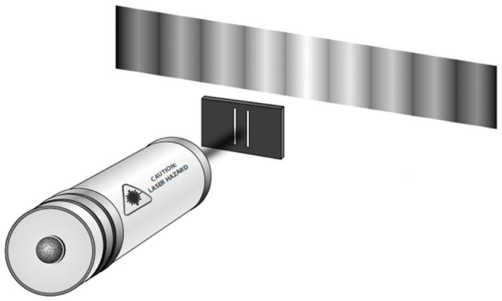
Question 22 (4 marks)

The diagram below shows the pattern formed when a red laser is shone through a double slit where the slits are 3.50×10^{-5} m apart. The screen is 5.50 m away from the double slit.



A student measures the distance between two adjacent bright bands to be 10.0 cm.

(a) Calculate the wavelength of the laser light. **2**

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(b) Outline a limitation of this experiment that impacts the reliability of the results. **2**

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Question 23 (3 marks)

An object of 5.25 kg moves around a point in a circle of radius 4.83 m. The object has a period of 4.10 s.

Calculate the acceleration of the object. **3**

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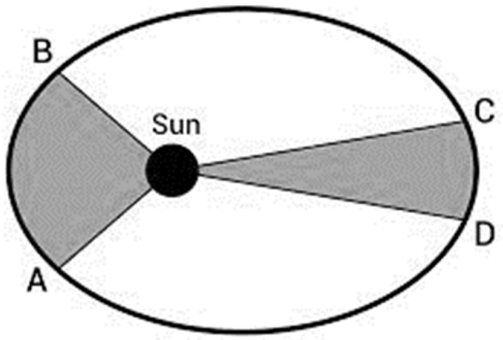
Question 24 (5 marks)

A planet is orbiting the Sun in an elliptical orbit as shown below where the shaded sections are of equal area.



(a) Justify whether the planet is travelling faster between A and B or between C and D. **3**

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(b) Explain why a geostationary satellite in orbit around the Earth has a constant total energy. **2**

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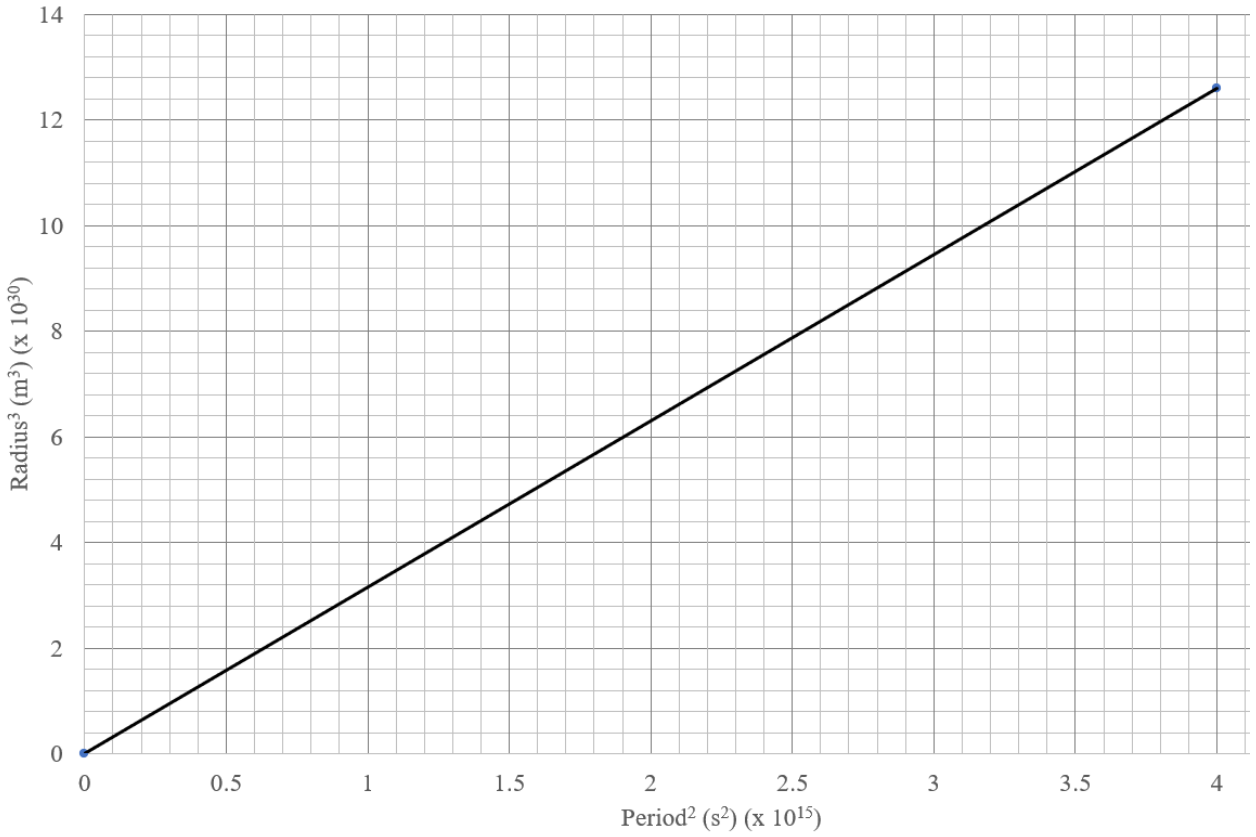
Question 25 (4 marks)

The graph below shows information about the moons of Jupiter.



Use the graph to determine the mass of Jupiter. **4**

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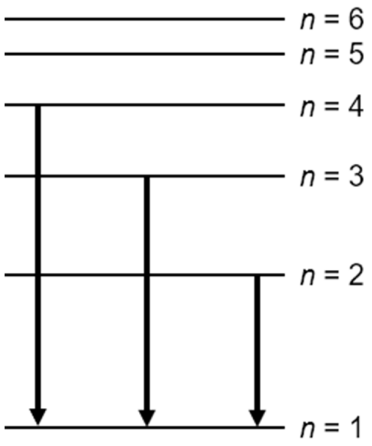
Question 26 (4 marks)

The diagram below shows three possible electron transitions that take place in a hydrogen atom.



A photon of energy 1.94×10^{-18} J is released from the hydrogen atom.

Which electron transition from the diagram causes this energy photon? **4**

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END OF BOOKLET 2

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2023

Task 4: Trial Examination

HSC Physics
Booklet 3

BOOKLET 3

Section II - PART 2 - 32 marks

- Attempt Questions 27-32
- Allow about 60 minutes for this part

Instructions:
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Extra writing booklets are available upon request. If you use a booklet, clearly indicate which question you are answering and indicate in this paper that a booklet has been used. Use a new booklet for each question.

EXTRA BOOKLETS USED: **(please circle)** YES / NO

IF EXTRA BOOKLETS USED - HOW MANY BOOKLETS USED? (please circle)

1 2 3 4 5 or write number here.....

Question 27 (5 marks)

Models of light have changed over time as new experiments have been conducted.

(a) Outline a property of light successfully explained by Huygens but not by Newton. **2**

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(b) Describe a significant contribution that Maxwell made to the classical theory of electromagnetism. **3**

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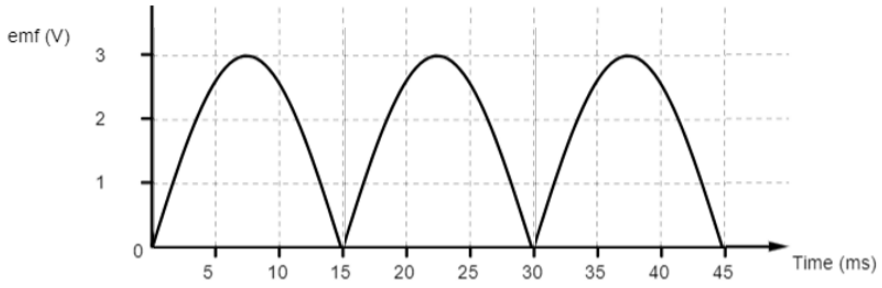
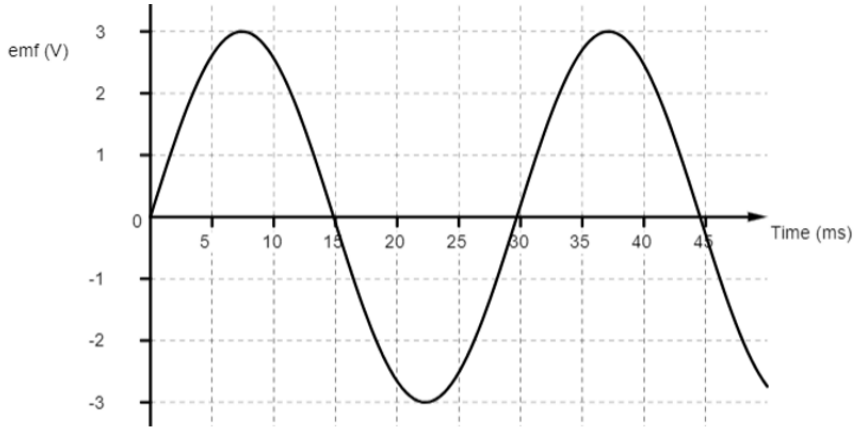
Question 28 (6 marks)

The three graphs below are all produced by AC or DC generators and show the changes in emf generated over time.

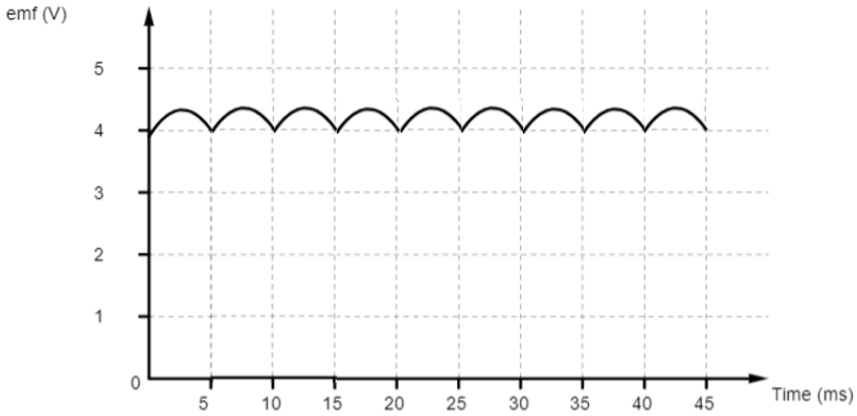
GRAPH 1



GRAPH 2



GRAPH 3



(a) Graph 1 and Graph 3 are produced by the same type of generator. **2**

Justify which structural feature of the generators results in the different shapes of Graph 1 and Graph 3.

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(b) Graph 1 and Graph 2 are produced by generators with different commutators. **4**

Explain how the different commutators result in the shapes of Graph 1 and Graph 2.

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Question 29 (4 marks)

Explain how the atomic model proposed by Bohr was able to overcome the significant limitation of Rutherford's "planetary" atomic model. **4**

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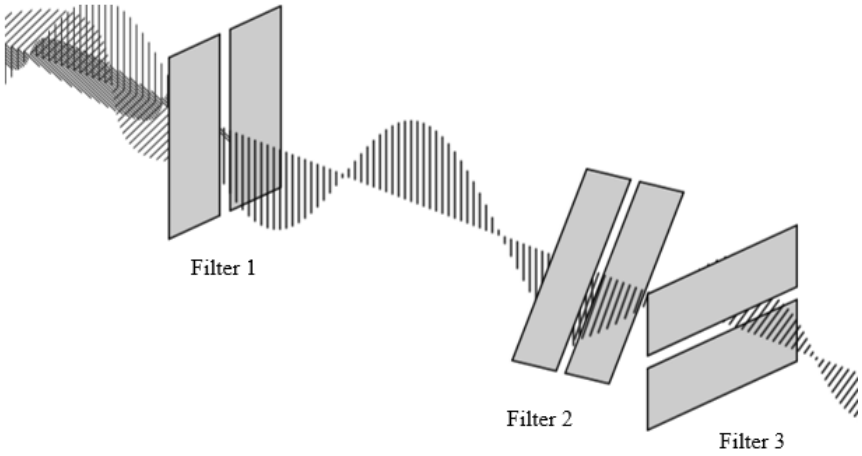
Question 30 (4 marks)

In the experimental set-up below there are three polarising filters. Unpolarised light of intensity 100 units is incident on filter 1.



The plane of polarisation of filter 3 is perpendicular to the plane of polarisation of filter 1. Both filter 1 and 3 are fixed in place. Filter 2 can be rotated.

(a) Identify both positions of filter 2 that will ensure that no light emerges from filter 3. **2**

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(b) Determine the intensity of light transmitted from filter 2 when the plane of polarisation of filter 2 is at an angle of 30° to that of filter 1. **2**

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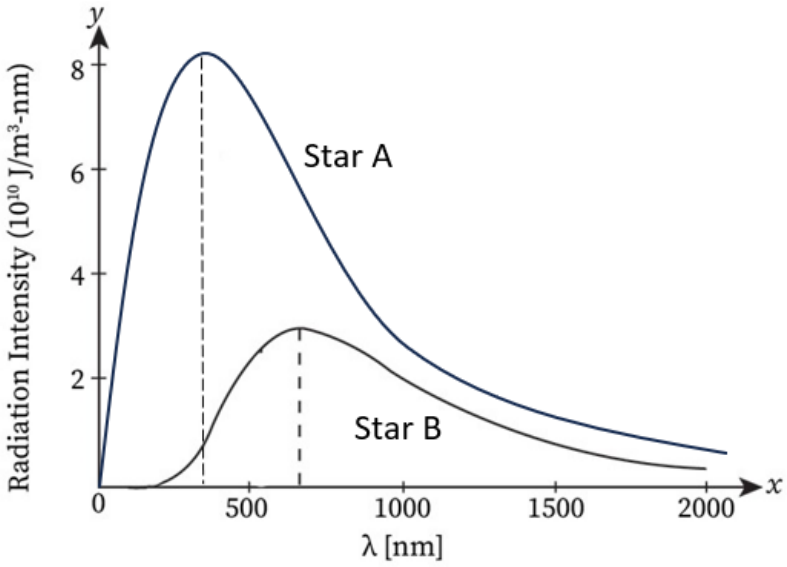
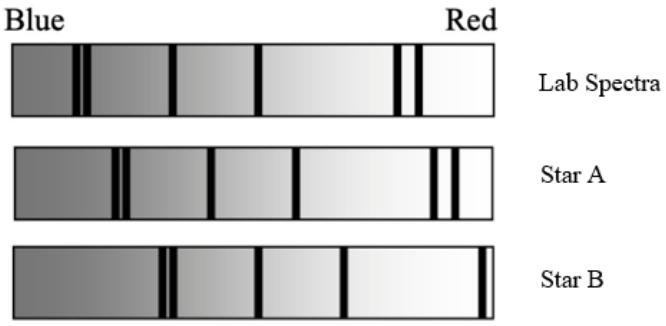
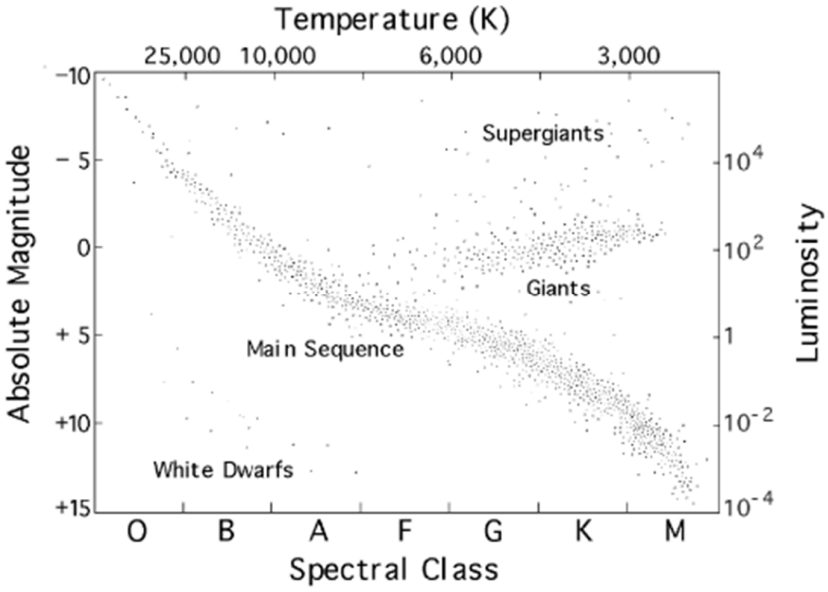
Question 31 (9 marks)

A range of data was collected for Stars A and B by scientists on Earth. All data collected is shown below. **9**







Star A has a luminosity of 1, while Star B has a luminosity of 10^2. The two stars undergo different types of fusion in the core.

