
Student Number

Barker College

Physics

2021 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

ANSWER SHEET

Staff Involved:

- MCA
- JVE
- CAD
- DCJ*

PM WEDNESDAY 18th AUGUST

70 COPIES

Section I – Multiple Choice
Choose the best response and fill in the response oval completely

Start Here →

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

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General Instructions:

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

Total marks: 100

Section I – 20 marks (pages 3 - 16)

- Attempt Questions 1 – 20
- Allow about 30 minutes for this section

Section II – 80 marks (pages 17 - 37)

- Attempt Questions 21 - 32
- Allow about 2 hours and 30 minutes for this section

Section I

20 marks
Attempt Questions 1 – 20
Allow 30 minutes for this section

Use Canvas to select your preferred response for Questions 1 – 20
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

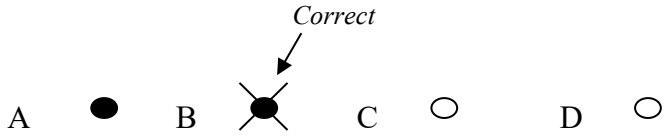
Sample 2 + 4 = A 2 B 6 C 8 D 9

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



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1. An efficient transformer will include a laminated iron core.

   What is the purpose of the laminations?

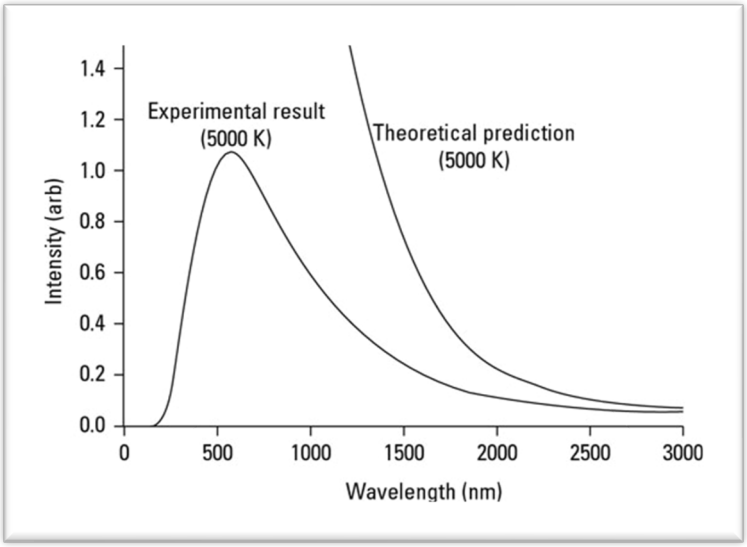
   A. To reduce the magnitude of eddy currents in the core.

   B. To increase the permeability of the core.

   C. To reduce the electrical resistance of the core.

   D. To reduce the flux linkage of the two coils through the core.

2. One of the factors leading to the development of a new quantum theory was the so-called "ultraviolet catastrophe" in the context of blackbody radiation spectra.



   This "ultraviolet catastrophe" refers to:

   A. Measurements could not be made when the object became too hot, such that it was emitting only ultraviolet radiation.

   B. Ultraviolet radiation from blackbody experiments was causing greater incidence of melanoma amongst scientists and their families.

   C. Despite agreement at lower frequencies between theory and measurement, as the frequencies of emission reach the ultraviolet region there is substantial divergence.

   D. Planck was concerned that his new quantum theory was not going to hold when blackbodies were exposed to high-intensity ultraviolet radiation.

3. A motor, battery, and ammeter are connected in series. When the motor is running at full speed, the ammeter has a reading of 0.10 A. While the motor is operating, a person holds the shaft of the motor and it stops.

Which row of the table CORRECTLY identifies the change in the ammeter reading and the reason for this change?

	Reading on ammeter	*Explanation*
A.	Decreases	Decrease in back emf
B.	Increases	Increase in back emf
C.	Decreases	Increase in back emf
D.	Increases	Decrease in back emf

4. An FM radio station transmits at a frequency of 103.2 MHz.

What is the energy, in electronvolts, of each photon of this frequency?

A. 4.268×10^{-13} eV

B. 6.838×10^{-26} eV

C. 6.838×10^{-23} eV

D. 4.268×10^{-7} eV

5. Nathaniel and Chelsea are both independently conducting an experiment to verify Newton's second law of motion.

Each is in a windowless train. Nathaniel's train is moving at constant $0.75c$, whilst Chelsea's train is slowing down at 5 m s^{-2}.

Which of the following statements is CORRECT?

A. Because the trains are windowless, both Nathaniel and Chelsea will produce results which verify Newton's second law.

B. Only Nathaniel's experiment will verify Newton's second law.

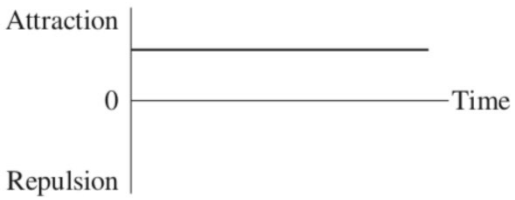
C. Chelsea's experiment might verify Newton's second law, but we would need to know how she controlled variables.

