Student Number								

2024 **HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION**

PHYSICS

General Instructions

- Reading Time – 5 minutes
- Working Time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formula sheet and Periodic Table are provided

Total marks: 100

Section I – 20 marks (pages 2-10)

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

Section II – 80 marks (pages 12-27)

- Attempt questions 21-34
- Allow about 2 hours and 25 minutes for this section

Section I
20 Marks

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

Use the Multiple-Choice Answer Sheet on page 11 for Questions 1 – 20

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1 Which of the following statements is true regarding how blackbody radiation changes as the temperature of the radiating object increases?

a) Both the maximum intensity and the peak wavelength increase.

b) The maximum intensity increases and the peak wavelength decreases.

c) Both the maximum intensity and the peak wavelength decrease.

d) The maximum intensity decreases, and the peak wavelength increases.

2 Which meson is responsible for the force that holds quarks together?

a) Gluon

b) Graviton

c) Photon

d) W boson

3 An 18.5 cm diameter wire loop is initially oriented perpendicular to a 1.5 T magnetic field. In 0.20 s, the loop is rotated so its plane is parallel to the field direction.

What is the average induced emf in the loop?

a) 0.10 V

b) 0.02 V

c) 0.20 V

d) 1.50 V

4 For a charged particle in an electric field, which of the following statements is NOT true for work done on the charge?

a) The work done on a charged particle is directly proportional to the strength of the electric field.

b) The work done on the charged particle is calculated using the magnitude of the displacement from the starting point.

c) The work done on the charged particle is dependent on the potential difference between the plates producing the electric field.

d) Doubling the charge of the particle has no impact on the work done on the charged particle.

5 A wheel with a diameter of 0.66 m experiences a tangential force of 5.30 N on its rim. Calculate the torque the wheel experiences.

a) 0.33 Nm

b) 1.75 Nm

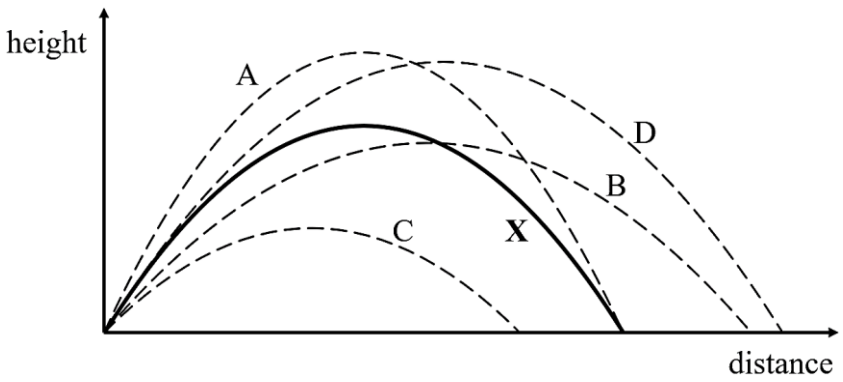
c) 2.65 Nm

d) 3.50 Nm

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

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

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



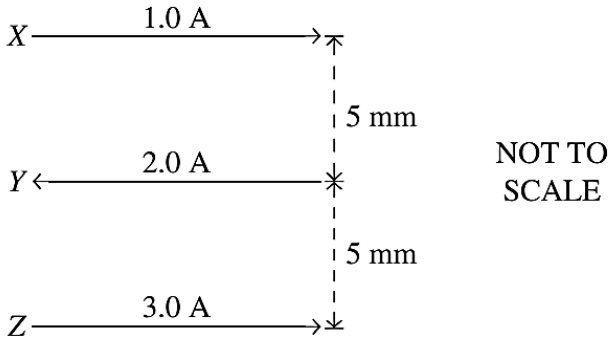
a) A

b) B

c) C

d) D

7 Three parallel current-carrying wires, X, Y and Z, are shown. The current in wire Y is flowing in the opposite direction to the currents in wires X and Z.



What is the net force acting on wire X?

a) $2 \times 10^{-5}\ N\ m^{-1}\ up$

b) $2 \times 10^{-5}\ N\ m^{-1}\ down$

c) $8 \times 10^{-5}\ N\ m^{-1}\ up$

d) $8 \times 10^{-5}\ N\ m^{-1}\ down$

8 What was the significance of previous discoveries about the hydrogen spectrum to Bohr in developing his model of the atom?

a) Previous work had provided the energy values associated with electron transfers.

b) It provided stimulus and direction for Bohr's developing ideas.

c) Previous experiments were used to explain the wavelength of the spectral lines.

d) Bohr knew that orbiting electrons did not emit electromagnetic radiation.

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

a) different cathode metals have the same threshold frequency.

b) less intense light requires a higher frequency for a photocurrent to be observed.

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

d) when conditions produce photocurrent, it is detected immediately.

10 A 30 V, 2.5 A DC current is run through a step-up transformer with 75 turns on the input side and 15 turns on the output side. What is the output voltage and current?

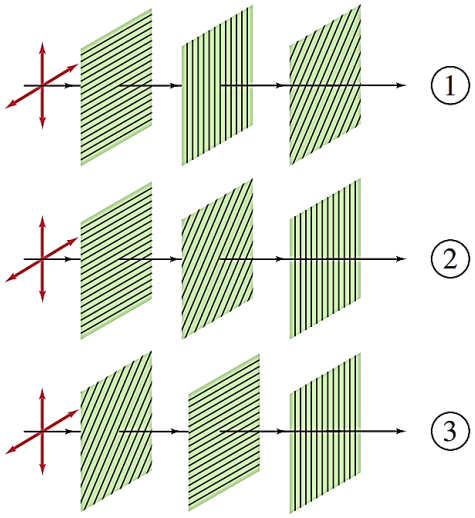
a) 6 V, 12.5 A

b) 6 V, 0.5 A

c) 150 V, 0.5 A

d) 150 V, 12.5 A

11 If unpolarised light is incident from the left on three polarisers, as shown below, in which of the following cases will some light get through?



a) Case 1 only

b) Case 2 only

c) Case 3 only

d) None

12 Kepler's Law of Periods, summarised in the equation $T^2 = kR^3$, shows a relationship between the orbital period and the radius of a planet orbiting a star.

In which of the following situations would a change in the value of the constant k, be needed?

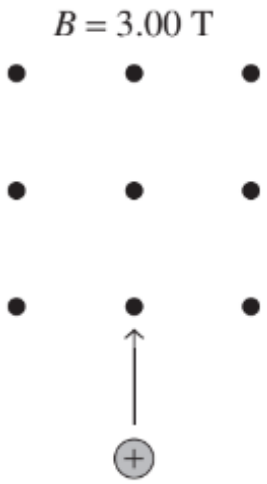
a) For a planet of the greater orbital period

b) For a planet of a smaller orbital radius

c) For an identical planet orbiting a different star

d) For a planet of different mass orbiting the same star

13 The diagram shows a proton being fired with a velocity of 1200 m/s into a uniform magnetic field of 3.00 T.



What is the acceleration of the proton as it enters the field?

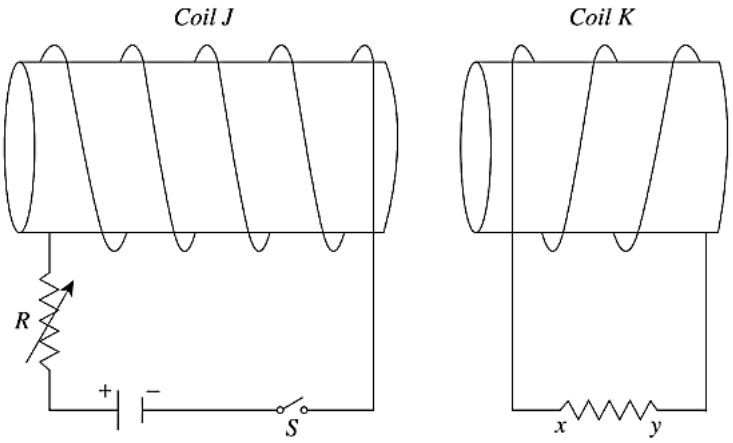
a) 5.78×10^{-16} m/s^2 to the right

b) 5.78×10^{-16} m/s^2 to the left

c) 3.45×10^{11} m/s^2 to the right

d) 3.45×10^{11} m/s^2 to the left

14 The apparatus shown in the diagram is used in an experiment to demonstrate Lenz's law.



In the experiment, the following sequence of changes is made to the apparatus:

1) Switch S is opened after having been closed for a short period of time.

2) Switch S is closed, and Coil K is brought closer to Coil J.

3) The resistance of R is decreased while switch S remains closed.

Which row of the table identifies the direction of the current in resistor xy after each change?