Compare the types of fusion occurring in the core of Star A and B and TWO other features of the stars. You must include information from all three stimulus diagrams in your response.

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Qu 31 cont

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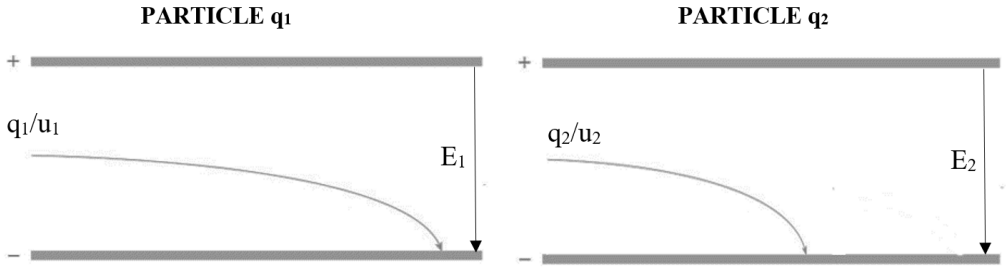
Question 32 (4 marks)

A charged particle, q_1, is projected horizontally into a vertical electric field, E_1, with an initial velocity of u_1. A particle of identical charge and mass, q_2, is projected horizontally into a different electric field, E_2, with an initial velocity of u_2.

The physical setup of the two parallel plates, including their length and distance between the two plates is identical.



It is known that $u_1 > u_2$ and $E_2 > E_1$ and that the particles will hit the bottom plates in both electric fields before leaving the field. **4**

A student predicted that particle q_1 will travel further than particle q_2 before hitting the bottom plate.

Analyse the accuracy of the prediction made by the student.

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END OF BOOKLET 3

Place sticker with student number in this box.

Place a sticker on any writing booklets used.

DO NOT PUT A STICKER ON EVERY PAGE.

2023

Task 4: Trial Examination

HSC Physics
Booklet 4

BOOKLET 4

Section II - PART 3 - 24 marks

- Attempt Questions 33-36
- Allow about 45 minutes for this part

Instructions:
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Extra writing booklets are available upon request. If you use a booklet, clearly indicate which question you are answering and indicate in this paper that a booklet has been used. Use a new booklet for each question.

EXTRA BOOKLETS USED: **(please circle)** YES / NO

IF EXTRA BOOKLETS USED - HOW MANY BOOKLETS USED? (please circle)

1 2 3 4 5 or write number here.....

Question 33 (5 marks)

Hubble's observations provided evidence that the universe is expanding.

(a) Describe the observations that led Hubble to conclude that the universe was expanding. **3**

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(b) Sketch a graph of the data collected during Hubble's observations and outline how it allows the age of the universe to be estimated. **2**

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Question 34 (7 marks)

Explain how the equations: **7**

- $K_{max} = hf - \emptyset$ proposed by Einstein in analysis of the photoelectric effect AND
- $\frac{1}{\lambda} = R(\frac{1}{n_f^2} - \frac{1}{n_i^2})$ used by Bohr for the analysis of emission spectra for hydrogen

are BOTH related to quantised energy and are BOTH consistent with the law of conservation of energy.

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More space on next page

Question 34 cont

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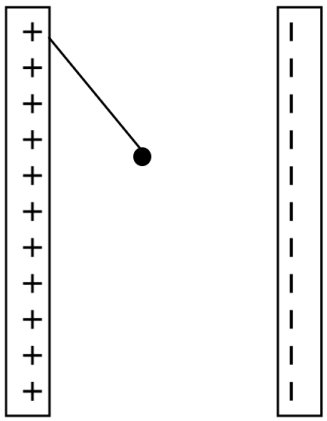
Question 35 (7 marks)

Two oppositely charged parallel plates are arranged vertically 8.5 cm apart with 15 000 V between them.

A ball of mass 2.7 g and carrying a charge of +69 nC is suspended by a massless string from the top of one plate as shown below.



(a) Calculate the magnitude of the tension in the string. **4**

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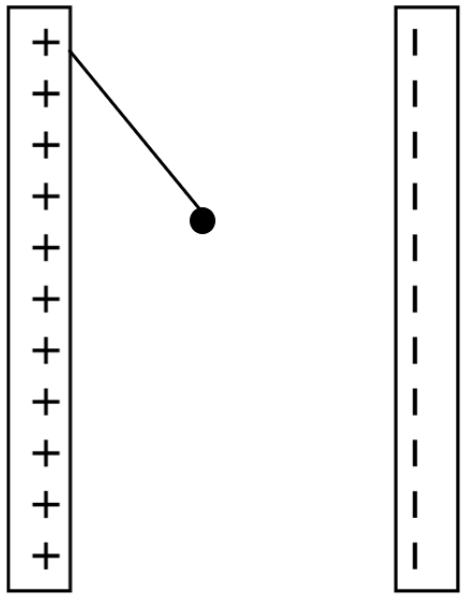
(b) Sketch on the diagram below the path of the ball if the string was to break. **3**

Justify your predicted path. Calculations are not required for this question.



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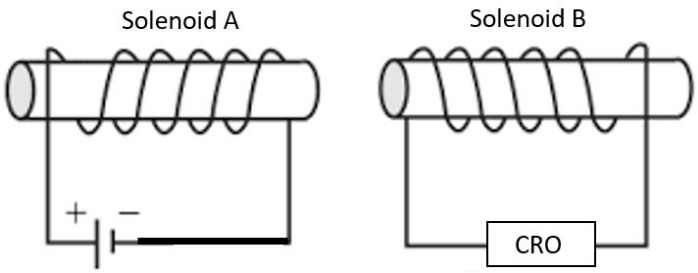
Question 36 (5 marks)

Two solenoids are positioned close to each other as shown in the diagram below. Solenoid A is connected to a power source. Solenoid B is connected to a cathode ray oscilloscope (CRO) that outputs data showing emf generated over a period of time.



An experiment was conducted to investigate how the CRO output from Solenoid B changes when the current in Solenoid A is changed. The table below shows two tests that were conducted with changes to the type of current (AC/DC) and the magnitude of the current in Solenoid A.

	Test 1	**Test 2**
Type of current	Direct current (DC)	Alternating current (AC)
Magnitude of current	1.5 A	3.0 A

Sketch and explain the observed CRO output (emf-time) from Solenoid B for Test 1 and Test 2. *Space for sketches is below.* **5**

More space over page.

Qu 36 continued

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END OF BOOKLET 4

MCQ Answers

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

Booklet 2

Q 21a (Band 2-4)

Criteria	Marks
Torque calculated correctly with correct unit	2
One correct step taken in attempting calculation	1

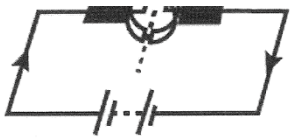
Marker comments

Generally, well done.

Almost all student selected the correct formula and substituted appropriate values.

Minor errors included: forgetting units, mislabelling units as nm instead of Nm and misreading values.

Sample Answer/Answer Points:



$T = nIA_{\perp}B$

(a) If the current flowing in the coil is 0.48 A, calculate the magnitude of the maximum torque produced by the motor. **2**

Eq.

$I = 0.48A$

$B = 4.52T$

$A = 0.13 \times 0.057$

$n = 1$

$T = 1 \times 0.48 \times 4.52 \times (0.13 \times 0.057)$

$T = 0.016076736...$

$\doteq 0.016$ Nm (3dp) ✓

2

Q 21b (Band 2-5)

Criteria	Marks
Torque equation used to correctly justify one change	2
One change identified or correct point made	1

Marker comments

Generally, well done.

Almost all students were able to link a correct variable from the equation to increasing torque.

Better answers identified the variable as having a proportional relationship.

Sample Answer/Answer Points:

(b) Justify one change to the motor that would increase the maximum torque. **2**

$T = nIAB$

- Increasing the strength of the magnetic field, through stronger magnets as $T \propto B$ as B increases (magnetic field) 2

T (Torque) increases directly proportionally.

Q 22a (Band 2-5)

Criteria	Marks
Correct calculation presented	2
At least one correct step in calculation	1

Marker comments

Generally, well done.

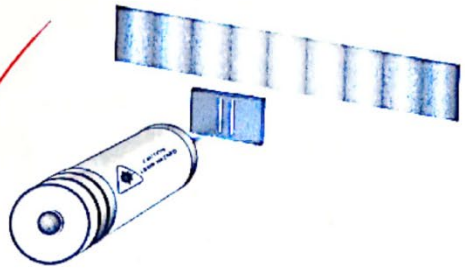
Almost all student selected the correct formula and substituted appropriate values.

Minor errors included: incorrect substitution, errors in converting to scientific notation.

Sample Answer/Answer Points:

Question 22 (4 marks)

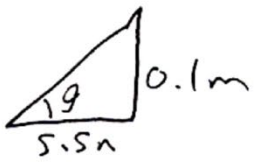
The diagram below shows the pattern formed when a red laser is shone through a double slit where the slits are 3.50×10^{-5} m apart. The screen is 5.50 m away from the double slit.



$d\sin\theta = m\lambda$

$\lambda = \frac{d\sin\theta}{m}$

$\Delta m = 1$



0.1m

A student measures the distance between two adjacent bright bands to be 10.0 cm.

(a) Calculate the wavelength of the laser light. 2

$\lambda = \frac{3.5\sin\theta \times 10^{-5}}{1}$

$\lambda = 3.5 \times 10^{-5} \times \frac{0.1}{5.5}$

$\lambda = 636.363\ldots \times 10^{-9}$ m

$\lambda = 640$ nm (2sf) ✓

$\sin\theta \div \tan\theta = \frac{Y}{L}$ for small angles

$\tan\theta = \frac{0.1}{5.5}$

2

Q 22b (Band 2-4)

Criteria	Marks
Correct identification of a limitation linked to reliability	2
Identification of a limitation in the experiment	1

Marker comments

Generally, well done.

Almost all student were able to link the problem of reliability to the subjective measurement of wide undefined maxima.

Errors included: Linking trials to an experiment where trials were not conducted, Confusing reliability with accuracy by measuring across multiple maxima.

Sample Answer/Answer Points:

(b) Outline a limitation of this experiment that impacts the reliability of the results. 2

A limitation of this experiment that impacts reliability of results is the ~~as~~ double slit diffraction grating and the wide, fuzzy maxima it produces. Due to the relatively large maxima, there is a level of subjectivity in recording ~~result~~ results, which impacts reliability due to the possibility for random error.

2

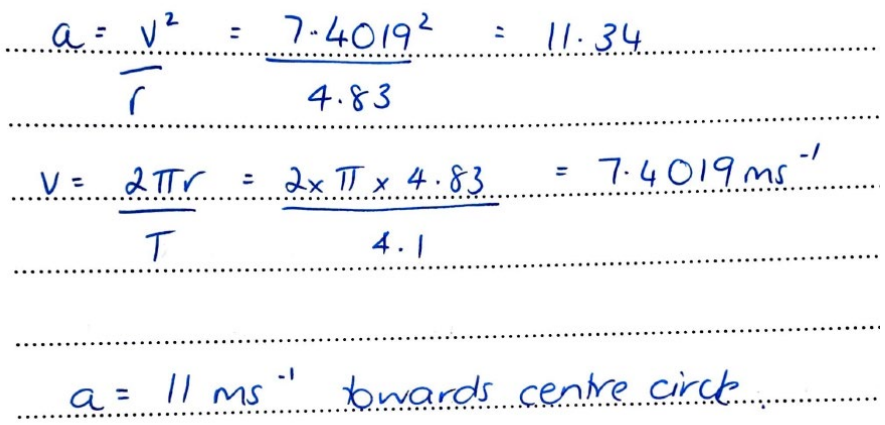
Q 23 (Band 2-5)

Criteria	Marks
Correct calculation of acceleration with correct direction identified	3
Mostly correct calculation of acceleration – missing direction or minor mistake in calculations	2
A correct step in the calculations OR direction identified	1

Marker Feedback:

- Th majority of students managed to find the magnitude of the acceleration.
- Very few students remembered that "acceleration" is a **vector quantity** and needs a direction in its answer.