D. Newton's second law cannot be verified in a moving frame of reference.

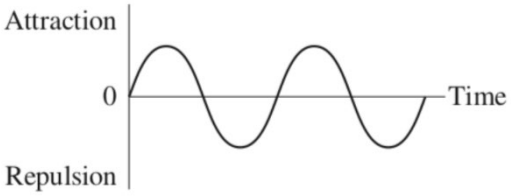
6. An AC supply is connected to a light globe by two long, parallel conductors, as shown.

Which graph shows the variation in time of the magnetic force between the parallel conductors?

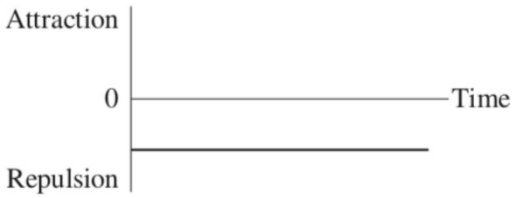
A.



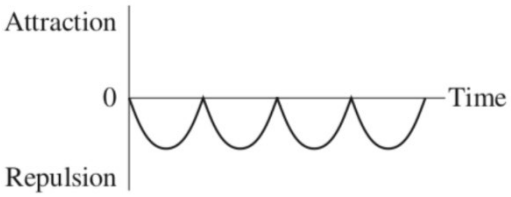
C.



B.



D.



7. The gravitational acceleration near Earth's surface is represented by *g*. Astronomers discover a new planet, P-36b, and estimate its mass to be three times that of Earth and with a radius half that of Earth.

Which of the following best approximates the gravitational acceleration on P-36b's surface?

A. 1.5*g*

B. 12*g*

C. 6*g*

D. *g* is unchanged (it is independent of location)

8. Two straight metal rods, *P* and *Q*, have the same length. They are each pivoted at one end and rotated with the same angular velocity so that they sweep out horizontal circular paths as shown in diagrams *X* and *Y*. A constant current *I* is flowing along each rod, as shown.

- In diagram *X*, a constant magnetic field is applied *at right angles to the plane* of the circular path.
- In diagram *Y*, a uniform magnetic field of the same magnitude is applied *in the plane* of the circular path.

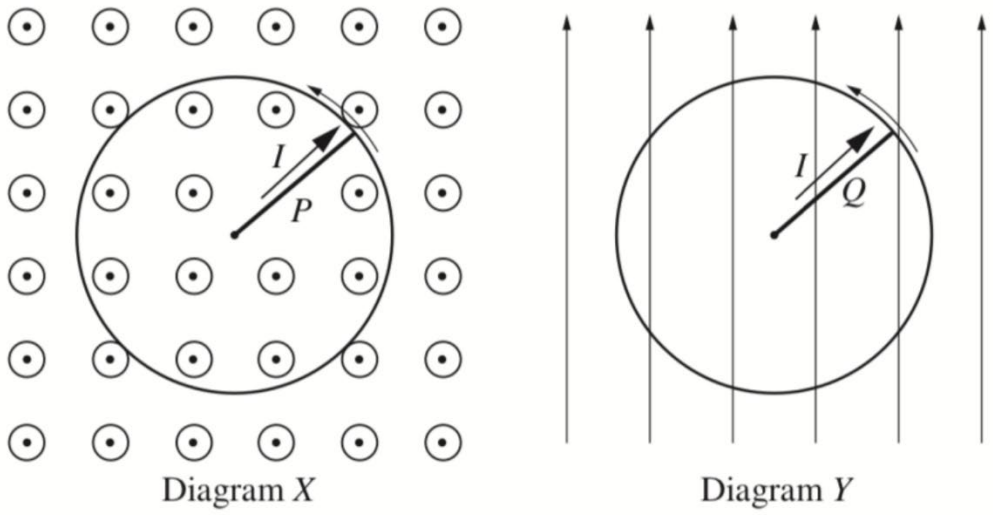


Diagram *X* Diagram *Y*

Which of the following statements about the forces acting on rod *P* and rod *Q* is CORRECT?

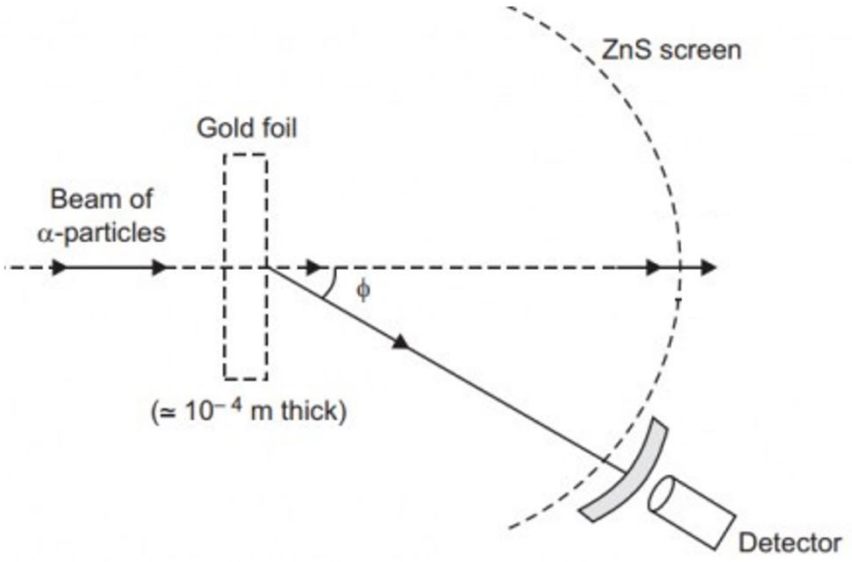
A. The magnitude of the force on *P* is always the same as the magnitude of the force on Q.