	1	*2*	*3*
a)	x to y	x to y	x to y
b)	x to y	y to x	y to x
c)	y to x	y to x	y to x
d)	y to x	x to y	y to x

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

At what height does the ball cross the goal line?

a) 0.83 m

b) 3.8 m

c) 5.4 m

d) 10.4 m

16 LEOSAR is a search and rescue satellite currently in a low Earth orbit of 850 km and must be brought down to a lower orbit of 650 km for a mission over the Pacific Ocean.

In order to be stable in the lower orbit, the speed of the LEOSAR satellite would need to

a) Increase by 105 m/s
b) Decrease by 105 m/s
c) Increase by 3115 m/s
d) Decrease by 3115 m/s

17 How long does it take to emit one million photons from a 10 mW laser with a frequency of 4.5×10^{14} Hz?

a) 3.0×10^{-11} s
b) 3.0×10^{-23} s
c) 3.4×10^{-22} s
d) 3.4×10^{-10} s

18 A physicist team is researching two planets, Ursae Majoris B and Ursae Majoris C, that orbit a distant star. The table shows some of the data that the team has gathered.

Planet	*Radius of orbit (m)*	*Orbital Period (s)*
Ursae Majoris B	6.2×10^{8}	4.2×10^{4}
Ursae Majoris C	1.56×10^{9}	$1 \cdot 68 \times 10^{5}$

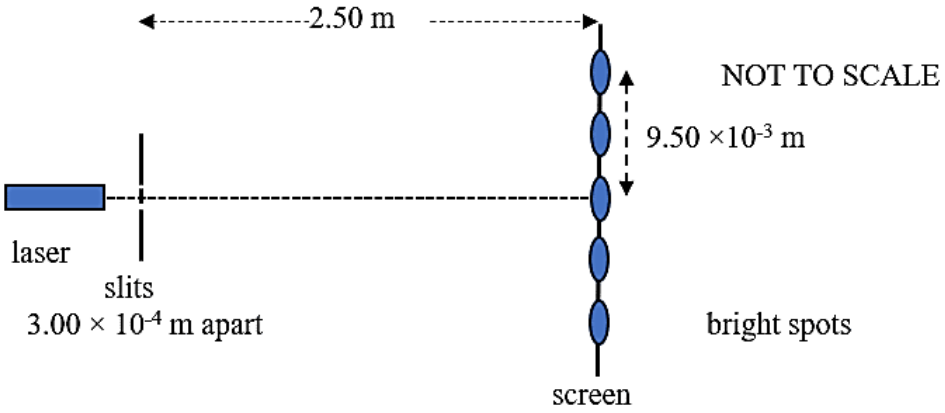
Based on the data in the table, which of the following statements is correct?

a) The acceleration due to gravity experienced by Ursae Majoris B is 2.5 times greater than that due to gravity experienced by Ursae Majoris C.
b) The acceleration due to gravity experienced by Ursae Majoris C is 2.5 times greater than that due to gravity experienced by Ursae Majoris B.
c) The acceleration due to gravity experienced by Ursae Majoris B is 6.3 times greater than that due to gravity experienced by Ursae Majoris C.
d) The acceleration due to gravity experienced by Ursae Majoris C is 6.3 times greater than that due to gravity experienced by Ursae Majoris B.

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

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

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



The laser wavelength is closest to:

a) 5.70×10^{-4} m

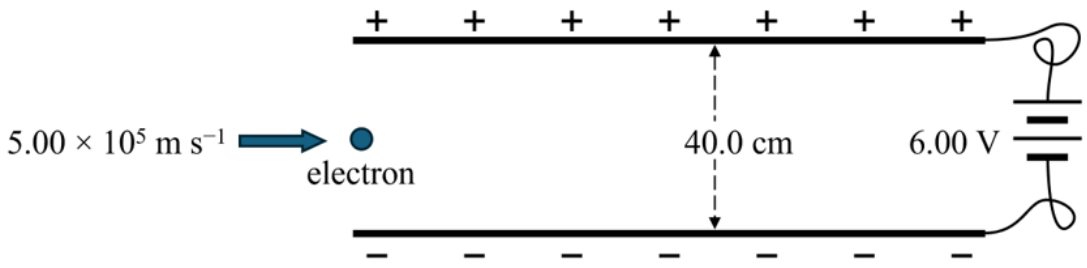
b) 1.14×10^{-6} m

c) 5.70×10^{-7} m

d) 1.14×10^{-9} m

20 An electron enters a uniform electric field created by a pair of parallel plates.

The plates are 40.0 cm apart and have a potential difference of 6.00 V between them, as shown in the diagram below.



The electron enters the electric field at 5.00×10^5 m s^{-1} in a direction parallel to the plates.

Assuming the electron enters the field exactly halfway between the plates, what is its speed when it collides with one of the plates?

a) 1.52×10^6 m s^{-1}

b) 1.03×10^6 m s^{-1}

c) 5.00×10^5 m s^{-1}

d) 1.14×10^6 m s^{-1}

End of Section I

2024 HSC Trial Examination

Physics Section I – Multiple Choice Answer Sheet

Instructions for answering questions in Section I

- Complete your answers 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.

A ○ **B** ○ **C** ⊗ **D** ⊗ ← correct

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 ○

Student Number								
Section I /20								
Section II /80								
Total /100								

Physics
Section II

80 marks
Attempt Questions 21-34
Allow about 2 hours 25 minutes for this section

Instructions

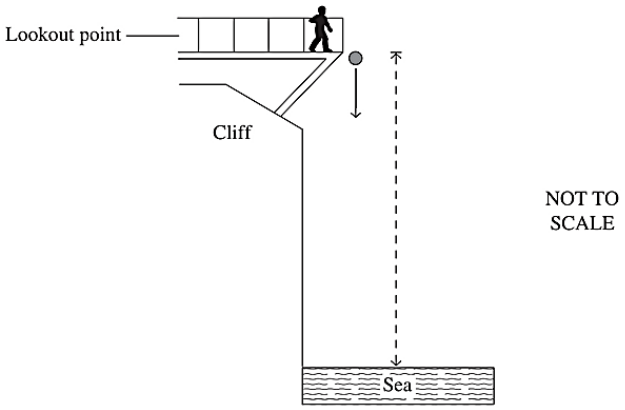
- Write your student number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the response.
- Show all relevant working in questions involving calculations
- Extra writing paper is available, please raise your hand to request more paper. If you use extra paper, clearly indicate your student number and which question you are answering.

Please turn over

Question 21 (5 marks)

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

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



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

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

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

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Question 22 (3 marks)

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

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Question 23 (7 marks)

A race car is moving around a banked circular track that has a radius of 90.0 m and an angle of banking of θ degrees, as shown in the diagram.

The car has a constant speed.

a) On the diagram, clearly show all of the forces acting on the car using labelled arrows. **2**

Question 23 continues on the following page

b) If the angle of banking is 10°, find the speed necessary so that no sideways force needs to be exerted between the tyres and the track. **3**

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Question 24 (8 marks)

a) Calculate the centripetal acceleration of the Earth as it orbits the Sun.
Use 1.50×10^{11} m as the radius of Earth's orbit. **3**

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b) A 1 500 kg spacecraft orbits the Earth at a distance of 4.00×10^{7} m and completes an orbit in 6.00 hours; how much does the centripetal force exerted on the spacecraft while in orbit differ from the gravitational force if it was on the surface? **3**

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c) Referring to Kepler's laws, describe how Earth's centripetal acceleration varies as its orbit takes it closer to the Sun and further away each year. **3**

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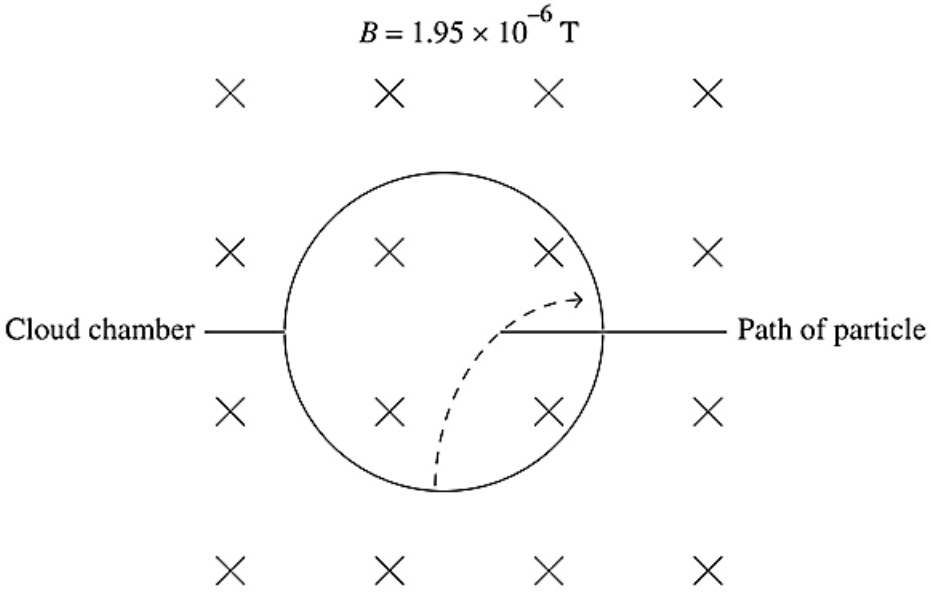
Question 25 (5 marks)