Sample Answer/Answer Points:



Q 24a (Band 2-6)

Criteria	Marks
Correct justification of AB as faster, using energy/Kepler's 2nd Mathematical justification used (formula/equations)	3
Mostly correct justification of AB as faster with minor errors or missing mathematical links	2
A correct point made	1

What worked well:

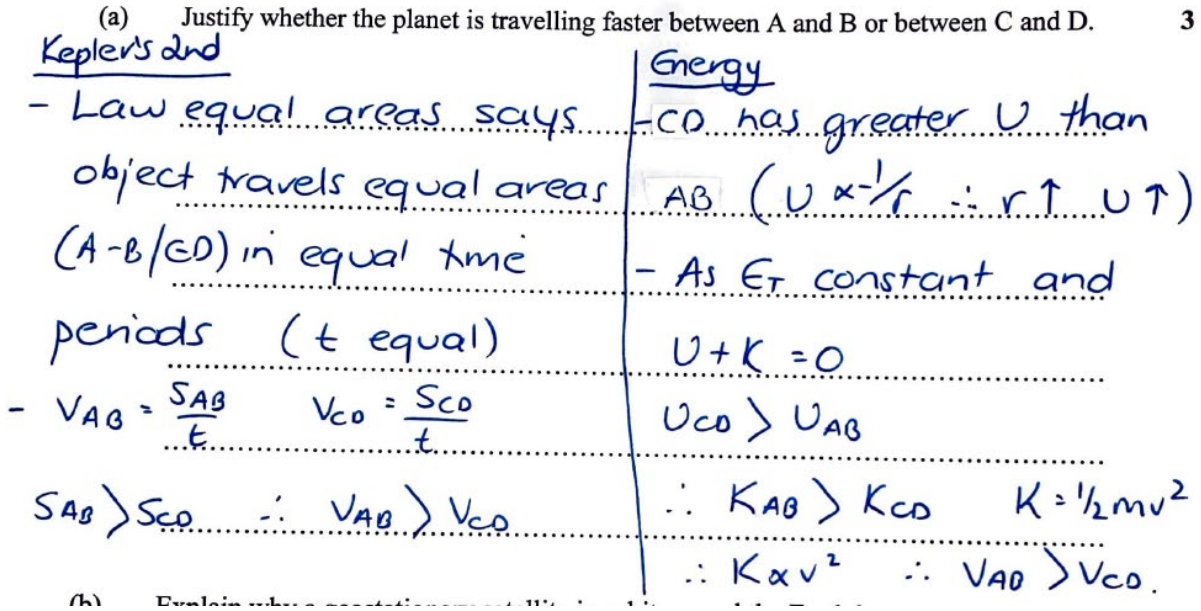
- Students who referenced **Kepler's 2nd law** or the **difference in energy** in the elliptical orbit generally did well in this question.

Even better if:

- Students knew **Kepler's 3 laws**.
- Students knew which of Kepler's laws are applicable to **circular orbital motion** vs **elliptical orbital motion**.
- Students' answers had a link to a **mathematical justification**.
- Students didn't try to justify by starting by using changes in U or K energy then **switching over** to Kepler's Laws or vice versa. It left the justification incomplete.

Sample Answer/Answer Points:

Note: Answer is valid using Kepler's 2nd law OR conservation of energy AND **MUST** use mathematical justification as part of answer. (This is not a student answer below as they were generally too long – this is a summarised teacher answer.)


(a) Justify whether the planet is travelling faster between A and B or between C and D. 3

Kepler's 2nd

- Law equal areas says object travels equal areas (A-B/C-D) in equal time periods (t equal)
- $V_{AB} = \frac{S_{AB}}{t}$ $V_{CD} = \frac{S_{CD}}{t}$

$S_{AB} > S_{CD}$ ∴ $V_{AB} > V_{CD}$

Energy

- CD has greater U than AB ($U \propto -1/r$ ∴ r↑ U↑)
- As E_T constant and $U + K = 0$

$U_{CD} > U_{AB}$

∴ $K_{AB} > K_{CD}$ $K = \frac{1}{2}mv^2$

∴ $K \propto v^2$ ∴ $V_{AB} > V_{CD}$.

(b) Explain why a geostationary satellite in orbit around Earth ...

Q 24b (Band 2-5)

Criteria	Marks
Correct justification of constant energy with reference to gravitational potential and kinetic energy	2
A correct point made	1

What worked well:

- Students who **linked total energy to kinetic and gravitational potential energy** answered this question well.

Even better if:

- Students **did not use** the equations: **U = mgh** and **K = $\frac{1}{2}$ mv²**, to explain gravitational potential and kinetic energy for **satellite motion**.

Sample Answer/Answer Points:

(b) Explain why a geostationary satellite in orbit around the Earth has a constant total energy. **2**

- Altitude doesn't change in geostationary orbit, as $KE = \frac{1}{2}mv^2$, where $v = \sqrt{\frac{GM}{r}}$, $KE = \frac{GMm}{2r}$

whilst $U = -\frac{GMm}{r}$

$E_{Total} = U + K = \frac{GMm}{2r} + \left(-\frac{GMm}{r}\right) = -\frac{GMm}{2r}$

Since r is constant (altitude constant), M_{Earth} constant, and $m_{satellite}$ constant and G constant. E_T is constant.

6

Q 25 (Band 2-6)

Criteria	Marks
Graph used to calculate mass Jupiter correctly with: • Two spread apart points annotated on graph • Slope calculated • Slope linked to Kepler's third law • Full working shown	4
Graph used to calculate mass Jupiter as above with minor errors or ONE omission	3
Substantial attempt to use graph to calculate mass Jupiter with multiple omissions or multiple errors	2
A correct step performed	1

What worked well:

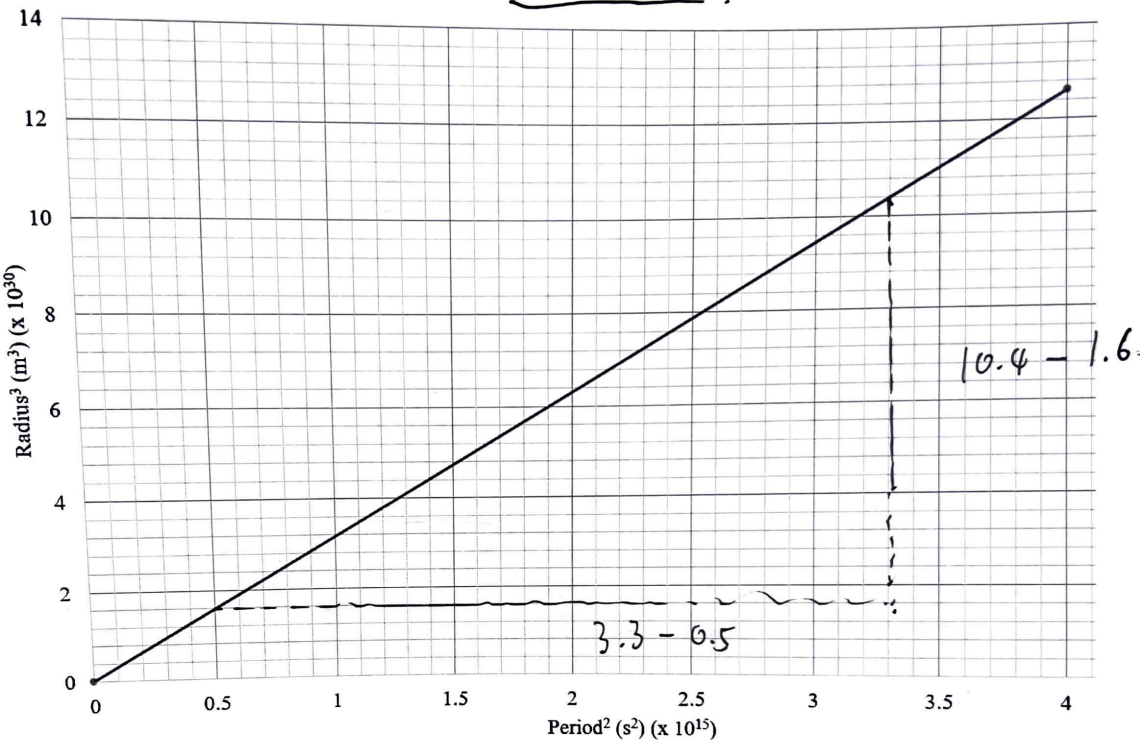
- Most students **annotated** on the graph.
- Most students **linked** the **gradient** to **Kepler's 3rd Law equation**.
- **Students showed full working** (and were not lazy/sloppy) to get to the answer – e.g., substituted the value for "G" into the equation.

Even better if:

- Students chose **two points on the gradient** that were **widespread**.
- Students found the gradient to find the mass and **did not just choose 1 point on the line**.

Sample Answer/Answer Points:

The graph below shows information about the moons of Jupiter.



Use the graph to determine the mass of Jupiter. **4**

According to kepler's third law, $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$.

gradient = $\frac{r^3}{T^2}$. $\Rightarrow$ gradient = $\frac{GM}{4\pi^2}$.

$\Rightarrow M = \frac{4\pi^2 \text{ gradient}}{G}$

gradient = $\frac{(10.4-1.6)\times10^{30}}{(3.3-0.5)\times10^{15}}$ ✓

$= \frac{4(3.14\ldots)^2(3.142\ldots)\times10^{15}}{6.67\times10^{-11}}$ ✓

$= 3.142\ldots \times10^{15}$.

$= 1.86 \times10^{27}$ kg. (3 S.f.). ✓

GOOD?

Q 26 (Band 2-6)

Criteria	Marks
Correct transition identified supported by extensive calculations showing full working out	4
Substantially correct calculations presented with minor errors or some working not shown	3
Some correct steps in the calculation presented with multiple errors	2
A correct step performed	1

What worked well:

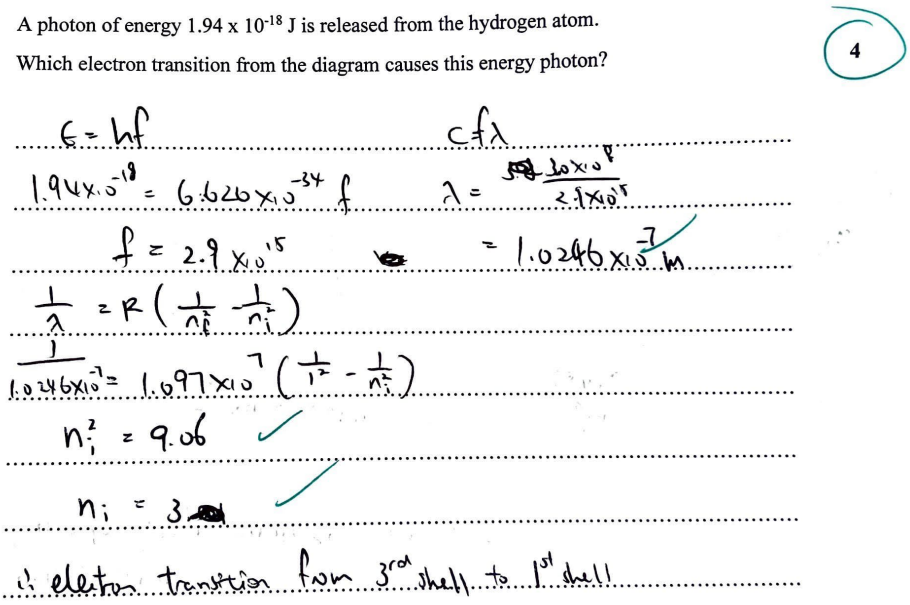
- Students who got full marks set their work out clearly, showing full working – making it easy for the marker to follow the logic from one step in the calculations to the next.

Even better if:

- Students substituted all values constants into the formulae ("R" and "h" where applicable).

Sample Answer/Answer Points:

Method 1:



Method 2: (alternative)

A photon of energy 1.94×10^{-18} J is released from the hydrogen atom.

Which electron transition from the diagram causes this energy photon? **4**

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

$n_f = 1$, $\frac{f}{c} = R\left(1 - \frac{1}{n^2}\right)$

$\lambda = \frac{c}{f}$ $\quad E = hcR\left(1 - \frac{1}{n^2}\right)$

$E = hf$ $\quad \left(1 - \frac{1}{n^2}\right) = \frac{E}{hcR}$ ✓

$\frac{1}{n^2} = 1 - \frac{E}{hcR}$

$n = \frac{1}{\sqrt{1 - \frac{E}{hcR}}}$

$E = 1.94 \times 10^{-18}$ J $\therefore$ $n = \frac{1}{\sqrt{1 - \frac{1.94 \times 10^{-18}}{(6.626 \times 10^{-34})(3 \times 10^{8})(1.097 \times 10^{7})}}}$

$= 3.01...$ ✓

$\therefore$ $n = 3$, so the transition from $n = 3$ to $n = 1$ causes this energy photon.

Booklet 3

Q 27a (Band 2-5)

Criteria	Marks
Relevant property correctly identified and outlined with detail	2
Relevant property identified OR model key feature identified	1

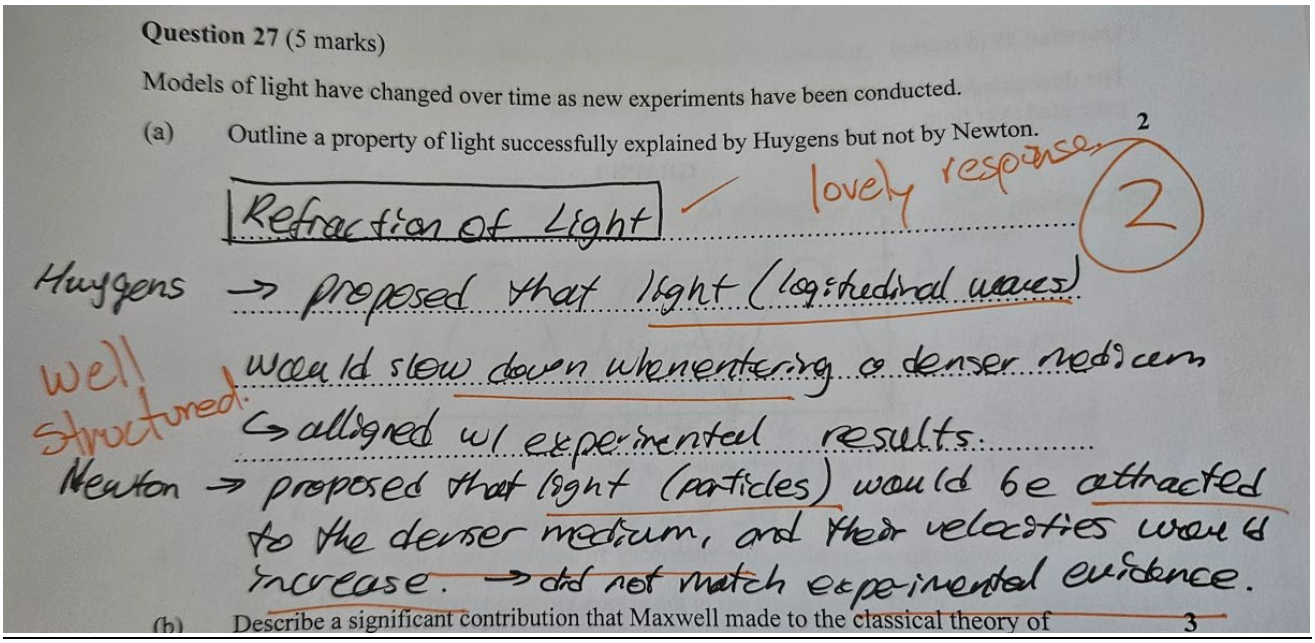
What **W**orked **W**ell (WWW):

- A well attempted question, whereby the correct property was identified.