B. The magnitude of the force on *P* is constant and the magnitude of the force on *Q* varies continually.

C. The magnitude of the force on *P* is constant and the magnitude of the force on *Q* is zero.

D. The magnitude of the force on *P* varies with time and the magnitude of the force on *Q* is constant.

9. In 1909, students of Rutherford, Geiger and Marsden, performed a series of experiments whereby alpha particles (α-particles) were fired towards a very thin layer of gold foil and their subsequent paths measured by a detector.



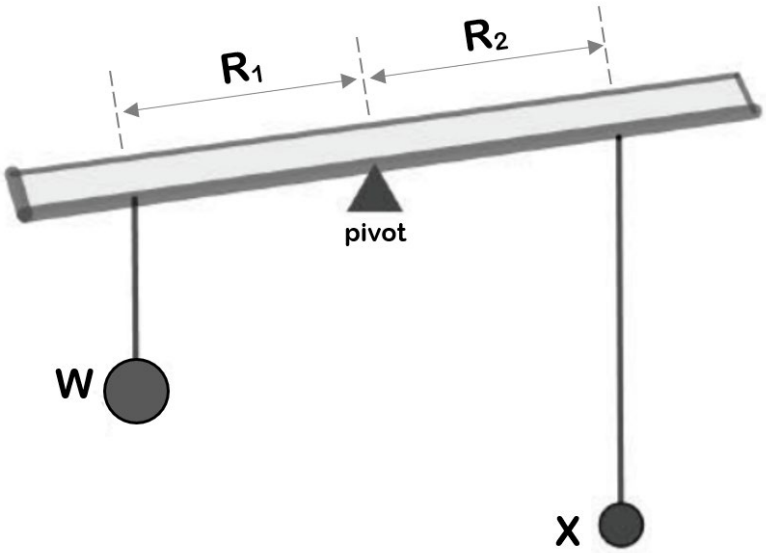
Which of the following rows CORRECTLY identifies their hypothesis and the corresponding observation of the α-particles?

	Hypothesis	***Observation***
A.	Most α-particles will be deflected through substantial angles (i.e. > 90°) during interaction with gold foil.	α-particle deflections consistent with hypothesis.
B.	Most α-particles will be absorbed by the nuclei of the gold foil.	All α-particles went straight through the gold foil, with no deflection.
C.	Most α-particles will pass through the foil undeflected, with an occasional slight deflection due to interaction with an electron.	Most α-particle paths consistent with hypothesis, though ~ 0.013% were deflected through angles > 90°.
D.	Most α-particles will pass through the foil undeflected, with an occasional slight deflection due to interaction with an electron.	α-particle deflections consistent with hypothesis.

10. Consider a system with two spheres, W and X, each suspended from a light rod by string of negligible mass. The mass of W is twice the mass of X.

The rod, when not being held, is free to pivot about a point.

The following diagram represents the system whilst being held and is NOT TO SCALE.



When released, X is observed to accelerate downwards.

Based on this information, which of the following must be TRUE?

A. $R_2 > 2R_1$

B. $R_2 < 2R_1$

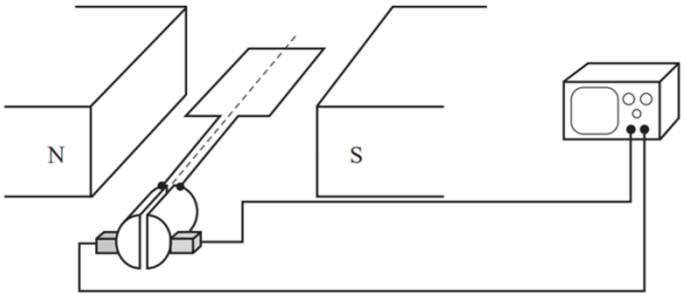
C. $R_2 = 2R_1$

D. $R_2 < R_1$

Questions 11 and 12 relate to the following stimulus:

Alex and Sophie are investigating the phenomenon of electromagnetic induction.

They set up an experiment, as per the diagram, where a generator (with a single 'coil') is rotated in a strong, uniform magnetic field. The loop is connected to an oscilloscope via a split-ring commutator.