A particle in an accelerator reaches a velocity of 2.50×10^4m s^{-1} before entering a Wilson cloud chamber. The cloud chamber is in a uniform magnetic field of 1.95×10^{-6} T. The diagram illustrates the particle's path as observed in the cloud chamber.



a) Identify whether the particle is positively or negatively charged and justify your response. **2**

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Question 25 continues on the following page

b) The radius of the particle's path is 5.0 cm.
Show that the charge-to-mass ratio of the particle is 2.6×10^{11} C kg^{-1} **3**

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Question 26 (7 marks)

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

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

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Question 26 continues on the following page

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

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Question 27 (4 marks)

a) How far above the Earth's surface will an object need to ascend for the acceleration of gravity to be half what it is at the surface? **2**

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b) How long would a day be if the Earth were rotating so fast that objects at the equator were apparently weightless? **2**

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Question 28 (8 marks)

A Physics student is provided with two pairs of polarised sunglasses and a light source of polarised light.

a) The two sunglasses are oriented at 42.0° to one another. The light source is polarised at a 21.0° angle.
What percentage of incoming intensity is transmitted once it has passed through both sunglasses? **2**

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b) Discuss how polarisation can be explained by comparing the particle model and wave models of light. **5**

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Question 29 (5 marks)

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

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Question 30 (5 marks)

A physicist conducted an experiment using a transformer. The results of the experiment are recorded in the table.

	Primary Coil	*Secondary Coil*
Voltage (V)	120	?
Current (mA)	3.0	30
Number of turns	?	5

a) If the transformer is 100% efficient, determine the secondary voltage and the number of turns in the primary coil. **2**

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b) A 95 W transformer is installed and has an output voltage of 12 V and an input current of 25 A.

Determine if the transformer is a step-up or step-down transformer and by what factor the voltage multiplied. **3**

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Question 31 (5 marks)
Using relevant equations and diagrams, describe how the motor effect plays a part in the operation of a simple DC electric motor. **5**

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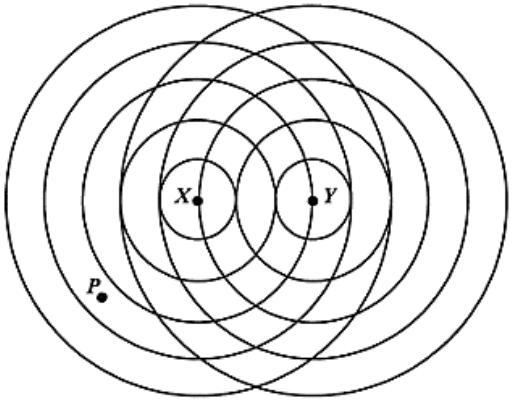
Question 32 (6 marks)
Two in-phase point sources, *X* and *Y*, are 0.30 m apart and produce identical waves with an amplitude of 0.26 m. The diagram has marked Point *P*, midway between wavefronts from *X*.



(a) Predict the amplitude of the interference of the waves at Point *P* at the instant shown. Justify your answer. **2**

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(b) Discuss how interference patterns were used to provide evidence for the nature of both light and matter. **4**

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Question 33 (7 marks)

Diagram 1 shows a small section of the spectrum for a mixture of gaseous elements.

Diagram 1

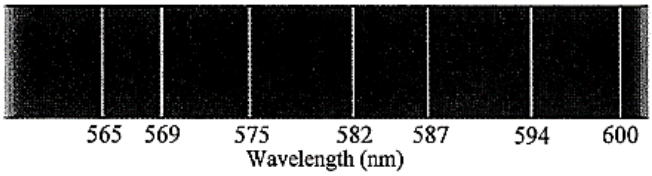
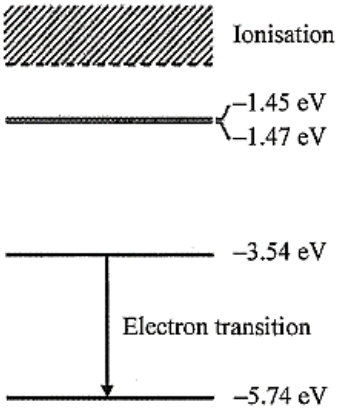


Diagram 2 shows the electron energy levels for a gaseous element *X*.

Diagram 2



A physics student states that the spectral line produced when an electron falls from the -3.54 eV energy level to the -5.74 eV level proves that element *X* is one of the gases in the mixture.

Critically evaluate the student's statement using your understanding of how spectral lines are produced. **7**

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Question 33 (continued)

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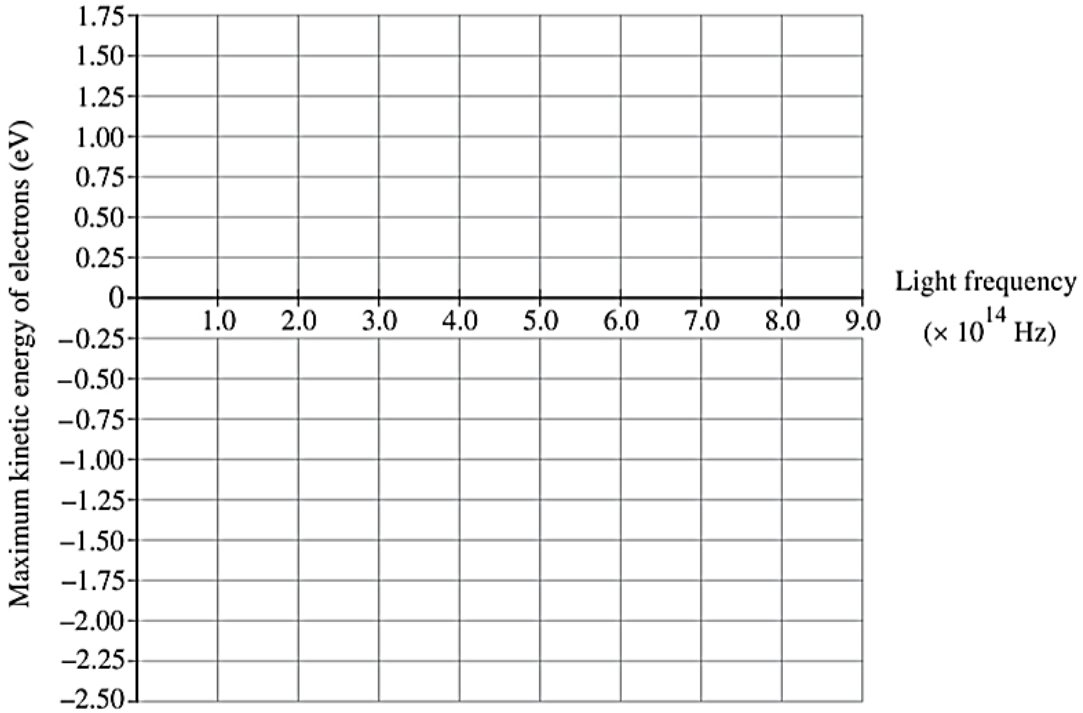
Question 34 (5 marks)

A team of physicists conducted an experiment to investigate the photoelectric effect. They directed light of different frequencies at the surface of a particular metal. The maximum kinetic energies of the electrons emitted by the metal were measured, and the data was recorded in the table.

Light Frequency (× 10^{14} Hz)	*Maximum kinetic energy of electrons (eV)*
5.6	0.01
6.0	0.18
6.5	0.41
7.1	0.70
7.9	0.97
8.8	1.31

a) Plot the data on the axes provided and, using the plotted data:

- Determine the work function (ϕ) of the metal.
- Calculate a value for Planck's constant **3**



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b) The team of physicists direct light of wavelength 420 nm at the metal.
Using the values for ϕ and h from part a), determine whether the photoelectric effect will occur. **2**

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End of Section II

End of Examination

Extra Writing Paper

If you use this space, clearly indicate **in the question** that you have continued it here, and **in this space** the question number.

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Student Number								

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Section I
20 Marks

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Allow about 35 minutes for this section

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a) Both the maximum intensity and the peak wavelength increase.

b) The maximum intensity increases and the peak wavelength decreases.

c) Both the maximum intensity and the peak wavelength decrease.

d) The maximum intensity decreases, and the peak wavelength increases.

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a) <u>Gluon</u>

b) Graviton

c) Photon

d) W boson

3 An 18.5 cm diameter wire loop is initially oriented perpendicular to a 1.5 T magnetic field.

In 0.20 s, the loop is rotated so its plane is parallel to the field direction.
What is the average induced emf in the loop?

a) 0.10 V

b) 0.02 V

c) <u>0.20 V</u>

d) 1.50 V

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b) The work done on the charged particle is calculated using the magnitude of the displacement from the starting point.

c) The work done on the charged particle is dependent on the potential difference between the plates producing the electric field.