Even **B**etter **I**f (EBI):

- Write specific and relevant content that pertains to the question.
- Structure your response in dot points. This assists you in the writing and also helps the reader when marking.
- They key verb is 'outline.' Don't merely identify the property.
- Link your property to the fact that the 'wave' model was Huygen's and the 'particle' model was Newton's.

Sample Answer 1:



Question 27 (5 marks)

Models of light have changed over time as new experiments have been conducted.

(a) Outline a property of light successfully explained by Huygens but not by Newton. 2

Refraction of Light ✓ lovely response 2

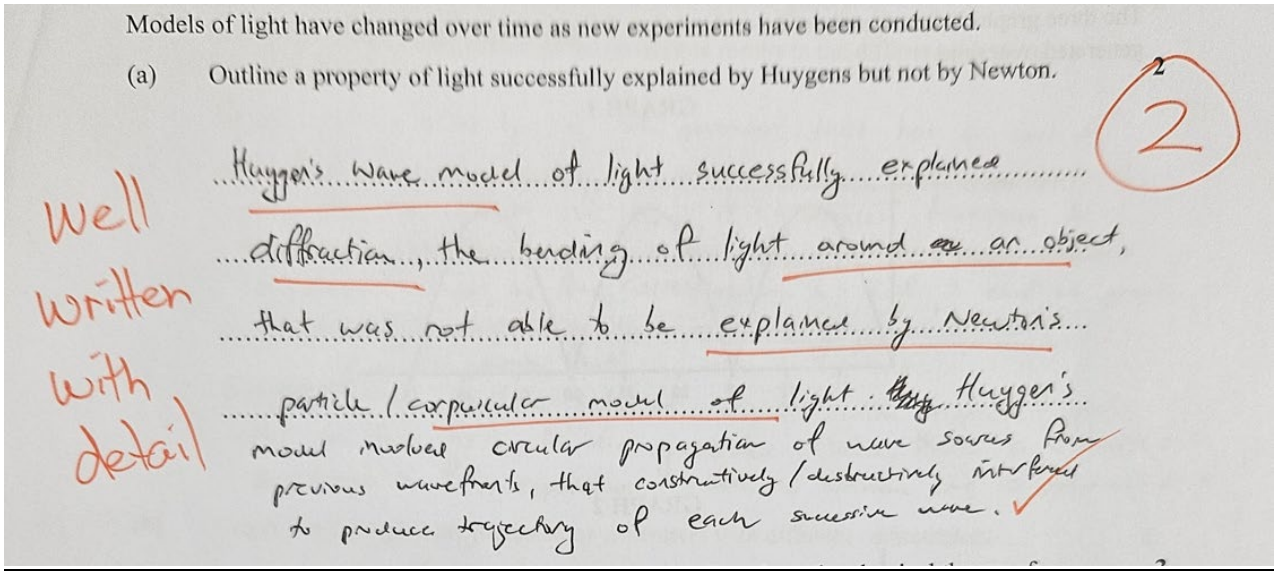
Huygens → proposed that light (longitudinal waves) would slow down when entering a denser medium ↳ aligned w/ experimental results.

well structured.

Newton → proposed that light (particles) would be attracted to the denser medium, and their velocities would increase. → did not match experimental evidence.

(b) Describe a significant contribution that Maxwell made to the classical theory of 3

Sample Answer 2:



Models of light have changed over time as new experiments have been conducted.

(a) Outline a property of light successfully explained by Huygens but not by Newton. 2

Huygen's wave model of light successfully explained diffraction, the bending of light around an object, that was not able to be explained by Newton's particle / corpuscular model of light. Huygen's model involved circular propagation of wave sources from previous wavefronts, that constructively / destructively interfered to produce trajectory of each successive wave.

2

Well written with detail

Q 27b (Band 2-6)

Criteria	Marks
Significant contribution described with detail and clearly linked to Electromagnetic theory.	3
Relevant contribution described with some detail on Electromagnetic theory.	2
Some relevant information.	1

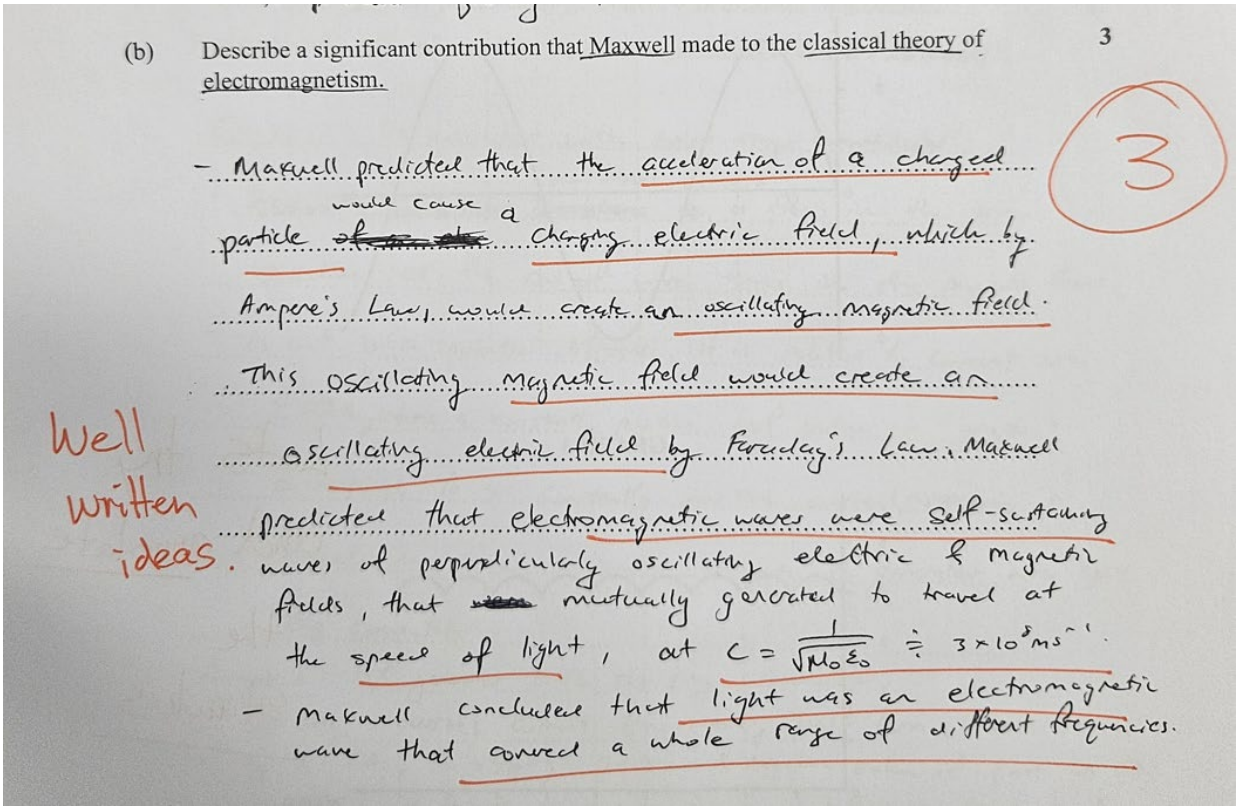
What **W**orked **W**ell (WWW):

- A well attempted question showing a good understanding of the classical theory of electromagnetism based on maxwell's equations.

Even **B**etter **I**f (EBI):

- When writing facts/ideas/concepts – they must ultimately LINK back and answer the question given. Don't just write a 'knowledge dump' and expect to be rewarded for memorising information. Responses must be written that address the given question.
- The contribution must be clearly written and well linked to the classical theory of electromagnetism – don't treat the ideas independently and separately - try and interrelate them.
- Structure your response in dot points. This assists you in the writing and also helps the reader when marking.
- If drawing a diagram or sketch (i.e a Electromagnetic wave), label the main aspects of your drawn diagram.

Sample Answer 1:



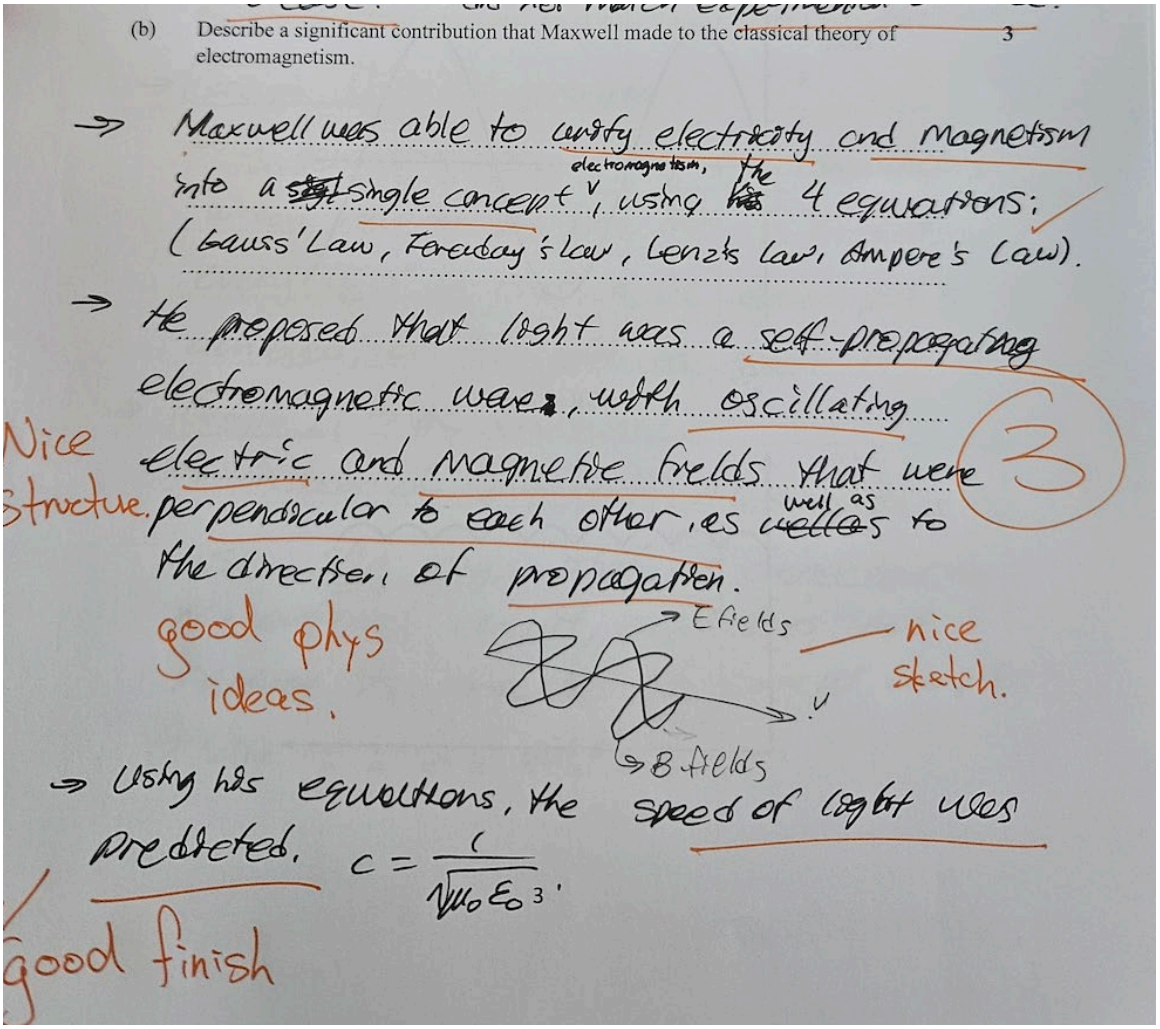
(b) Describe a significant contribution that Maxwell made to the classical theory of electromagnetism. 3

- Maxwell predicted that the acceleration of a charged particle would cause a changing electric field, which by Ampere's Law, would create an oscillating magnetic field. This oscillating magnetic field would create an oscillating electric field by Faraday's Law. Maxwell predicted that electromagnetic waves were self-sustaining waves of perpendicularly oscillating electric & magnetic fields, that mutually generated to travel at the speed of light, at $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \approx 3 \times 10^8 ms^{-1}$.
- Maxwell concluded that light was an electromagnetic wave that covered a whole range of different frequencies.

3

Well written ideas.

Sample Answer 2:



(b) Describe a significant contribution that Maxwell made to the classical theory of electromagnetism. 3

→ Maxwell was able to unify electricity and magnetism into a single concept (electromagnetism), using the 4 equations: (Gauss' Law, Faraday's law, Lenz's law, Ampere's Law).

→ He proposed that light was a self-propagating electromagnetic wave, with oscillating electric and magnetic fields that were perpendicular to each other, as well as to the direction of propagation.

Nice structure.

good phys ideas.

nice sketch.

⇒ Using his equations, the speed of light was predicted. $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$.