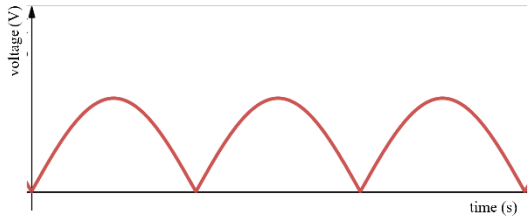
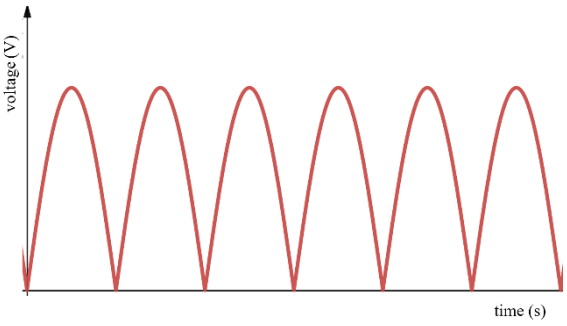
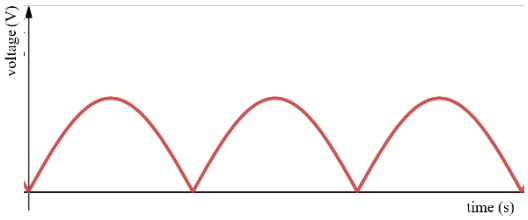
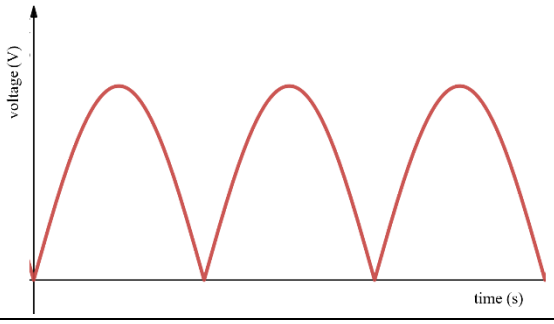
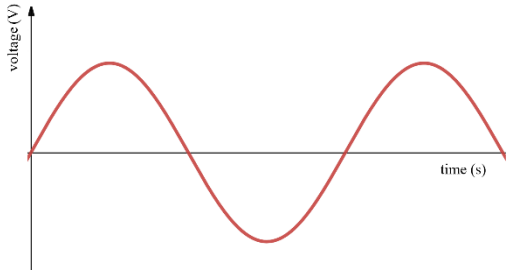
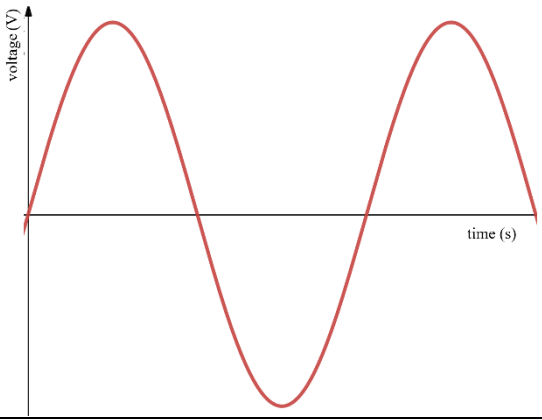
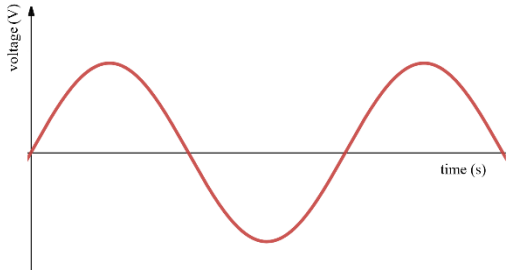
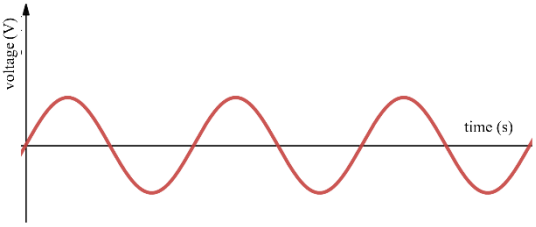


The coil is rotated at 50 revolutions per minute (rpm), then at 100 rpm, and finally at 150 rpm. In each case, the output on the oscilloscope shows the maximum voltage (*emf*) for each rotation speed.

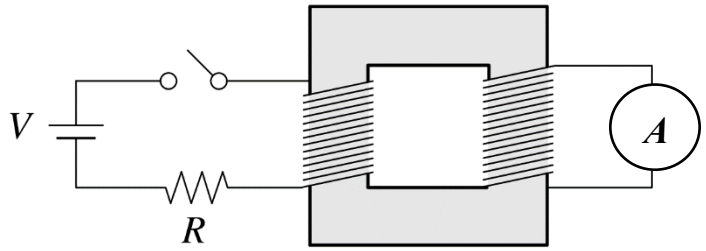
11. Which of the following CORRECTLY identifies the variables in this experiment?

	Independent variable	***Dependent variable***	***A controlled variable***
A.	speed of rotation	strength of magnetic field	maximum *emf*
B.	speed of rotation	maximum *emf*	strength of magnetic field
C.	maximum *emf*	speed of rotation	strength of magnetic field
D.	maximum *emf*	strength of magnetic field	speed of rotation

12. Which of the following could be the display on the oscilloscope for the 50 rpm and the 100 rpm, respectively?

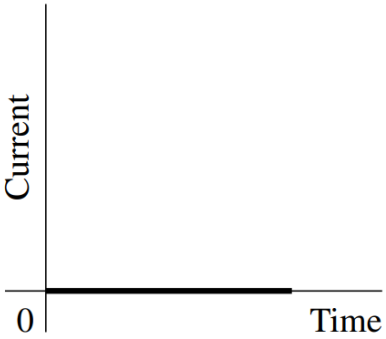
	Rotational speed of coil (rpm)	
	50	***100***
A.		
B.		
C.		
D.		