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b) **1.75 Nm**

c) 2.65 Nm

d) 3.50 Nm

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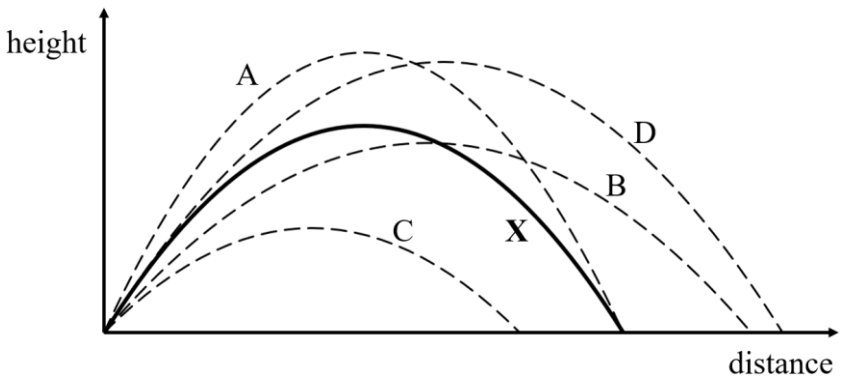
Another projectile is launched with identical speed and angle but on the surface of a planet where the gravitational acceleration is less than 9.8 m s^{-2}.

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



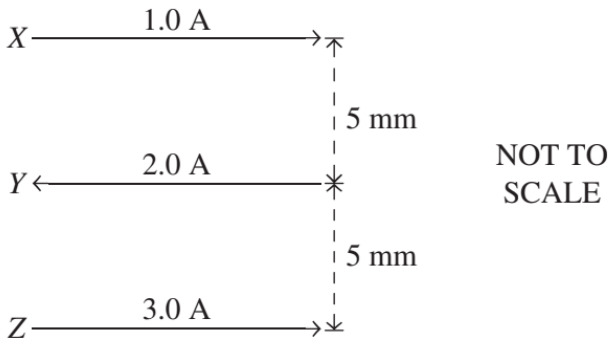
a) A

b) B

c) C

d) <u>D</u>

7 Three parallel current-carrying wires, X, Y and Z, are shown. The current in wire Y is flowing in the opposite direction to the currents in wires X and Z.



What is the magnitude of the net force acting on wire X?

a) $\mathbf{2 \times 10^{-5}\ N\ m^{-1}\ up}$

b) $2 \times 10^{-5}\ N\ m^{-1}\ down$

c) $8 \times 10^{-5}\ N\ m^{-1}\ up$

d) $8 \times 10^{-5}\ N\ m^{-1}\ down$

8 What was the significance of previous discoveries about the hydrogen spectrum to Bohr in developing his model of the atom?

a) Previous work had provided the energy values associated with electron transfers.

b) **<u>It provided stimulus and direction for Bohr's developing ideas.</u>**

c) Previous experiments were used to explain the wavelength of the spectral lines.

d) Bohr knew that orbiting electrons did not emit electromagnetic radiation.

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

a) different cathode metals have the same threshold frequency.

b) less intense light requires a higher frequency for a photocurrent to be observed.

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

d) when conditions produce photocurrent, it is detected immediately.

10 A 30 V, 2.5 A DC current is run through a step-up transformer with 75 turns on the input side and 15 turns on the output side. What is the output voltage and current?

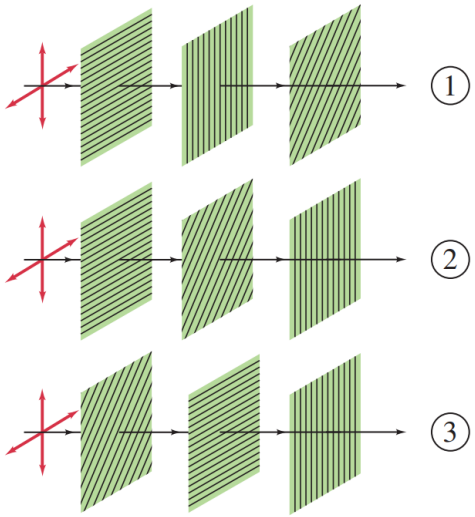
a) 6 V, 12.5 A

b) 6 V, 0.5 A

c) 150 V, 0.5 A

d) 150 V, 12.5 A

11 If unpolarised light is incident from the left on three polarisers, as shown below, in which of the following cases will some light get through?



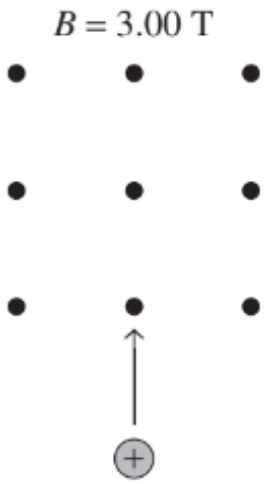
a) Case 1 only
b) Case 2 only
c) Case 3 only
d) None

12 Kepler's Law of Periods, summarised in the equation $T^2 = kR^3$, shows a relationship between the orbital period and the radius of a planet orbiting a star.

In which of the following situations would a change in the value of the constant k, be needed?

a) For a planet of the greater orbital period
b) For a planet of a smaller orbital radius
c) <u>For an identical planet orbiting a different star</u>
d) For a planet of different mass orbiting the same star

13 The diagram shows a proton being fired with a velocity of 1200 m/s into a uniform magnetic field of 3.00 T.



What is the acceleration of the proton as it enters the field?

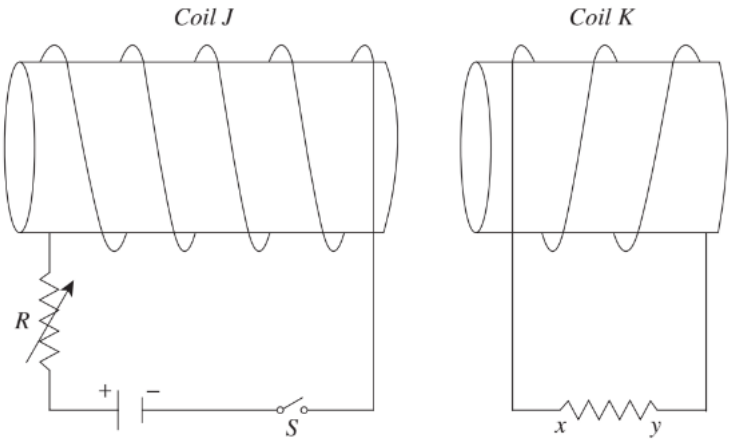
a) 5.78×10^{-16} m/s^2 to the right

b) 5.78×10^{-16} m/s^2 to the left

c) $\mathbf{3.45 \times 10^{11}}$ m/s^2 to the right

d) 3.45×10^{11} m/s^2 to the left

14 The apparatus shown in the diagram is used in an experiment to demonstrate Lenz's law.



In the experiment, the following sequence of changes is made to the apparatus:

1) Switch S is opened after having been closed for a short period of time.

2) Switch S is closed, and Coil K is brought closer to Coil J.

3) The resistance of R is decreased while switch S remains closed.

Which row of the table identifies the direction of the current in resistor xy after each change?

	1	*2*	*3*
a)	x to y	x to y	x to y
b)	**x to y**	**y to x**	**y to x**
c)	y to x	y to x	y to x
d)	y to x	x to y	y to x

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

At what height does the ball cross the goal line?

a) 0.83 m

b) 3.8 m

c) 5.4 m

d) 10.4 m

16 LEOSAR is a search and rescue satellite currently in a low Earth orbit of 850 km and must be brought down to a lower orbit of 650 km for a mission over the Pacific Ocean.

In order to be stable in the lower orbit, the speed of the LEOSAR satellite would need to

a) <u>Increase by 105 m/s</u>

b) Decrease by 105 m/s

c) Increase by 3115 m/s

d) Decrease by 3115 m/s

A is correct and **B** is incorrect. The speed of the satellite would need to increase in the lower orbit.

$$v_{\text{at 850 km orbit}} = \sqrt{\frac{GM}{r}}$$

$$= \sqrt{\frac{(6.67\times10^{-11})\times(6.0\times10^{24})}{(6.371\times10^{6})+(0.85\times10^{6})}}$$

$$= \sqrt{\frac{4.002\times10^{14}}{7.221\times10^{6}}}$$

$$= 7444.57\ldots \text{ m s}^{-1}$$

$$v_{\text{at 650 km orbit}} = \sqrt{\frac{GM}{r}}$$

$$= \sqrt{\frac{(6.67\times10^{-11})\times(6.0\times10^{24})}{(6.371\times10^{6})+(0.65\times10^{6})}}$$

$$= \sqrt{\frac{4.002\times10^{14}}{7.021\times10^{6}}}$$

$$= 7549.86\ldots \text{ m s}^{-1}$$

Change in speed:

$$\Delta v = 7549.86\ldots - 7444.57\ldots$$

$$= 105 \text{ m s}^{-1}$$

C and **D** are incorrect. These options do not include Earth's radius in the calculations.