3

good finish

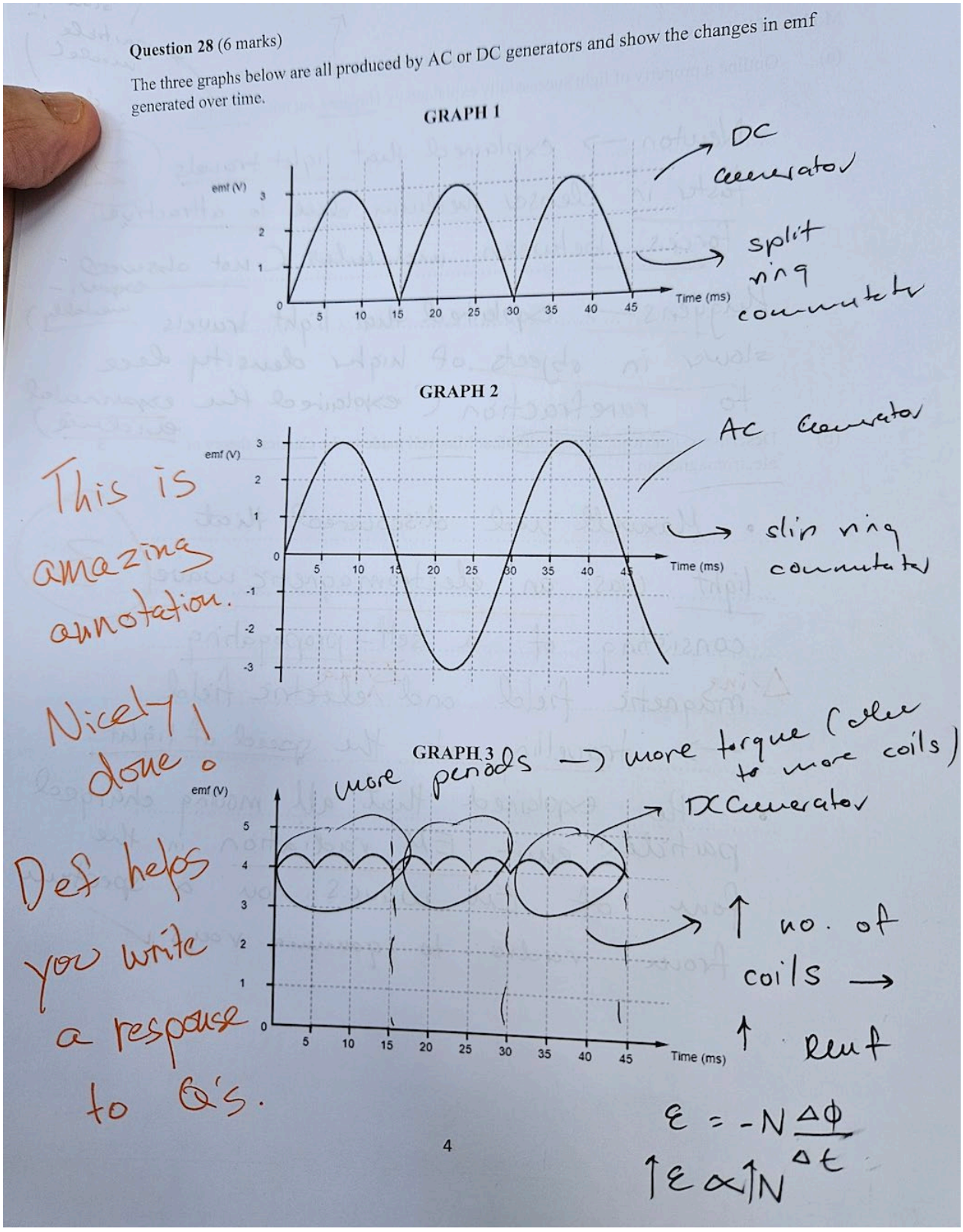
Q 28a (Band 2-5)

Criteria	Marks
Correct structural feature described (that reflects the shape of the graph) and reason is clearly shown (i.e linked to emf output).	2
Correct structural feature identified (that reflects the shape of the graph).	1

Even **B**etter **I**f (EBI):

- There is a one whole page of stimulus provided for this question. It is remarkable that **only 6%** of the physics cohort annotated the given stimulus. Ensure you annotate/label the stimulus. It helps you understand the given question and also helps you to write a response.
- **R**ead **T**he **Q**uestion (RTQ) – it mentions 'structural'; so address this aspect.
- A 'radial magnet' will NOT reflect the shape of graph 3.
- If drawing a diagram or sketch (i.e a simple motor), label the main aspects of your drawn diagram that relate to the question.
- Use specific physics terminology and language, ensure you can correctly name and identify the parts of a simple motor. E.g stating that graph 3 has more 'wires' is incorrect syntax. This implies that it has more 'turns' on the coil. It is clearer and more specific to state 'Multiple or 3 rotor coils in the armature.'
- Clearly link your ideas and relate them to Graph 1 and graph 3 – don't presume that the reader (marker) will make this link on your behalf.
- Structure your response in dot points. This assists you in the writing and also helps the reader when marking.

Sample of good, annotated stimulus:



Question 28 (6 marks)

The three graphs below are all produced by AC or DC generators and show the changes in emf generated over time.

GRAPH 1

GRAPH 2

This is amazing annotation.

Nicely done.

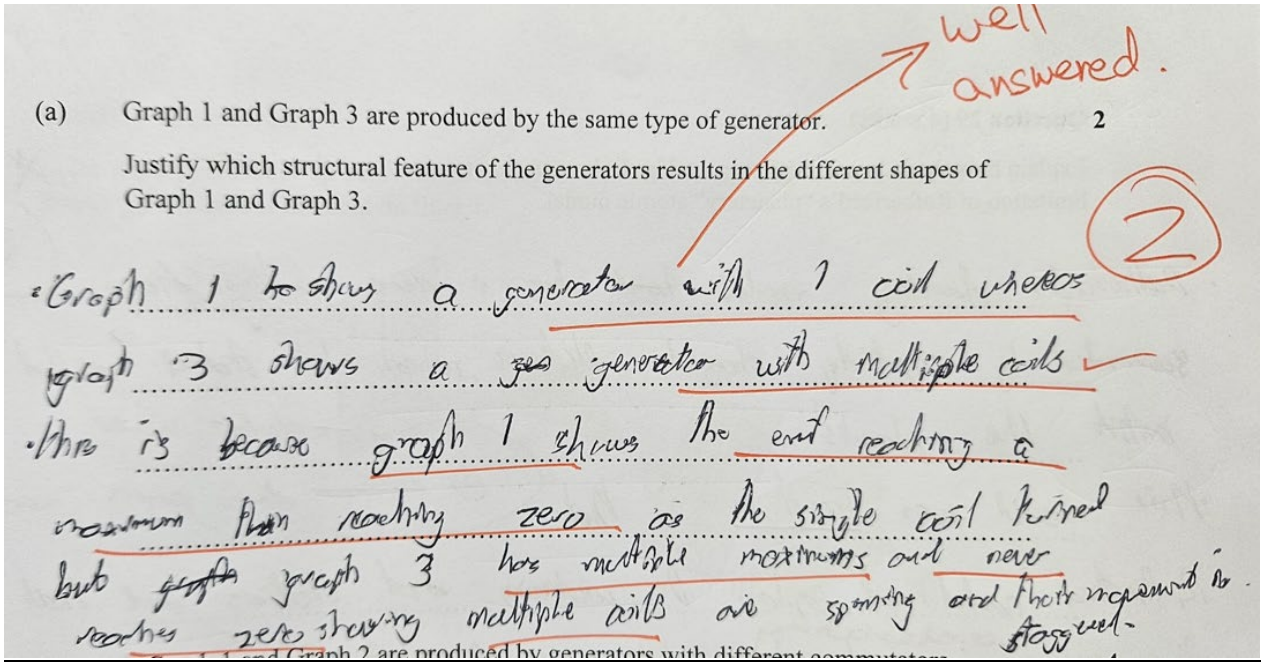
Def helps you write a response to Q's.

GRAPH 3

$\varepsilon = -N\frac{\Delta\phi}{\Delta t}$

$\uparrow \varepsilon \propto \uparrow N$

Sample 1:



(a) Graph 1 and Graph 3 are produced by the same type of generator. 2

Justify which structural feature of the generators results in the different shapes of Graph 1 and Graph 3.

well answered.

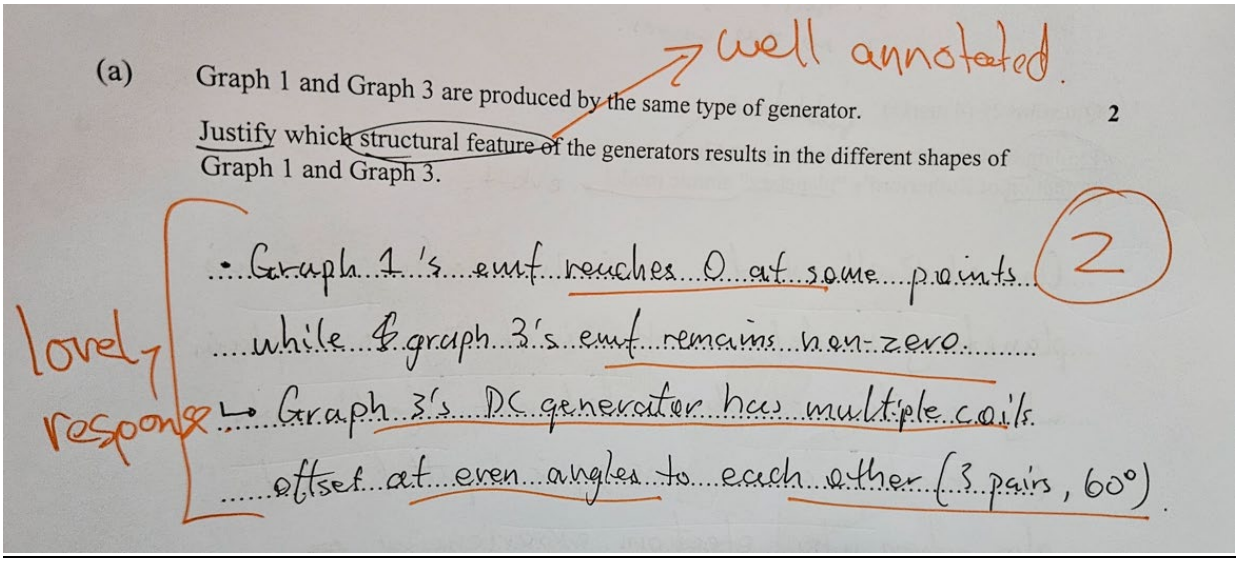
2

• Graph 1 shows a generator with 1 coil whereas graph 3 shows a generator with multiple coils

• This is because graph 1 shows the emf reaching a maximum then reaching zero as the single coil turned but graph 3 has multiple maximums and never reaches zero showing multiple coils are spaced and their movement is staggered.

Graph 2 are produced by generators with different commutators

Sample 2:



(a) Graph 1 and Graph 3 are produced by the same type of generator. 2

Justify which structural feature of the generators results in the different shapes of Graph 1 and Graph 3.

well annotated.

2

level response

- Graph 1's emf reaches 0 at some points while graph 3's emf remains non-zero.
- Graph 3's DC generator has multiple coils offset at even angles to each other (3 pairs, 60°).

Q 28b (Band 4-6)

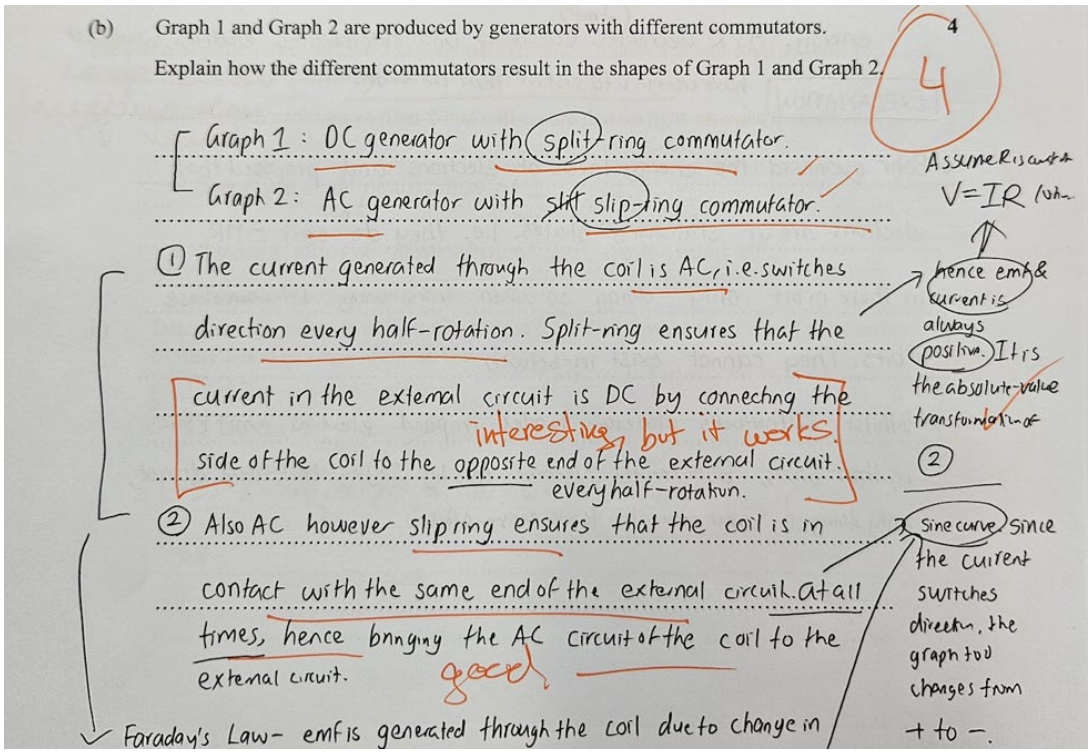
Criteria	Marks
Extensive explanation of commutator structure and function; clearly linked to emf output on graph.	4
Thorough explanation of commutator structure and function (with minor error or omission); linked to emf output on graph.	3
Sound explanation of commutator structure or function with some link to emf output.	2
A relevant point made	1

What **W**orked **W**ell (WWW):

- A well attempted question and pleasing to see that most responses show good structure.
- Many responses correctly identified that Graph 1 = DC with a split ring and Graph 2 = AC slip ring.

Even **B**etter **I**f (EBI):

- To attain full 4 marks, both the structure and function of the commutator was required to account for the shape of the graphs. Therefore, elaborate on written ideas and increase the depth and detail of your response. This does not mean that you re-write the same ideas in different ways – it does not score any 'extra' marks.
- There is a one whole page of stimulus provided for this question. It is remarkable that **only 6%** of the physics cohort annotated the given stimulus. Ensure you annotate/label the stimulus. It helps you understand the given question and also helps you to write a response.
- If drawing a diagram or sketch (DC split ring vs AC slip ring), label the main aspects of your drawn diagram that relate to the question.
- Use specific physics terminology and language, ensure you can correctly name and identify the commutators. There is NO slit ring or two rings!
- Sample Answer:



Q 29 (Band 2-6)

Criteria	Marks
EMR/KE limitation of Rutherford model extensively explained Relevant part of Bohr's model described Extensive explanation of how Bohr model addresses Rutherford limitation	4
EMR limitation of Rutherford model explained Sound-thorough explanation of how Bohr model addresses Rutherford limitation	3
Limitation of Rutherford model described Identification of relevant part of Bohr's model (stationary states)	2
A relevant point made about either the Bohr or Rutherford model	1

Marker feedback:

- The majority of students correctly identified the non-emission of electromagnetic radiation and subsequent spiral into the nucleus as the most significant limitation
- The majority of students were able to identify Bohr's stationary/stable states as addressing the above limitation

Issues:

- While identification was correct, explanations were not clear / complete / present.
    - To fully explain the EM radiation emission you had to make reference to UCM, centripetal acceleration and accelerating charged particles producing EM radiation.
    - To fully explain the Bohr model component you had to make clear that while in the stationary states, the electrons were not accelerating and why (note Bohr DID use UCM as the mechanims for electron orbits) OR had constant energy. Too many students simply stated there were stationary states and thus the limitation was addressed. You needed to explain WHY.
- A lot of students had trouble narrowing down what was required in this question. Things that were common, but not required included:
    - The Geiger-Marsden experiment – not relevant to the question
    - Any detail about the Rutherford nucleus composition, mass problem – nothing with the nucleus has anything to do with the Bohr model so was NOT relevant to this question.
    - Bohr model information about electrons moving between energy levels, emission spectra, the Rydberg equation – none of that is relevant to the idea of stationary states.
- Mixing up models – there was a bit of confusion about where matter waves (de Broglie) fits in. Bohr did not propose matter waves nor had any explnaation for his "stationary states".