13. The primary coil of a transformer is connected to a battery, a resistor, and a switch. The secondary coil is connected to an ammeter.

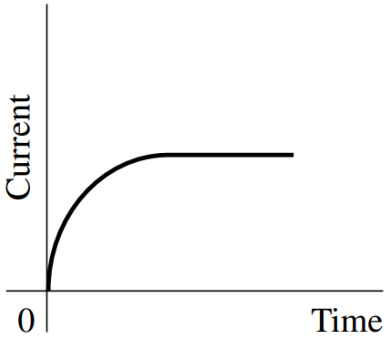


Which of the following graphs best represents the current in the secondary circuit when the switch is CLOSED?

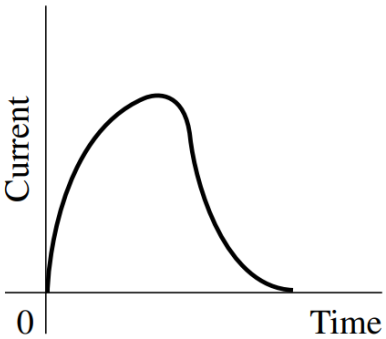
(A)



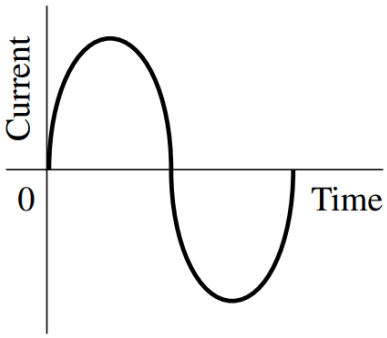
(B)



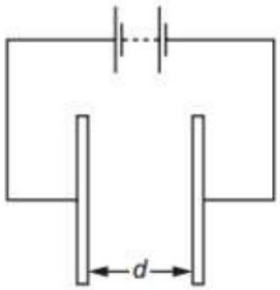
(C)



(D)

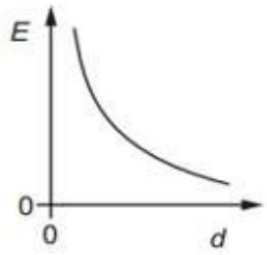


14. The diagram shows two metal plates connected to a constant high voltage.

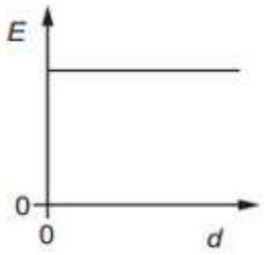


Which graph shows the variation of the electric field strength, E, midway between the two plates as the distance between the two plates is increased?

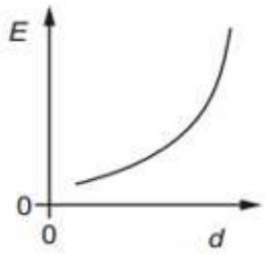
(A)



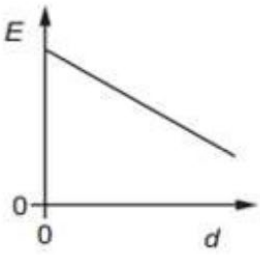
(B)



(C)



(D)



15. A laser, with a wavelength of 536 nm, is pointed through a card that has a pair of small slits cut into it. A wall, 5.54 m away, is used as a screen to record the pattern of bright spots, which are measured to be 3.30 cm apart.

Calculate the separation distance between the two slits.

A. 900 μm

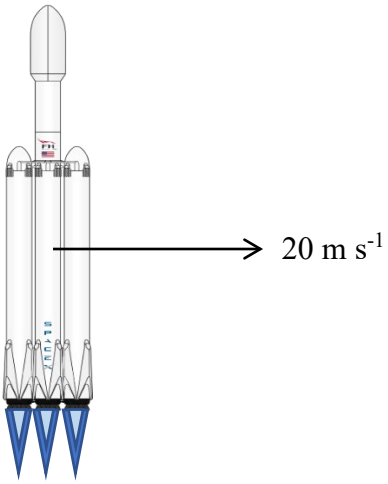
B. 341 μm

C. 31.9 μm

D. 90.0 μm

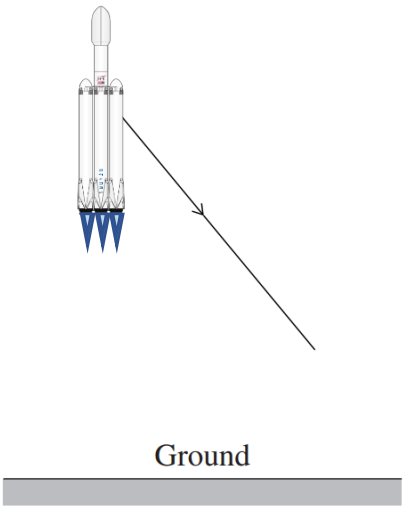
16. A multi-use rocket is returning to Earth after launching satellites, using its engines to make a controlled landing.