17 How long does it take to emit one million photons from a 10 mW laser with a frequency of 4.5×10^{14} Hz?

a) <u>3.0×10^{-11} s</u>

b) 3.0×10^{-23} s

c) 3.4×10^{-22} s

d) 3.4×10^{-10} s

18 A physicist team is researching two planets, Ursae Majoris B and Ursae Majoris C, that orbit a distant star. The table shows some of the data that the team has gathered.

Planet	*Radius of orbit (m)*	*Orbital Period (s)*
Ursae Majoris B	6.2×10^{8}	4.2×10^{4}
Ursae Majoris C	1.56×10^{9}	$1 \cdot 68 \times 10^{5}$

Based on the data in the table, which of the following statements is correct?

a) The acceleration due to gravity experienced by Ursae Majoris B is 2.5 times greater than that due to gravity experienced by Ursae Majoris C.

b) The acceleration due to gravity experienced by Ursae Majoris C is 2.5 times greater than that due to gravity experienced by Ursae Majoris B.

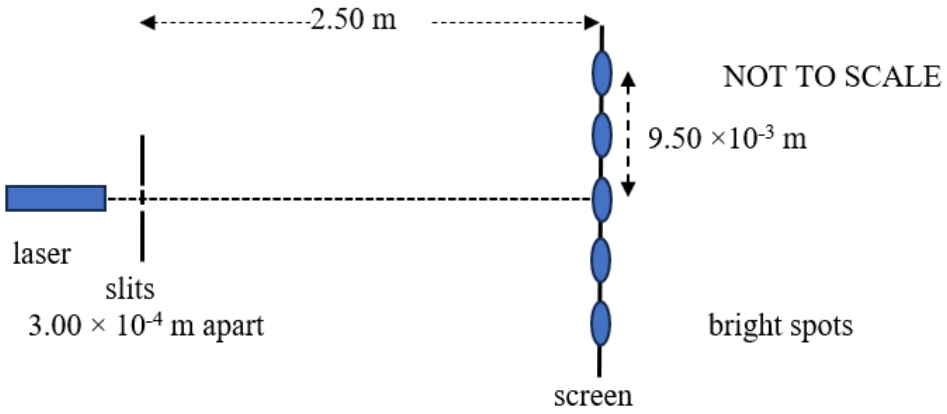
c) <u>The acceleration due to gravity experienced by Ursae Majoris B is 6.3 times greater than that due to gravity experienced by Ursae Majoris C.</u>

d) The acceleration due to gravity experienced by Ursae Majoris C is 6.3 times greater than that due to gravity experienced by Ursae Majoris B.

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

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

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

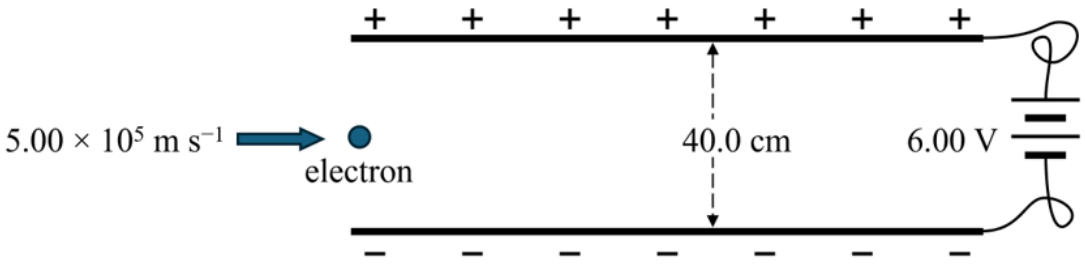


The laser wavelength is closest to:

a) 5.70×10^{-4} m
b) 1.14×10^{-6} m
c) 5.70×10^{-7} m
d) 1.14×10^{-9} m

20 An electron enters a uniform electric field created by a pair of parallel plates.

The plates are 40.0 cm apart and have a potential difference of 6.00 V between them, as shown in the diagram below.



The electron enters the electric field at 5.00×10^5 m s^{-1} in a direction parallel to the plates.

Assuming the electron enters the field exactly halfway between the plates, what is its speed when it collides with one of the plates?

a) 1.52×10^6 m s^{-1}

b) 5.00×10^5 m s^{-1}

c) 1.03×10^6 m s^{-1}

d) $\underline{1.14 \times 10^6 \text{ m s}^{-1}}$

End of Section I

Student Number								

2024 HSC TRIAL EXAMINATION

PHYSICS : Section I – Multiple Choice Answer Sheet

Instructions for answering questions in Section I:

- Complete you answers 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.

A ○ **B** ○ **C** ⊗ **D** ⊗ correct

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 ○

Student Number								
Section I /20								
Section II /80								
Total /100								

Physics
Section II

80 marks
Attempt Questions XXXXXX
Allow about 2 hours 25 minutes for this section

Instructions

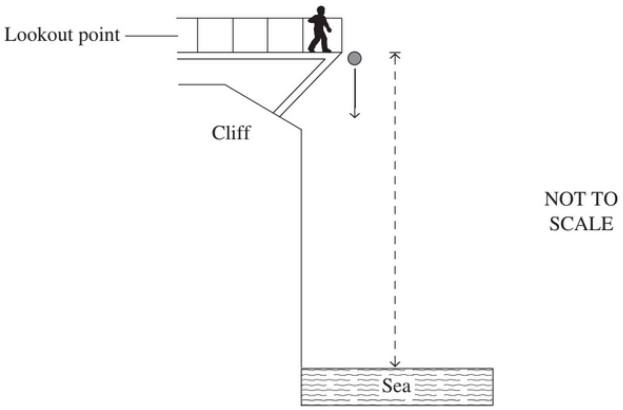
- Write your student number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the response.
- Show all relevant working in questions involving calculations
- Extra writing paper is available, please raise your hand to request more paper. If you use extra paper, clearly indicate your student number and which question you are answering.

Please turn over

Question 21 (5 marks)

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

a) As shown in the diagram, a visitor accidentally rolls a ball off the lookout point. It takes 3.5 seconds for the ball to land in the sea below. **2**



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

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Marking Criteria	Marks
• Provides the correct solution using the required variables AND the correct formula	**2**
• Provides some relevant working	**1**

$u = 0$

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

$t = 3.5 \text{ s}$

$s = ?$

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

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

$$= 60 \text{ m}$$

b) The tourist site also offers helicopter sightseeing tours. A passenger in one of the helicopters drops their phone while trying to take a photo of the scenery. When the phone is dropped, the helicopter is 200 m above the ground and travelling at a horizontal speed of 50.0 m s^{-1}. **3**

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

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Marking Criteria	Marks
• Provides the correct solution.	**3**
• Calculates the phone's time of flight	**2**
• Provides some relevant working .	**1**

ay = 9.8 m s^{-2}
ax = 0 m s^{-1}
u = 50 m^{-1}
The angle of projection is 0° because the phone was dropped from the helicopter. Therefore:

$$u_x = u\cos\theta$$
$$= 50\cos(0)$$
$$= 50 \text{ m s}^{-1}$$
$$u_y = u\sin\theta$$
$$= 50\sin(0)$$
$$= 0 \text{ m s}^{-1}$$

Calculating the phone's time of flight gives:

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

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

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

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

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

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

$$s_x = u_x t$$

$$= 50.0 \times 6.38\ldots$$

$$= 319 \text{ m}$$

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

Question 22 (3 marks)

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

Marking Criteria	Marks
• Correctly calculates lowest observed frequency	**3**
• Shows some working to determine lowest observed frequency	**2**
• Provides some relevant information	**1**

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

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

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

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

Question 23 (7 marks)

A race car is moving around a banked circular track that has a radius of 90.0 m and an angle of banking of θ degrees, as shown in the diagram.