Good bits:

- Great use of diagrams, headings and dot points – almost all students had excellent and clear presentation of information
- The majority of students had a lot of detail in their responses, with much more effort to include the physics involved not just statements.

Sample Answer:

Question 29 (4 marks)

Explain how the atomic model proposed by Bohr was able to overcome the significant limitation of Rutherford's "planetary" atomic model.

4

According to Rutherford's "planetary" atomic model, he states that electron orbits around the nucleus in a circular motion. As such, there must be a_c → moving charged electron → emit EMR (but can't be detected). Also, if EMR is emitted, e^- should lose energy and spiral towards the nucleus. e (O) → e^- (O)

Therefore, this is a limitation. Later, Bohr uses his model to overcome that. He states that electron is in stationary state and sitting in electron shell with constant energy (i.e. no energy loss). Therefore, if e^- don't lose energy, it won't emit EMR and then lose energy, causing e^- to spiral into the nucleus.

great response!

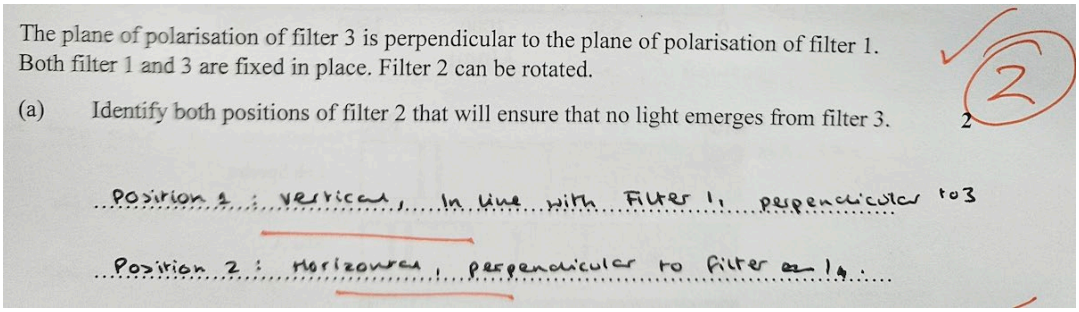
Q 30a (Band 2-5)

Criteria	Marks
Both positions (of different angle) correctly identified.	2
One position correctly identified	1

Even **B**etter **I**f (EBI):

- **R**ead **T**he **Q**uestion (RTQ) – it mentions 'both positions'; so address this aspect.
- Having filter 2 at 0° and 180° or, 90° and 270° is technically the same position. When finished a response, read over the given question and your response and check that you have fully answered the question.

Sample 1:


The plane of polarisation of filter 3 is perpendicular to the plane of polarisation of filter 1.
Both filter 1 and 3 are fixed in place. Filter 2 can be rotated.

(a) Identify both positions of filter 2 that will ensure that no light emerges from filter 3. 2

Position 1 : vertical, in line with Filter 1, perpendicular to 3

Position 2 : Horizontal, perpendicular to filter no 1.

2

Q 30b (Band 2-5)

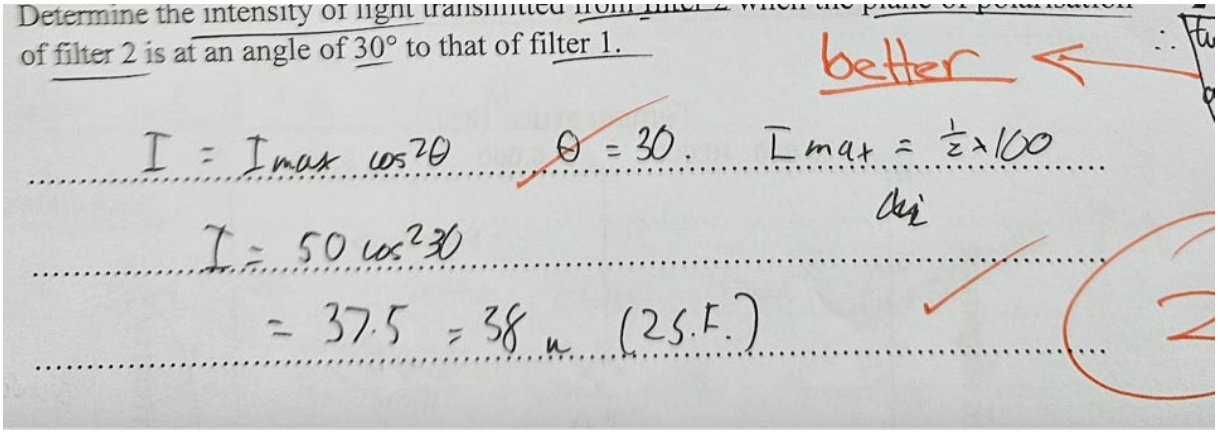
Criteria	Marks
Correct calculation performed and working shown.	2
A correct step in the calculation shown.	1

What **W**orked **W**ell (WWW): A well attempted question showing working.

Even **B**etter **I**f (EBI):

- **R**ead **T**he **Q**uestion (RTQ) and annotate the stimulus to assist you unpacking the question – some students omitted the fact that light after filter 1 is halved. i.e 50 units.
- Show Full and relevant working – don't take short cuts.

Sample :



Q 31 (Band 2-6)

Criteria	Marks
• All three stimulus used including calculations of temperature from BB graph • Correct identification of star type using HR diagram • Extensive comparison of fusion types presented • Extensive comparison of two other features • Concise and relevant information presented (no extra information)	9
• All three stimulus used with substantial levels of detail • Identification of star type using HR diagram with justification • Three features included, TWO at extensive level, ONE at thorough level	8
• All stimulus used with good levels of detail • Identification of star type using HR diagram justified (may be incorrect if temp not calculated – luminosity must match) • Thorough comparison of fusion types presented – errors/omissions • Thorough comparison of two other features – minor errors/omissions	7
• At least TWO stimulus used • Identification of star type using HR diagram justified (may be incorrect if temp not calculated – luminosity must match) • THREE features included at minimum sound level – TWO at thorough level	6
• At least TWO stimulus used • Identification of star type attempted with some justification • Sound comparison of THREE features – errors/omissions	5
• At least TWO stimulus used • Identification of star type attempted • Sound comparison of TWO features – errors/omissions	4
• At least TWO stimulus used • Identification of star type attempted • Sound comparison of ONE feature – errors/omissions	3
1-2 relevant points made	1-2

Marker comments:

You will notice annotations with So (sound), Th (Thorough) and Ext (Extensive) next to your features (if they were easy to find) – they should help you find why you got the mark you did (see MG above for more detail).

STRUCTURE:

- Very clear from a lot of students, great use of headings for the features and similarities/differences.
- Reminder that a list of Star A features and a list of Star B features is NOT a comparison.
- Mixing up all features together often made it hard to find three features and decide on sound/thorough/extensive.

USE OF STIMULUS:

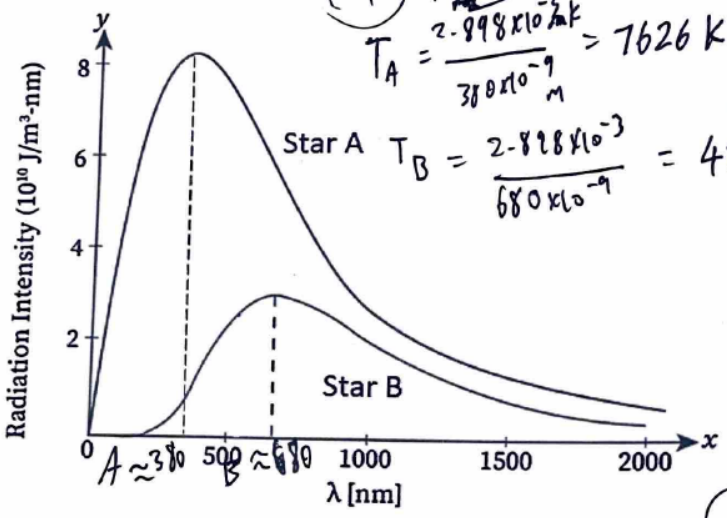
- All students used all three stimulus (provided question was attempted with a reasonable level of effort).
- HOWEVER – the first stimulus had numbers on it – it was disappointing that a significant number of students told me HOW to find the temperature using that graph – then just didn't do it.
- Finding temperature would have been useful as the luminosity alone did not define the type of star – which was then important for the type of fusion. Plotting the temperature against the luminosity

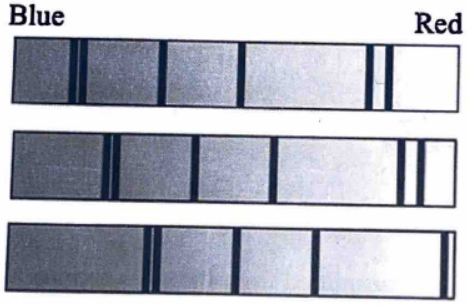
would have identified Star B as a Red Giant (please include the Red, there are also Blue and White Giants) NOT a main sequence star. A was main sequence for most people, but in the wrong part of the main sequence belt – thus affecting the type of fusion and other characteristics like colour.

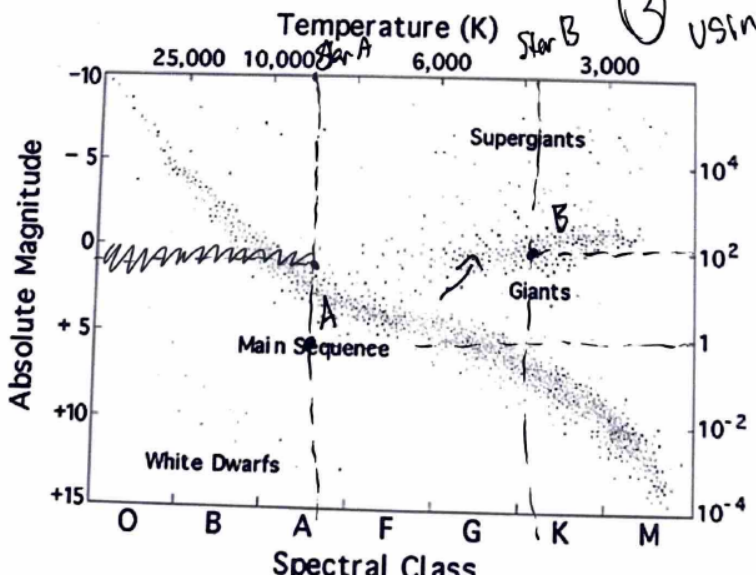
- Lack of annotations was disappointing. An example of good annotations is shown below. Probably would have achieved 4-5 marks even without any writing.

Question 31 (9 marks)

A range of data was collected for Stars A and B by scientists on Earth. All data collected is shown below.







CONTENT MISCONCEPTIONS:

This content is ALWAYS on the exam in one form or another – it has been MCQ, written qu and extended answer over the last 20 years.

There are a few misconceptions you all urgently need to deal with:

- Identification of stars – poorly done across the board – majority of students did not use Stimulus 1 and 3 together to correctly plot and thus identify the stars correctly (there was ECF given for this – if your identification was wrong it was still technically possible to get 8 – as some people did).
- FUSION:
    - Red giants do NOT fuse hydrogen to helium – they undergo post main sequence fusion (only four boys could identify this, only two boys could describe it to any extent). This involves fusing of progressively higher mass elements as the core becomes more hot and dense as each fuel runs out in turn.
    - Very few students could explain/identify why higher mass main sequence stars undergo CNO fusion but smaller mass stars undergo p-p fusion. This needs to be related to heat in core required to fuse small vs larger elements.
    - CNO fusion does not result in the formation of carbon, nitrogen and oxygen in larger stars. CNO fusion is hydrogen to helium fusion ONLY.
    - Writing out the equations for p-p and CNO fusion does not show understanding. Analysis and explanation and description is required, not just a regurgitation of equations that shows your memory skills.
- What Graph 1 tells you:
    - It does not tell you CORE temperature. Thus you cannot link type of fusion to radiation intensity. The Wien's law graph only gives you the surface temperature.
    - Rate of fusion. Radiation intensity is not necessarily linked to rate of fusion (tip – not great comparing rate of fusion in two different types of stars that are undergoing much different processes). Rate of fusion is best compared with two main sequence stars.
    - It does not give you information about size, or even directly colour. The colour comes from the spread of the wavelengths NOT the peak wavelength alone.

Other bits worth noting:

- Extensive and thorough require more than just a statement or brief 1-2 line description – you need detail, equations, correct and specific terminology.

FEATURES THAT COULD HAVE BEEN COMPARED:

- Translational velocity – from the amount of red shift seen in stimulus 2
- Density atmosphere – from the width of the bands seen in stimulus 2
- Chemical composition – from the pattern of the bands seen in stimulus 2
- Rotational velocity – from the width of the bands seen in stimulus 2
- Surface temperature – from stimulus 1 – calculations required for a decent mark on this point – should also have been linked to colour.

Sample Answer:

Star A has a luminosity of 1, while Star B has a luminosity of 10^2. The two stars undergo different types of fusion in the core.

Compare the types of fusion occurring in the core of Star A and B and TWO other features of the stars. You must include information from all three stimulus diagrams in your response.

Temperature & and Stellar Classification

- Stars are black bodies, hence their emitted EM radiation is dependant only on temperature
  - ↳ Apply wiens law, $\lambda_{max} = \frac{b}{T}$ $\therefore T = \frac{b}{\lambda_{max}}$
- For Star A, $\lambda_{max} = 350 \times 10^{-9}$ m For Star B, $\lambda_{max} = 662.5 \times 10^{-9}$ m
- $\therefore T_A = \frac{2.898 \times 10^{-3}}{350 \times 10^{-9}} = 8280°K$ $T_B = \frac{2.898 \times 10^{-3}}{662.5 \times 10^{-9}} = 4374°K$
- $\therefore$ the temperature of the two stars can be determined ~~from~~ using wiens law, by matching the most prominent wavelength
- However, this also allows us to determine the stars position on the Hertzsprung Russel Diagram as now Temp in Kelvin and luminosity are known.
  - ↳ Here we can determine that star A is is a higher F class stellar object, in the middle range of the main sequence Band
  - ↳ Star B is a red giant at its much cooler temperature with a stellar classification of K, thus is likely a much older star that was initially on the main sequence, but has cooled as its outer gas layers expand. It will presumably age to become a White Dwarf in later life.