While travelling horizontally at 20 m s^{-1}, as shown in the diagram, the engines fire and the thrust becomes 63 kN upwards. At this time, the mass of the rocket is 7800 kg.

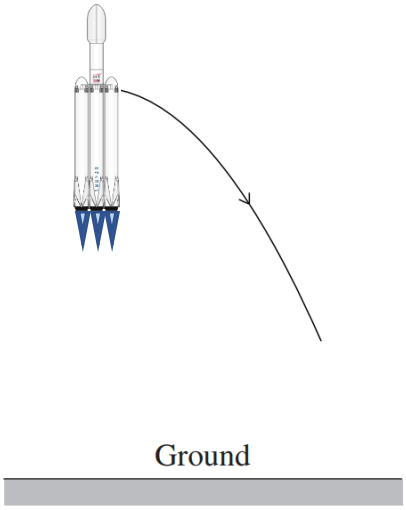


Which diagram shows the probable trajectory of the rocket if this thrust is maintained?

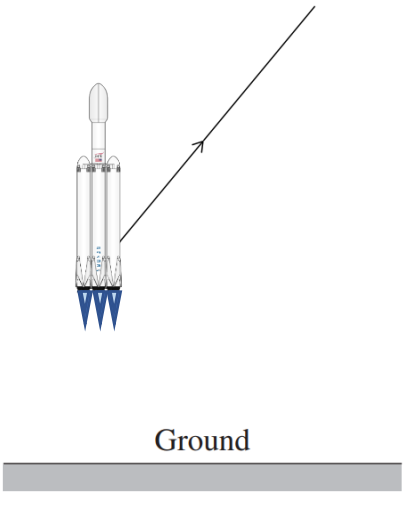
A.



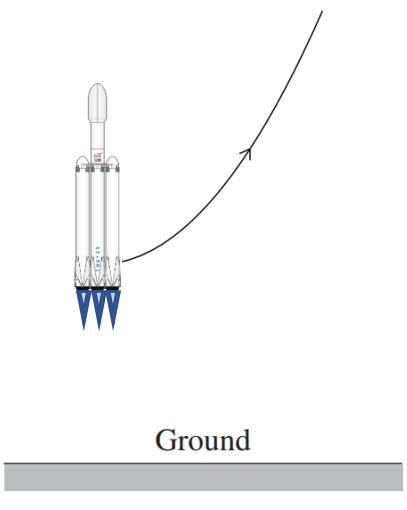
B.



C.



D.



17. A beryllium-8 nucleus, initially at rest, decays into two alpha particles:

$$^{8}_{4}\text{Be} \rightarrow {}^{4}_{2}\text{He} + {}^{4}_{2}\text{He}$$

The mass* of a beryllium-8 nucleus and alpha particle are given:

$^{4}_{2}$He	4.002603 amu
$^{8}_{4}$Be	8.005305 amu

*<u>Note</u>: *'amu' is another symbol used for 'u', the atomic mass unit.*

According to Einstein's mass-energy equivalence, the kinetic energy of ONE of the alpha particles is closest to:

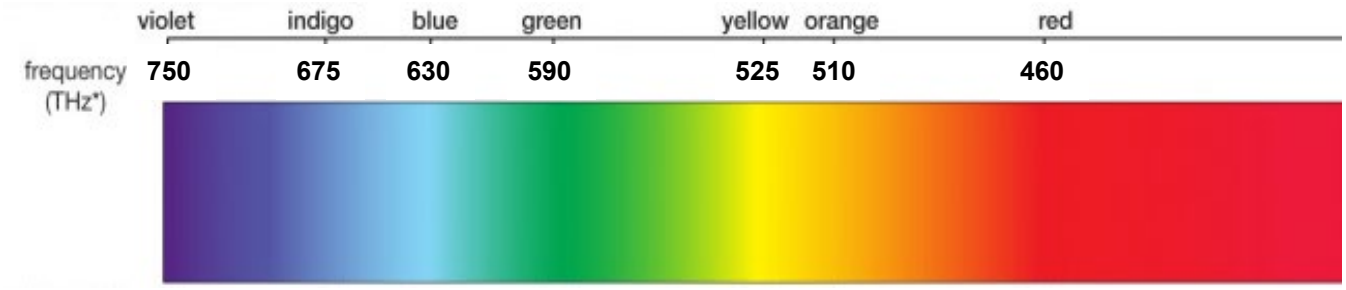
A. 46.2 keV

B. 92.4 keV

C. 65.0 keV

D. 180 keV

18. Through a telescope, a student observes a star as being 'yellow-orange' in colour. He recalls that stars can be considered black bodies.