The car has a constant speed.

a) On the diagram, clearly show all of the forces acting on the car using labelled arrows. **2**

Marking Criteria	Marks
• Forces acting identified with correct labels and arrows (Gravity/Weight and Normal)	**2**
• One force identified correctly with arrow and label	**1**

b) If the angle of banking is 10°, find the speed necessary so that no sideways force needs to be exerted between the tyres and the track. **3**

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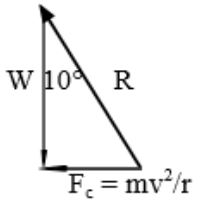
Marking Criteria	Marks
• Correct calculations made to show correct answer given	
• Some appropriate steps towards correct answer made but with an error	**2**
• A correct step (diagram or calculation) shown	**1**

Find the car's speed when angle of banking is 10°:
Assume net force equals centripetal force
Use: reaction force + weight force = centripetal force:



So: $\tan 10° = [mv^2/r]/mg$

$$v = \sqrt{gr\tan 10°}$$
$$= \sqrt{9.8 \times 90.0 \times \tan 10°}$$
$$= 12.5 \text{ m s}^{-1}$$

Question 24 (8 marks)

a) Calculate the centripetal acceleration of the Earth as it orbits the Sun.
Use 1.50×10^{11} m as the radius of Earth's orbit. **3**

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Marking Criteria	Marks
• Correct answer provided	**3**
• Appropriate calculations and assumptions made with an error or omission	**2**
• A correct step or calculation shown	**1**

$$a_c = \frac{v^2}{r} \quad \text{where } v = \frac{2\pi r}{T} = \frac{2\pi \times (1.50 \times 10^{11})}{365 \times 24 \times 60 \times 60} = 2.99 \times 10^4 \text{ m s}^{-1}$$
$$= \frac{(2.99 \times 10^4)^2}{1.50 \times 10^{11}}$$
$$= 5.95 \times 10^{-3} \text{ m s}^{-2} \text{ towards the Sun}$$

A 1,500 kg spacecraft orbits the Earth at a distance of 4.00×10^7 m and completes an orbit in 6.00 hours; how much does the centripetal force exerted on the spacecraft while in orbit differ from the gravitational force if it was on the surface? **3**

$$v = \frac{2\pi R}{T}$$
$$v = \frac{2\pi \times 4.00 \times 10^7 m}{21600 s} = 11635.528\, ms^{-1}$$

$$a_c = \frac{v^2}{R} = 3.3846 m_s^{-1}$$
$$F_c = ma_c = 1500 \times 3.3846 = 5076.96N$$
$$F_g = m \cdot g = 1500 \cdot 9.81 = 14715N$$
$$\Delta F = 14715 - 5076.96 = 9510.04N$$

Marking Criteria	Marks
• Correct answer with working provided and correct amount of significant figures used.	**3**
• Several steps of relevant working provided but an error made	**2**
• A correct step towards the answer provided	**1**

b) Referring to Kepler's laws, describe how Earth's centripetal acceleration varies as its orbit takes it closer to the Sun and further away each year. **3**

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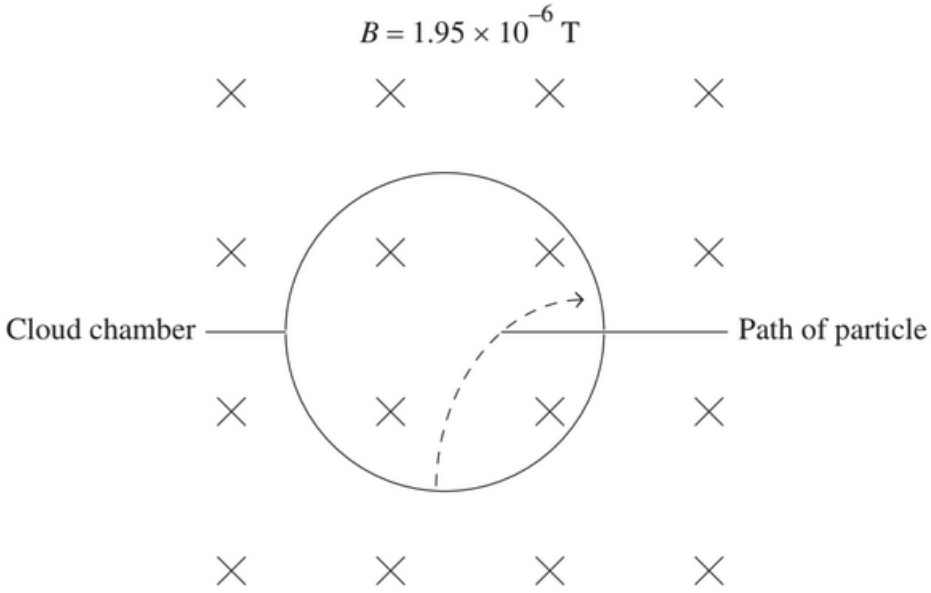
Marking Criteria	Marks
• Correct description of variation provided and linked to more than one of Kepler's Laws	**3**
• Correct description of variation provided but not linked to more than one of Kepler's Laws	**2**
• One aspect of the variation in a_c is referenced	**1**

Kepler's first law states that the orbit of the planets is elliptical, so that the radius of the orbit – i.e. distance between Earth and Sun, varies over the course of a year. When closer, Earth's orbital speed increases (as also stated by Kepler's third law – equal areas are swept out by a planet's orbit in equal time). This has the consequence of increasing Earth's centripetal acceleration, given $a_c = v^2/r$. The opposite occurs when Earth is further from the Sun, and its a_c decreases

Question 25 (5 marks)

A particle in an accelerator reaches a velocity of 2.50×10^4m s^{-1} before entering a Wilson cloud chamber. The cloud chamber is in a uniform magnetic field of 1.95×10^{-6} T. The diagram illustrates the particle's path as observed in the cloud chamber.



a) Identify whether the particle is positively or negatively charged and justify your response. **2**

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Marking Criteria	Marks
• Correctly identifies it as negatively charged and states a correct reason	**2**
Correctly identifies it as a negatively charged BUT does not state a correct reason	**1**

negatively charged (as B is into the page and the particle arcs to the right)

b) The radius of the particle's path is 5.0 cm.
Show that the charge-to-mass ratio of the particle is 2.6×10^{11} C kg^{-1} **3**

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Marking Criteria	Marks
• Substitutes into the relevant formula correctly	**3**
• Attempts to substitute into the relevant formula	**2**

• Identifies the relevant formula	**1**

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

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

$$\frac{q}{m} = \frac{v}{rB}$$

$$= \frac{2.50 \times 10^4}{0.050 \times 1.95 \times 10^{-6}}$$

$$= 2.6 \times 10^{11} \text{ C kg}^{-1}$$

Question 26 (7 marks)

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

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

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{9.109 \times 10^{-31} \times 2 \times 10^{7}} = 3.6 \times 10^{-11} \text{ m}$$

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

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

Davisson and Germer's experiment involved scattering electrons off a nickel crystal and observing the resulting diffraction pattern. This pattern, similar to that produced by light waves, confirmed the wave-like behaviour of electrons. Since diffraction is a wave phenomenon, their results supported de Broglie's theory that particles, like electrons, exhibit wave properties. This was a key experimental validation of the concept of matter waves.

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

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

Since wavelength is inversely proportional to mass, a larger mass reduces wavelength to values that are undetectable or meaningless. As per the relationship, $\lambda = \frac{h}{mv}$.

Question 27 (4 marks)

a) How far above the Earth's surface will an object need to ascend for the acceleration of gravity to be half what it is at the surface? **2**

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Marking Criteria	Marks
• Correctly determines the height at which g is half	**2**
• Provides some relevant information	**1**

The acceleration due to the Earth's gravity at a location at or above the surface is given by $g = GM_{\text{Earth}}/r^2$, where r is the distance from the center of the Earth to the location in question. Find the location where $g = \frac{1}{2} g_{\text{surface}}$.

$$\frac{GM_{\text{Earth}}}{r^2} = \frac{1}{2}\frac{GM_{\text{Earth}}}{R_{\text{Earth}}^2} \rightarrow r^2 = 2R_{\text{Earth}}^2 \rightarrow r = \sqrt{2}R_{\text{Earth}}$$

The distance above the Earth's surface is as follows:

$$r - R_{\text{Earth}} = \left(\sqrt{2}-1\right)R_{\text{Earth}} = \left(\sqrt{2}-1\right)(6.38\times10^6 \text{ m}) = \boxed{2.64\times10^6 \text{ m}} = 0.414\ R_{\text{Earth}}$$

b) How long would a day be if the Earth were rotating so fast that objects at the equator were apparently weightless?