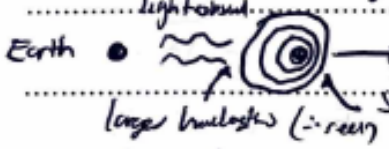
Ext

More space over page

Qu 31 continued

Translational Velocity

- Translational velocity can be determined through an examination of absorption spectra, by observing red shifts as seen by the data the scientist collected
- This apparent 'shifting' of wavelengths is a result of the doppler effect.



↳ The degree of this wavelength compared to the lab spectra can be utilised as an indication of recessional speed

↳ Hence star B has a greater recessional speed than star A, as its elemental absorption lines are shifted to higher wavelengths.

↳ Additionally, this can be used as an indication of distance, as Hubble states $\frac{V}{D} = H_0$, $\therefore D = \frac{V}{H_0}$, although this will not always be a guarantee, but could serve as a sufficient estimate or observation to rely upon in the data.

Ext

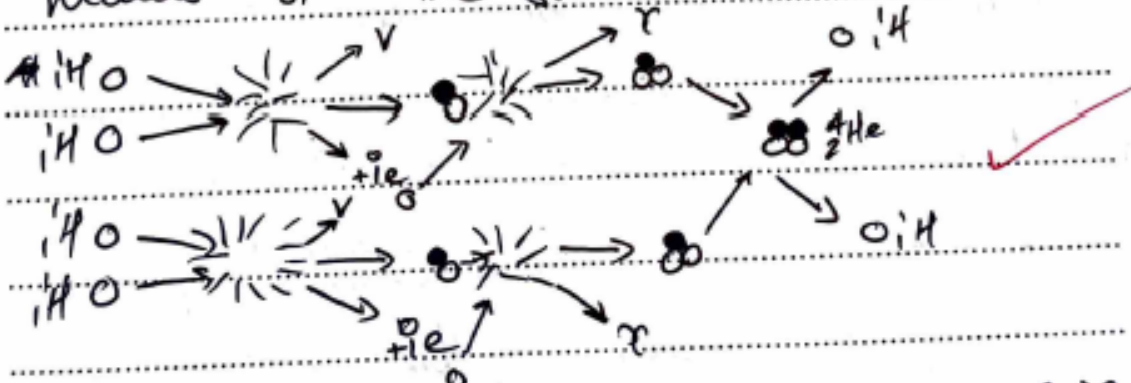
Star A has a luminosity of 1, while Star B has a luminosity of 10^2. The two stars [illegible] types of fusion in the core.

Compare the types of fusion occurring in the core of Star A and B and TWO other features of the stars. You must include information from all three stimulus diagrams in your response.

Difference

Star A → Fusion Process : Proton-Proton Chain

- Star A is a mid solar mass star that is apart of the main sequence group of stars, according to the Hertzsprung-Russel diagram (view annotations).
- This means the star undergoes proton-proton chain reactions by fusing hydrogen to form helium, occuring in the cheese nucleus of the star.



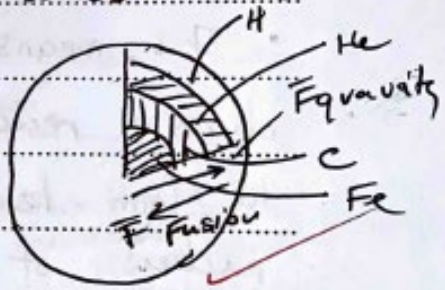
Net eqn: $4\,^1_1H \rightarrow {}^4_2He + 2\,^0_{+1}e + 2\nu + 2\chi$

Qu 31 continued

Difference

Star B → Fusion Process: Post main sequence fusion

- Star B is a real giant star, with a much bigger solar mass compared to Star A.
- Hence, the star undergoes post main sequence fusion as it is fusing together heavier elements (until iron) to form larger and much more dense nuclei, fusion occurs when $\bar{F}$ fusion and $\bar{F}$ gravity are at equilibrium → allow for layers of each element to form over time



Q 32 (Band 2-6)

Criteria	Marks
Correct mathematical justification of BOTH range components: • time compared correctly • range equation used to show prediction was accurate Statement made regarding the prediction	4
Substantially correct mathematical justification of BOTH range components with some reference to range equation	3
Some correct mathematical justification of time with a link to range	2
A correct point made	

Marker Comments:

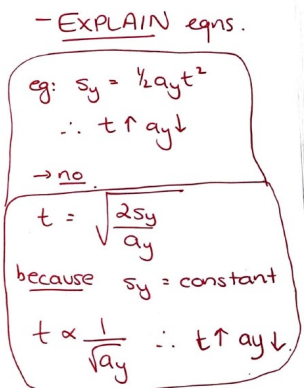
Generally a pretty well done question, most students recognised projetile motion and made substantial attempts to address the components of the range equation.

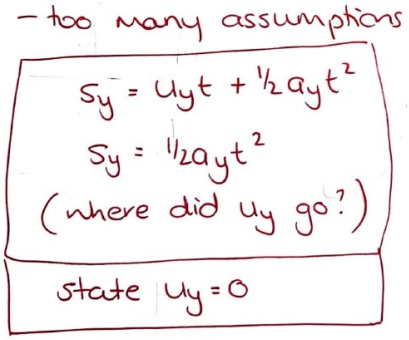
A few issues to address:

- Work is NOT being done in this situation – energy changes are not a valid method as the particle is moving in two dimensions.
- Minimal/no use of mathematical equations. This is the Trial, next up is final HSC exams. You cannot make statements like "increased force on the particle means a lower time of flight" – back this up with mathematical justification (link and rearrange equations to show relationships).

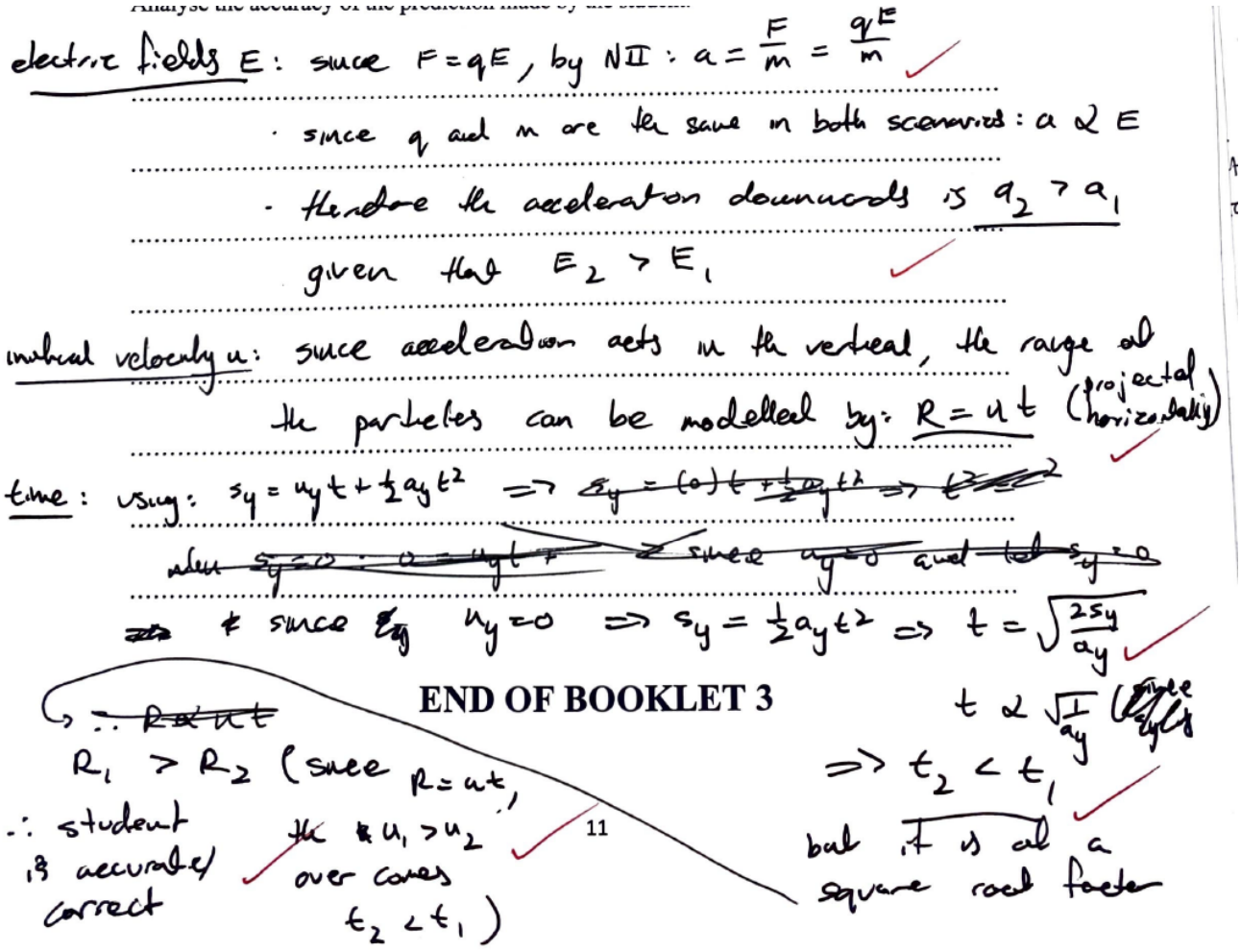
HOWEVER a number of issues with mathematical justification (taking shortcuts, not showing all working, selection of incorrect equations) resulted in a lot of 3 marks awarded that should easily be full marks.

- Too many assumptions are being made – you can't just remove something from an equation because it is zero – you have to make that statement.
- You need to rearrange equations to show proportionality. Too many students are just writing an equation then stating that two factors in that equation have a relationship. You need to identify that other factors are zero/constant and SHOW the proportionality by making one of the factors the subject of the equation.
- You can't remove something from an equation because it is constant then just keep it as an equation – if you are removing constant factors it becomes a proportionality statement NOT an equation with an equals sign.
- And your maths has to be correct. You can't ignore a sqare/square root or other maths factor.





Sample Answer/Answer Points:



Booklet 4

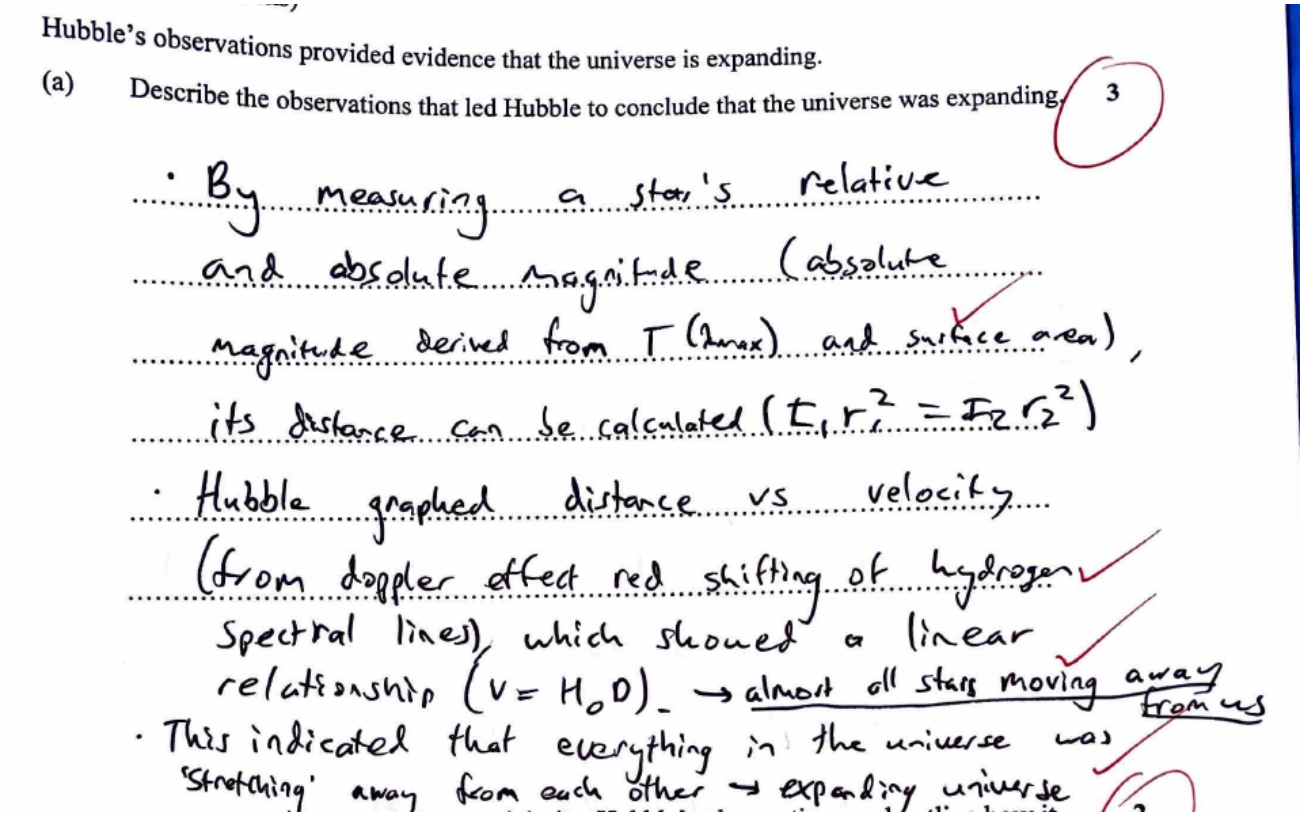
Q 33a (Band 2-5)

Criteria	Marks
Thorough description of observations relating to red-shift and speed/distance of galaxies/stars	3
Sound description of observations relating to red-shift	2
A correct point made	1

Markers comments:

- A lot of non-knowledge demonstrated here:
  - Background microwave radiation was NOT Hubble.
  - Majority of students did not mention spectra or spectral lines – stars are not redshifted, the spectral lines from the star's emission spectra is red-shifted. No mention of spectra = max 1 mark as this is the key to Hubbles observations
- Better answers referred to the stretching of space leading to the increased wavelengths – providing a link to the expanding universe (as mentioned in the question). This was not necessarily required for three marks if the answer was thorough in other aspects of the response.
- Too many students just provided statements without explanations/justifications.
- Too much detail missing – you need to explain your statements.

Sample Answer/Answer Points:



Hubble's observations provided evidence that the universe is expanding.