Using the student's observation and the chart above (1 THz = 10^{12} Hz), the approximate surface temperature of this star is:

A. 4750 K

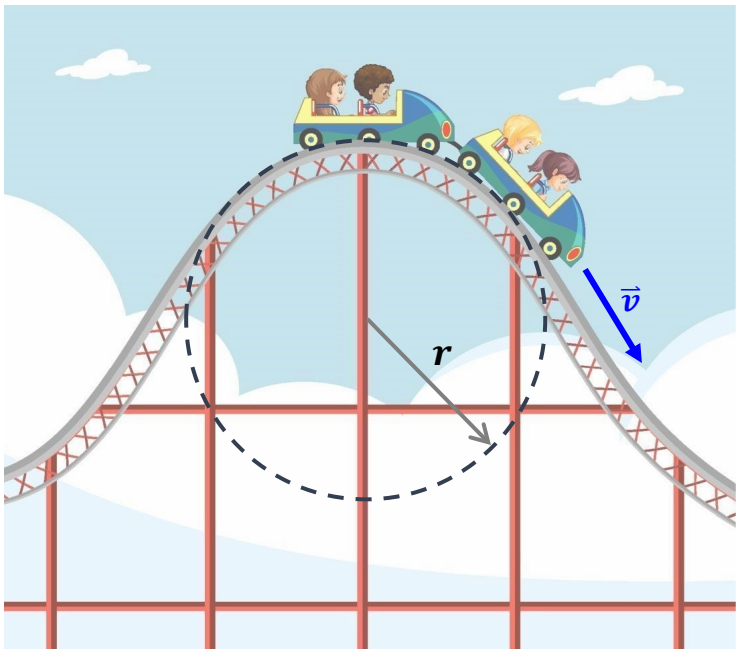
B. 5000 K

C. 5100 K

D. 5520 K

19. A rollercoaster car is moving fast, over the top of a circular segment of track, as depicted in the diagram below.

The radius of the circular segment is r.



Considering the interaction between an occupant and the seat, which of the following is the correct expression for the upwards force applied by the seat, $\vec{F}_{\text{seat}}$, on the occupant when the rollercoaster is going over the top of the circular segment?

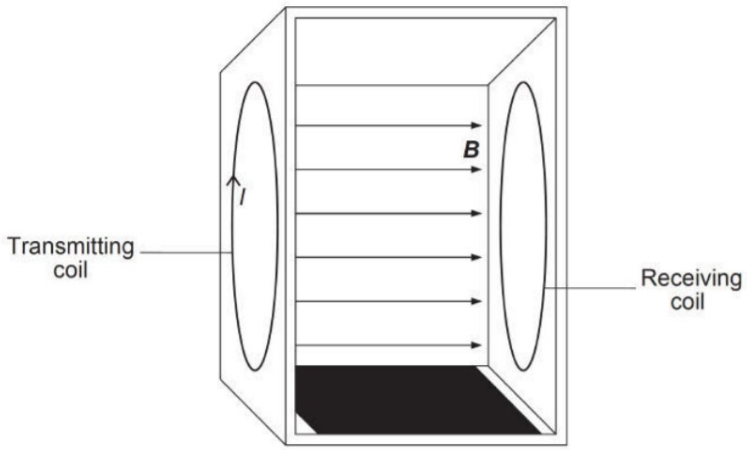
A. $\vec{F}_{\text{seat}} = mg + \frac{mv^2}{r}$

B. $\vec{F}_{\text{seat}} = m\left(g - \frac{v^2}{r}\right)$

C. $\vec{F}_{\text{seat}} = mg + F_{\text{normal}}$

D. $\vec{F}_{\text{seat}} = mg$

20. A simplified diagram representing an airport security gate is shown below.



The transmitting coil, on the left side, has an alternating current which induces a magnetic field within the gate.

The receiving coil, with radius 50.0 cm and consisting of 35 turns, experiences an induced *emf* of magnitude 28.5 mV.

Identify the rate at which magnetic flux density is changing within the receiving coil.

A. 1.04×10^{-3} Wb s^{-1}

B. 1.81×10^{-3} Wbs^{-1}

C. 3.63×10^{-3} Wb s^{-1}

D. 5.18×10^{-4} Wb s^{-1}

End of Section I

Student Number

Barker College

Physics

Section II Answer Booklet

80 marks

Attempt Questions 21 – 32

Allow about 2 hours and 30 minutes for this section

Instructions:

- Write your Student Number on every answer page.
- Answer the questions on lined paper. These spaces provide guidance for the expected length of response.
- BEGIN EACH NEW QUESTION ON A NEW PAGE.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Student Number

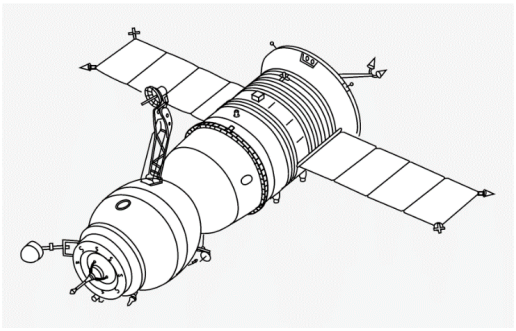
ANSWER THIS QUESTION ON A NEW PAGE

Question 21 (6 marks)

A telecommunications satellite is in low-Earth orbit at an altitude of 780 km (above sea level).

The mass of the satellite is 1500 kg.

The satellite is always in a circular orbit.



(a) Calculate the gravitational force between the Earth and satellite in its orbit. **2**

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(b) Calculate the speed of the satellite in its orbit. **2**

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(c) Engineers determine that its altitude must change to improve transmission.
The new altitude will be 67 km LOWER than its initial orbit.