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Marking Criteria	Marks
• Correctly determines the length of the day where weightlessness occurs at the equator.	**2**
• Provides some relevant information	**1**

For an object to be apparently weightless, the object would have a centripetal acceleration equal to g. This is the same as asking what the orbital period would be for an object orbiting the Earth with an orbital radius equal to the Earth's radius. To calculate, use $g = a_R = \frac{v^2}{R_{Earth}}$, along with $v = 2\pi R_{Earth}/T$, and solve for T.

$$g = \frac{v^2}{R_{Earth}} = \frac{4\pi^2 R_{Earth}}{T^2} \rightarrow T = 2\pi\sqrt{\frac{R_{Earth}}{g}} = 2\pi\sqrt{\frac{6.38\times10^6 \text{ m}}{9.80 \text{ m/s}^2}} = \boxed{5.07\times10^3 \text{ s}} (\approx 84.5 \text{ min})$$

Question 28 (8 marks)

A Physics student is provided with two pairs of polarised sunglasses and a light source of polarised light.

a) The two sunglasses are oriented at 42.0° to one another. The light source is polarised at a 21.0° angle.
What percentage of incoming intensity is transmitted once it has passed through both sunglasses? **2**

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Marking Criteria	Marks
• Correctly determines the transmitted intensity as a percentage	**2**
• Provides some relevant working	**1**

The angle between the light and the polariser for the first transmission is 21.0°, and for the second transmission, it is 42.0°.
$I_1 = I_0 \cos 21.0°$; $I_2 = I_1 \cos 42.0° = I_0 (\cos 21.0°)(\cos 42.0°) = 0.4813I0$
Thus, the transmitted intensity is 48.1% of the incoming intensity.

b) Discuss how polarisation can be explained by comparing the particle model and wave models of light. **5**

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Marking Criteria	Marks
• Outlines polarisation. AND • Explains that polarisation cannot be explained by the particle model of light. AND • Explains that polarisation cannot be explained by the longitudinal wave model of light. AND • Outlines electromagnetic waves. AND • Explains how polarisation supports the transverse wave model of light	**5**
• Any FOUR of the above points	**4**
• Any THREE of the above points	**3**
• Any TWO of the above points	**2**
• Provides some relevant information	**1**

If light passes through one polariser and then passes through a second polariser that is perpendicular to the first, then none of the light that passes through the first polariser will pass through the second. Newton's particle model of light cannot explain this because it describes light as a stream of particles, which should pass through both polarisers. Explaining polarisation with Huygens' longitudinal wave model is also impossible. Longitudinal waves cannot be polarised because the direction of oscillation of a longitudinal wave is parallel, not perpendicular to the direction of propagation.

Polarisation supports the transverse wave model of light. According to this model, light waves are electromagnetic waves with an electric field and a magnetic field that oscillate perpendicular to each other. This means that a polariser can pass through or block the electric and magnetic fields depending on its polarisation axis.

5

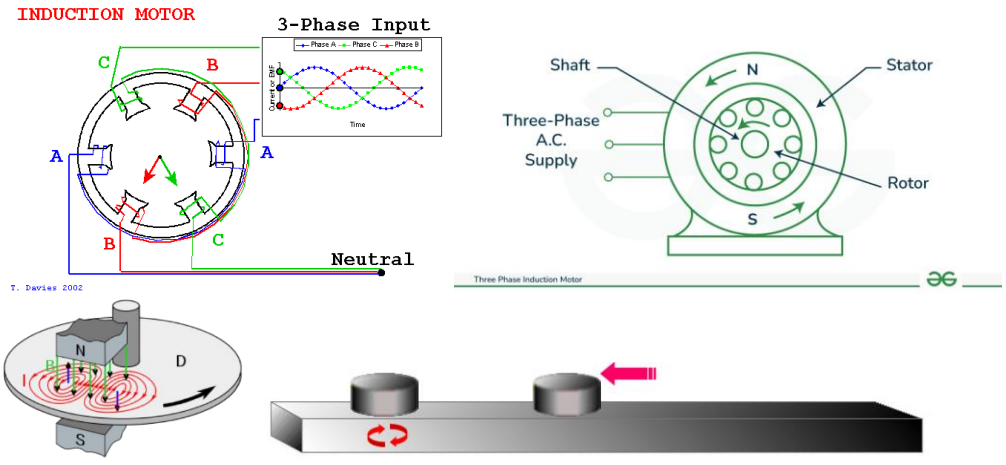
Question 29 (5 marks)

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

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

AC induction motors and EM braking both fundamentally rely on EM induction concepts as dictated by Faraday's law and Lenz's law. Both systems do not involve physical contact between the moving parts reducing damage and hence ongoing maintenance costs.
AC induction motors are based on having the rotor constructed in the form of a "squirrel" cage with two rings at each end connected by conducting rods. The stator is made up of 3 sets of electromagnetic coils which are out of phase to each other by 120 degrees, arranged radially around the rotor. When current is fed through the stator coils it creates an apparent rotating magnetic field due to the phase difference. As stated by Faraday's law, the rotor will experience that change in flux, so there will be induced emf, and hence induced current which induces its own magnetic field. The cage will rotates to reduce the relative motion between the rotor and the apparent rotating magnetic field according to Lenz's law to oppose the change that is causing the induction.

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



Markers feedback:

Common errors

- *EM braking explained only via an experimental set up of a rotating disc in a field rather than linking it back to the braking system used in trains or in amusement park rides.*
- *For AC induction the how the rotating magnetic field is obtained and its role not clearly linked to the effect.*

Question 30 (5 marks)

A physicist conducted an experiment using a transformer. The results of the experiment are recorded in the table.

	Primary Coil	*Secondary Coil*
Voltage (V)	120	?
Current (mA)	3.0	30
Number of turns	?	5

a) If the transformer is 100% efficient, determine the secondary voltage and the number of turns in the primary coil. **2**

Marking Criteria	Marks
• Calculates V_s AND • Determines N_p	**2**
• Provides some relevant working	**1**

$$V_p I_p = V_s I_s$$

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

$$= \frac{120 \times 3.0}{30}$$

$$= 12 \text{ V}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$N_p = \frac{V_p N_s}{V_s}$$

$$= \frac{120 \times 5}{12}$$

$$= 50 \text{ turns}$$

b) A 95 W transformer is installed and has an output voltage of 12 V and an input current of 25 A.
Determine if the transformer is a step-up or step-down transformer and by what factor the voltage multiplied. **3**

Marking Criteria	Marks
• Correctly determines the type of transformer AND • Calculates the factor in which the voltage is amplified	**3**
• Correctly determines the type of transformer AND • One error included in working out	**2**
• Provides some relevant working	**1**

We assume 100% efficiency and find the input voltage from $P = IV$.

$$P = I_P V_P \quad \rightarrow \quad V_P = \frac{P}{I_P} = \frac{95 \text{ W}}{25 \text{ A}} = 3.8 \text{ V}$$

Since $V_P < V_S$, this is a step-up transformer.

$$\frac{V_S}{V_P} = \frac{12 \text{ V}}{3.8 \text{ V}} = 3.2$$

Markers feedback:

Mostly done well. Common error – swapping the primary voltage with secondary.

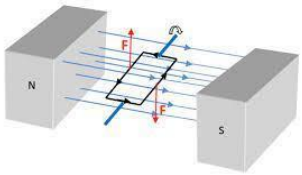
Question 31 (5 marks)

Using relevant equations and diagrams, describe how the motor effect plays a part in the operation of a simple DC electric motor.

Marking Criteria	Marks
• Relevant equations and diagrams used to clearly describe the role of the motor effect in the operation of a DC motor	**5**
• As above but with an error or omission	**4**
• Motor effect is explained correctly • Several relevant equations	**3**
• Several correct aspects of the motor effect and/or the operation of a DC motor identified • At least one relevant equation stated	**2**
• A correct aspect of the motor effect or the operation of a DC motor identified	**1**

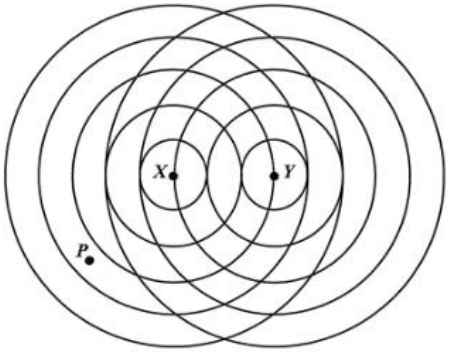
Sample Answer:
The motor effect is quantified by the formula F = BIlsinθ where a current carrying conductor is within a magnetic field, the current and field being at an angle θ to each other.

To turn a DC motor, torque $\tau = nIA_{\perp}B$. In the case of a simple DC motor, 2 sides of a rectangular loop within a magnetic field have a force acting on them due to the motor effect. The force on side AB is down and up on side CD. This force is in opposite directions as the current is flowing around the loop so a net torque is produced.
In the diagram, the torque produced is clockwise, from the arrows showing the forces on the two sides of the loop where I is perpendicular to B. Once the motor turns 180 degrees, the current direction has to reverse to obtain a unidirectional torque. The current direction is reversed by the split ring commutator.



Question 32 (6 marks)

Two in-phase point sources, *X* and *Y*, are 0.30 m apart and produce identical waves with an amplitude of 0.26 m. The diagram has marked Point *P*, midway between wavefronts from *X*.



(a) Predict the amplitude of the interference of the waves at Point *P* at the instant shown. Justify your answer.

Marking Criteria	Marks
• Identifies amplitude and destructive interference	**2**
• Identifies amplitude OR destructive interference	

Sample Answer:
At point P, the wave from X is a trough, and from Y, it is a crest. AS the waves will cancel, it is a position of destructive interference with 0 amplitude.
Markers feedback:
Common error – interpreting the diagram as if there's no wavefronts from Y reaching the point P.