(a) Describe the observations that led Hubble to conclude that the universe was expanding. 3

· By measuring a star's relative and absolute magnitude (absolute magnitude derived from T (λ_{max}) and surface area), its distance can be calculated ($L_1 r_1^2 = L_2 r_2^2$)

· Hubble graphed distance vs velocity (from doppler effect red shifting of hydrogen spectral lines) which showed a linear relationship ($v = H_0 D$) → almost all stars moving away from us

· This indicated that everything in the universe was 'stretching' away from each other → expanding universe

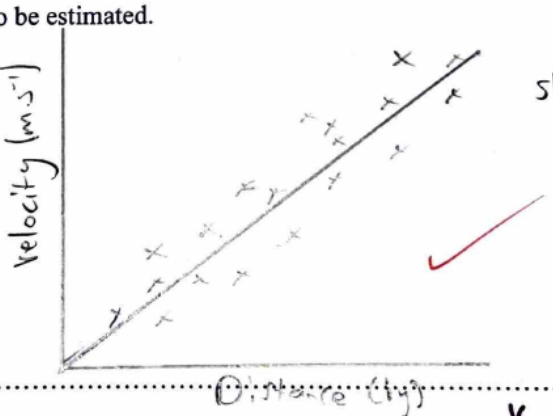
Q 33b (Band 2-5)

Criteria	Marks
Correct graph sketched and related to correct calculation for age of universe	2
A correct point made or correct graph sketched	1

Sample Answer/Answer Points:

- A lot of students did not know this content and guessed literally almost everything in Module 8 (HR diagram, spectra, fundamental forces – you really need to know your content).
- Those that could provide the correct velocity/distance sketch graph – very few could relate the inverse slope to the age of the universe.

(b) Sketch a graph of the data collected during Hubble's observations and outline how it allows the age of the universe to be estimated. 2



Slope = H_0 (Hubble's constant) = $\frac{v}{s}$

Assuming H_0 has not changed over time:

- H_0 represents a $\frac{\text{velocity}}{\text{distance}}$ i.e. the ratio of velocity: distance stars have been travelling at since the Big Bang → that time

$\frac{1}{t}$ where t is the time since the Big Bang

i. $\frac{1}{H_0}$ estimates t, the age of the universe.

Q 34 (Band 2-6)

Criteria	Marks
Extensive explanation of both **equations** in reference to both quantised energy and conservation of energy Extensive and relevant physics theory used in support of explanations Concise and relevant information included (no irrelevant information)	7
Thorough explanation of both **equations** in reference to both quantised energy and conservation of energy Thorough and relevant physics theory used in support of explanations	5-6
Sound explanation of at least ONE **equation** for both quantised energy and conservation of energy OR sound explanation of BOTH **equations** for EITHER quantised energy or conservation of energy	3-4
Several correct points made	2
A correct point made	1

Marker's notes:

- Lack of concision – MOST OF YOU WROTE WAY TOO MUCH WITH LITTLE ADDED VALUE - lots of wasted time and energy writing unnecessary detail that does not address the question. (see below)
- Generally, not well done with many students not effectively addressing the question.
- This question is about the EQUATIONS and every part of your response needed to explicitly and clearly be connected to the relevant EQUATION.
- A full response without clear and explicit connections to equations throughout each section earns a maximum of 3 marks! You must ensure you are ATQ not doing a braindump of knowledge.
- This question was begging for clear structure and four subheadings – one for each equation for each of conservation of energy and quantised energy (eg Conservation of energy – PE effect, Conservation of energy – emission spectra, quantisation of energy – PE effect, quantisation of energy – emission spectra). (see below)
- The question is built around two syllabus dot points (see below). You MUST know the syllabus to succeed in the subject but many students were clearly connecting the two equations with quantisation and conservation of energy for the first time *in this question*:

- analyse the photoelectric effect $K\text{max}\_=hf-\phi$ as it occurs in metallic elements by applying the law of conservation of energy and the photon model of light, (ACSPH119) AND

- relate qualitatively and quantitatively the quantised energy levels of the hydrogen atom and the law of conservation of energy to the line emission spectrum of hydrogen using:
    - $E=hf$
    - $E=hc/\lambda$
    - $1/\lambda=R[1/nf2-1/ni2]$ (ACSPH136)

- Handwriting was challenging – if words cannot be read they cannot be marked AND if each word is hard to read there is no flow to the writing.
- Poorly constructed phrases and sentences that didn't make sense.

- Question features emission spectra but many students were addressing absorption of photons.
- The Rydberg equation addresses the energy conserved in the interaction between electron energy level changes and the emitted photon NOT between the energy absorbed by the electron and the energy emitted by the electron.
- Diagrams can support this answer effectively, but few were used (even fewer were effective).
- Phrases from the question should be used in your response - *abides conservation of energy, the equation relates to quantisation of energy*.

Sample Answer/Answer Points:

Conservation of energy – PE effect (coded PE on script)

The equation Kmax=$hf-\phi$ relates to conservation of energy since it can be rearranged to indicate that hf = K_{max} + ϕ. In this equation hf is the energy that is input into the interaction between metal and incident light in the form of photon energy from $E=hf$ whilst K_{max} represents the energy of emitted photoelectrons and ϕ represents the energy absorbed by the metal. This sum is the energy after the interaction between metal and incident light. It can be seen then that hf = K_{max} + ϕ indicates that E_{in} = E_{out} i.e. the *equation abides by conservation of energy*.

Conservation of energy – emission spectra (coded SE on script)

From the equation $1/\lambda=R[1/nf2-1/ni2]$ $1/\lambda$ is proportional to the energy of the emitted photon from $E=hf$ and $E=hc/\lambda$ whilst $R[1/nf2-1/ni2]$ is proportional to the energy lost by the electron as it moves from n_i to n_f since $1/n^2$ is proportional to energy of electron level n. Hence it can be seen that this equation equates energy emitted due to the electron transition to energy change of the electron and thus *abides conservation of energy.*

Quantisation of energy – PE effect (coded PQ on script)

The equation Kmax=$hf-\phi$ relates to quantisation of energy since the energy of the photon represented by hf is from the equation $E=hf$ which was used by Planck to propose the quantisation of energy. Hence it can be seen that *the equation relates to quantisation of energy*.

Quantisation of energy – emission spectra (coded SQ on script)

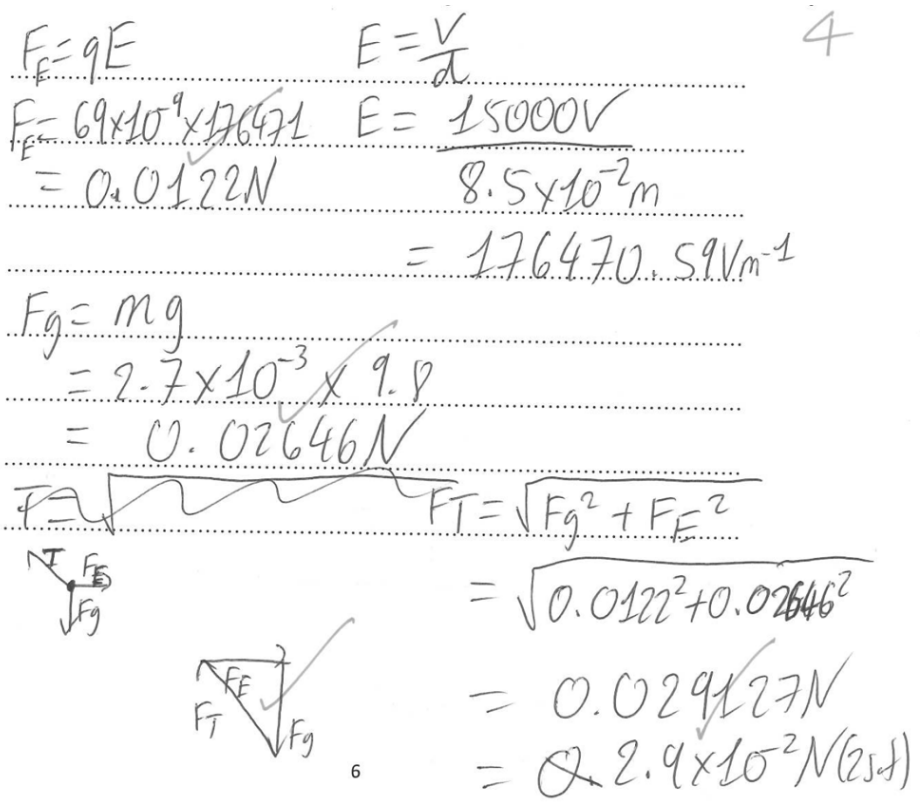
From the equation $1/\lambda=R[1/nf2-1/ni2]$ $1/\lambda$ is related to the energy of the emitted photon from $E=hf$ and $E=hc/\lambda$ and thus relates to the quantised energy of the emitted photon whilst $R[1/nf2-1/ni2]$ is related to the quantised electron energy levels n_i and n_f since $1/n^2$ is proportional to energy of electron level n. Hence it can be seen that *the equation relates to quantisation of energy of both the photon emitted and the electron energy levels*.

Q 35a (Band 2-6)

Criteria	Marks
Gravitational and electric forces calculated and used to determine overall force and thus tension force showing full working Vector sketch included as part of answer or clear link of sum vector sum of F_E and F_g to tension	4
Gravitational and electric forces calculated and used to determine overall force with minor errors or omissions.	3
Some correct steps in the calculation of gravitational/electric/overall forces	2
A correct step performed OR a correct vector sketch presented identifying relevant forces	1

Marker's notes:

- MOST students did very well in this (3 or 4)
- A number of students not effectively addressing the question.
- Read the question – this is not UCM as multiple students assumed!
- Clarity of working and reasoning was often weak
- Simple calculation errors abounded – more care needed
- Some students ignored gravity?
- Vector diagrams have arrows just like they have since you started Physics
- Confusion about direction of tension abounded
- Writing tension = $\sqrt{FE^2 + Fg^2}$ is NOT ENOUGH to show full working.
- This question is about the EQUATIONS and every part of your response needed to explicitly and clearly be connected to the relevant EQUATION.



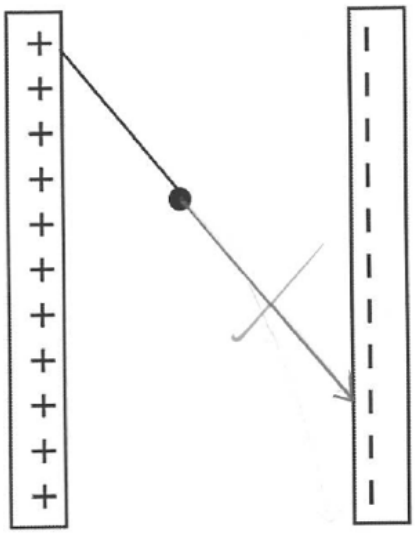
Q 35b (Band 4-6)

Criteria	Marks
Extensive justification of BOTH constant forces acting on or constant accelerations experienced by the ball Correct prediction and justification of final path (straight line)	3
Thorough description of BOTH constant forces A prediction of final path given OR extensive justification that reaches the wrong conclusion	2
A correct point made or a correct sketch	1

Marker's notes:

- A number of students just did not get it but MANY DID VERY WELL
- A number of students had completely correct logic but reached the wrong conclusion.
- Clarity of reasoning was often weak/lacking detail

Sample Answer/Answer Points:



lovely!

+ As the charge is positive, it will be attracted to the negative plate, hence travelling right.
+ The electric field is uniform, hence the ball experiences a constant acceleration right.
+ The ball also experiences a constant gravitational acceleration downwards ✓
+ The gravitational force is ~~greater hence~~ it travels slightly more downwards than ~~to~~ right.
+ As both are constant, the ball will travel in a straight line as shown as there is a constant net force in that direction.

Q 36 (Band 2-6)

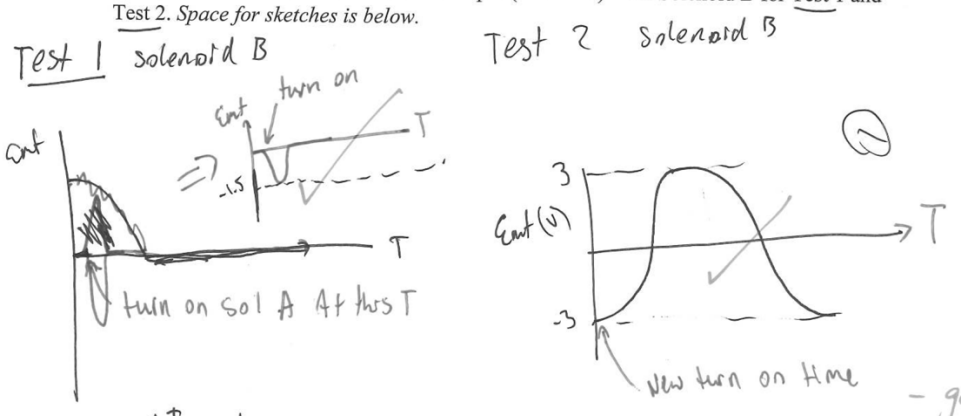
Criteria	Marks
BOTH CRO sketch graphs correct showing flat DC and alternating AC Extensive explanation of BOTH graph shapes with reference to relevant physics theory	5
BOTH CRO sketch graphs correct Thorough explanation of BOTH graph shapes with minor errors/omissions	4
ONE CRO sketch graph correct with thorough explanation of graph shape OR BOTH CRO sketch graphs correct with sound explanation of both graph shapes	3
ONE CRO sketch graph correct with sound explanation of graph shape OR Limited correct attempt to sketch or explain BOTH graph shapes	2
A correct point made OR a correct graph	

Marker's notes:

- Question is about the graph you sketched – your response MUST address the shape of the graph clearly and explicitly
- A number of students were unclear about a DC supply – review this
- Save the word 'induced' for emf and use 'created', 'formed' etc for magnetic fields and other quantities
- Clarity was often weak due to poor use of scientific language/use of ambiguous terms (like constant change of flux vs continuous change of flux)
- Many students struggled to provide sufficient detail for the sinusoidal nature of the Test 2 output emf

Sample Answer/Answer Points:

Sketch and explain the observed CRO output (emf-time) from Solenoid B for Test 1 and Test 2. *Space for sketches is below.*



But as $t \uparrow$, there is no longer a $\Delta\Phi$, so the Emf remains constant at $\mathcal{E} = 0$.

Qu 36 continued

Test 1. Initially as 1.5A of DC current ~~is running~~ runs through Solenoid A, it 'turns into a magnet' that has a constant polarity: ~~(0000)~~

(2) – As this B field intersects with solenoid B, there is a $\Delta\Phi$ and according to Faradays law: $\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$, will induce an Emf. The direction of this Emf will be such to oppose the $\Delta\Phi$, and hence, negative Emf initially.

Test 2.: On the other hand, solenoid A is 'fed' an AC current of 3.0A, essentially 'turning it into a magnet' with an oscillating polarity:

N S => S N => N S

Refer to ② for same logic of $\Delta\Phi \Rightarrow$ Emf $\Rightarrow$ opposes

– However, as the B_{fed} is constantly changing for Solenoid A, the Φ will also be changing in solenoid B.

– This results in a sinusoidal pattern as shown in ① where constant oscillation requires the Solenoid B to oppose $\Delta\Phi$.