(b) Discuss how interference patterns were used to provide evidence for the nature of both light and matter.

Marking Criteria	Marks
• Shows a clear understanding of how the work of Young and Davisson and Germer, changed the previous models for the nature of light and matter, resulting in the acceptance of the dual nature of light and matter. • States how these experiments changed the existing models given by Newton changed to support Huygen's and deBroglie's.	**4**
• Outlines the work of Young and Planck changed the previous models for the nature of light and matter, resulting in the acceptance of the dual nature of light and matter.	**3**
• Outlines relevant work by Young and Planck	**2**
• Outlines relevant work by Young OR Planck	**1**

Sample Answer:
Initially, light was thought to be composed of particles, a view supported by Newton. However, Thomas Young's famous double-slit experiment revealed an interference pattern, which showed light behaving as a wave, contradicting the particle theory. This wave-like

pattern, characterised by alternating bright and dark fringes, supported the wave model of light. This supported Huygen's wave model of light.

The nature of matter was also reconsidered when the Davisson and Germer experiment showed that electrons, previously thought to be only particles, could produce interference patterns when scattered off a crystal and the wavelength was found to support deBroglie's matter wave through calculations. This diffraction pattern, similar to light's interference, provided compelling evidence that electrons exhibit wave properties under certain conditions. Thus, light and matter were recognised to possess dual wave-particle characteristics, shaping our modern understanding of quantum mechanics.

Markers feedback:

Common error –Only mentioned about the experiments but failed to DISCUSS how they shaped our understanding of light and matter. Many students did not mention the existing models and/or which models/predictions were supported through these experiments.

Question 33 (7 marks)

Diagram 1 shows a small section of the spectrum for a mixture of gaseous elements.

Diagram 1

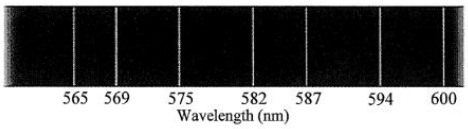
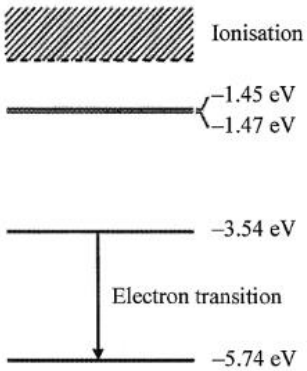


Diagram 2 shows the electron energy levels for a gaseous element *X*.

Diagram 2



A physics student states that the spectral line produced when an electron falls from the -3.54 eV energy level to the -5.74 eV level proves that element *X* is one of the gases in the mixture. Critically evaluate the student's statement using your understanding of how spectral lines are produced.

Marking Criteria	Marks
• Shows a clear understanding of the production of spectral lines and their wavelength - 1 • Calculates the wavelength correctly - 3	**7**

• Provides a judgement by relating it to the evidence in diagram 1 - 1 • Explains a reason why more evidence is needed - 2	
• Shows a clear understanding of the production of spectral lines and their wavelength and calculates the wavelength correctly • States a reason why more evidence is needed	**6**
• Shows a good understanding of the production of spectral lines and their wavelength and calculates the wavelength correctly • States evidence that supports the student's statement	**4-5**
• Shows some understanding of the production of spectral lines and attempts to calculate the wavelength	**2-3**
• Provides some relevant information	**1**

Spectral lines are produced when an electron in an excited state moves from a higher energy level to a lower energy level emitting a photon of which the wavelength depends on the energy difference.

Energy change for the transition shown $= 5.74 - 3.54$ eV $= 2.2$ eV

$= 2.2 \times 1.6 \times 10^{-19} = 3.52 \times 10^{-19}$ J

$$\Delta E = hf = \frac{hc}{\lambda},$$

$$3.52 \times 10^{-19} = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$$

$$\lambda = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{3.52 \times 10^{-19}}$$

$$\lambda = 5.647 \times 10^{-7}\ \text{m} = 565\ \text{nm}$$

This is the wavelength for the far-left line in the spectrum which provides evidence supporting the student's statement.
The role of Science is to provide evidence supporting theories but can never 'prove' a theory or statement in the same way as mathematicians prove relationships. However, one line does not identify the element as different elements may have one or two identical spectral lines.
Further analysis would need to be done to provide more evidence to indicate the existence of element X in this mixture such as showing that one or more other lines match electron jumps for element X.

Markers feedback:
Most students calculated the wavelength correctly as 564nm.
Many gave a judgement that it does not match so the statement is incorrect – which is not completely valid. As it is very close to the 565nm line, it is still possible that element X is present in the sample, but further analysis is required.
Some students went on to calculate the wavelength for other transitions – excellent!
And at least 1 identified that there a systematic error of 1nm for all lines. – great data analysis.

Question 34 (5 marks)

A team of physicists conducted an experiment to investigate the photoelectric effect. They directed light of different frequencies at the surface of a particular metal. The maximum kinetic

energies of the electrons emitted by the metal were measured, and the data was recorded in the table.

Light Frequency ($\times 10^{14}$ Hz)	*Maximum kinetic energy of electrons (eV)*
5.6	0.01
6.0	0.18
6.5	0.41
7.1	0.70
7.9	0.97
8.8	1.31

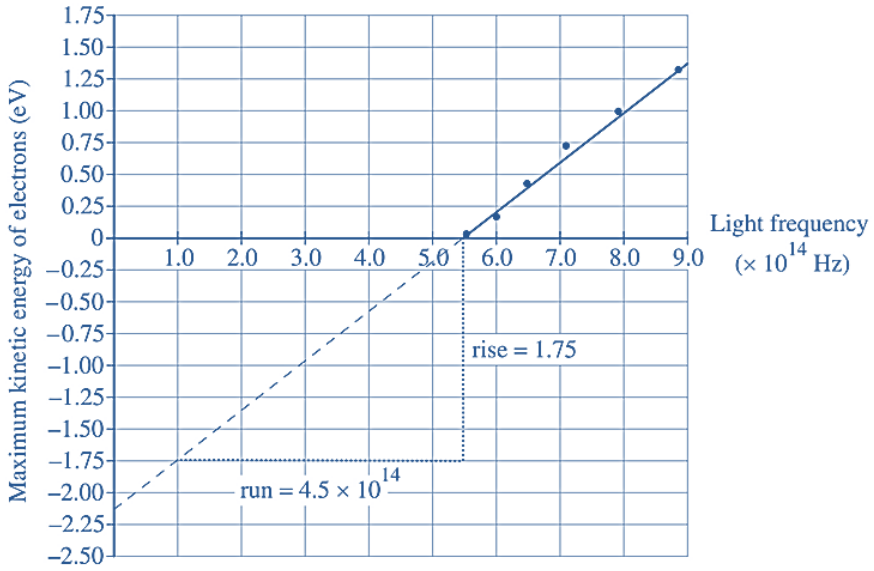
a) Plot the data on the axes provided and, using the plotted data:

- Determine the work function (ϕ) of the metal.

Calculate a value for Planck's constant

- **3**

Marking Criteria	Marks
• Plots all data points AND draws a line of best fit. AND • Determines f of the metal by extrapolating the line. AND • Calculates h by calculating the gradient of the line	**3**
• Any TWO of the above points	**2**
• Any ONE of the above points	**1**



$\phi = 2.13$ eV *(based on extrapolation of the line of best fit and identifying the y-intercept)*

$$h = \frac{\text{rise}}{\text{run}}$$
$$= \frac{0-(-1.75)}{(5.5\times10^{14}-1.0\times10^{14})}$$
$$= \frac{1.75}{4.5\times10^{14}}$$
$$= 3.9\times10^{-15} \text{ eV s}$$

Note: For the work function, ϕ, accept responses in the range 2.10–2.30 eV. For Planck's constant, h, accept responses in the range 3.5–4.5 × 10^{-15} eV s.

Markers feedback:
Mostly done well. Common error – not reading the question carefully which asked you to use the graph to find the work function and then Planck's constant.

b) The team of physicists direct light of wavelength 420 nm at the metal.
Using the values for ϕ and h from part a), determine whether the photoelectric effect will occur.

Marking Criteria	Marks
• Calculates the maximum kinetic energy of the electrons emitted. AND • Determines that the photoelectric effect will occur	**2**
• Calculates the maximum kinetic energy of the electrons emitted	**1**

$$K_{max} = \frac{hc}{\lambda} - \phi$$
$$= \frac{3.9\times10^{-15}\times3.00\times10^{8}}{4.20\times10^{-7}} - 2.13$$
$$= 0.66 \text{ eV}$$

Thus, as there is energy remaining from the photon after the electron has escaped the metal, photoelectric effect will occur.

2

Markers feedback:
Mostly done well. Common error – not using the info from part a but used the constant from the data sheet.

End of Section II

End of Examination