Calculate the change in gravitational potential energy once the satellite is at its lower orbital altitude. **2**

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Student Number

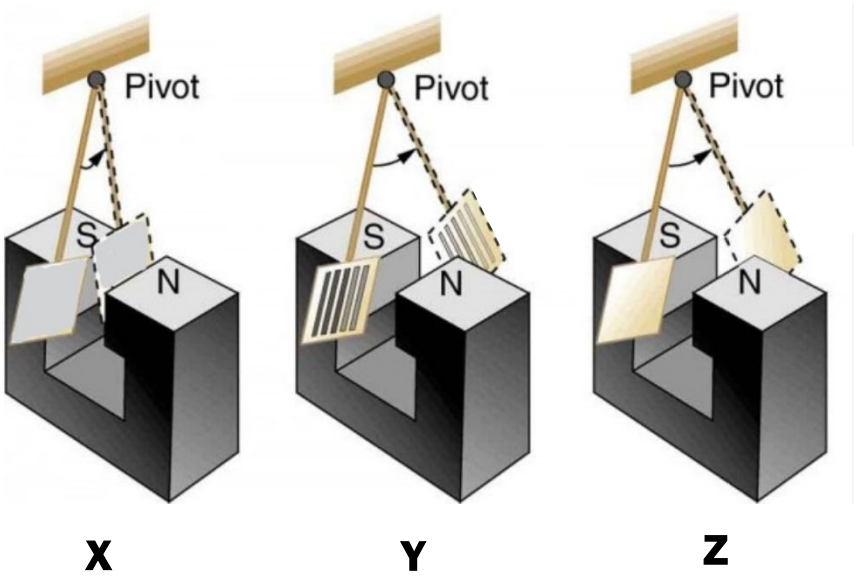
ANSWER THIS QUESTION ON A NEW PAGE

Question 22 (4 marks)

Consider the diagrams below, representing part of Sally's research into electromagnetism.

There are three square plates, each connected to a thin, rigid rod. Each plate can be attached to a frictionless pivot, allowing it to swing between the poles of a very strong, permanent magnet.

A simple experiment was conducted to observe the motion when each plate was released from the same position and allowed to swing into the magnetic field. The observations were recorded.



X **Y** **Z**

Plate used	Description of square plate	Observation after entering magnetic field
X	• Made from aluminium • Solid plate; no laminations or other materials.	Plate is quickly brought to rest; did not continue swinging out the other side.
Y	• Made from copper • Parallel 'slits' cut out of plate, leaving a grid-like appearance	Plate continued swinging through the magnetic field and out the other side.
Z	## material unknown ##	Plate continued swinging through the magnetic field and out the other side.

Question 22 continues on page 20

Student Number

Question 22 (continued)

(a) Based upon the observed motion of plate Z, propose a property of this plate. **1**

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(b) Explain why the solid plate X (made from aluminium, a non-magnetic material) is brought to rest so suddenly between the poles of the magnetic field. **3**

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End of Question 22

Student Number

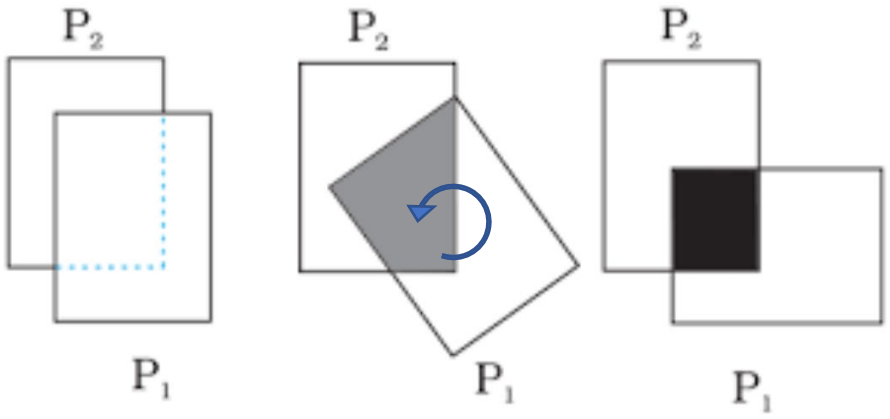
ANSWER THIS QUESTION ON A NEW PAGE

Question 23 (5 marks)

A teacher takes two pieces of 'polaroid' and holds them, one on top of the other, in front of a bright light globe.

One of the polaroids, P_1, is gradually rotated through 90°. As it rotates, you observe the section of the overlapping polaroids darkening until you cannot see any light coming through.

The teacher's demonstration is represented by a sequence of images, from left to right, below. (The source of the light is behind the polaroid, P_2.)



(a) State the model of light supported by the property of polarisation. **1**

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(b) Explain why, as one of the polaroids is rotated through 90°, that the intensity of light coming through the overlapping sections is reduced. **2**

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Question 23 continues on page 22

Student Number

Question 23 (continued)

(c) Calculate the angle between the plane-polarised light (which is the light that has transmitted through P_2) and the orientation of P_1, such that the polarised light observed from the overlapping section is reduced in intensity by 85%. **2**

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End of Question 23

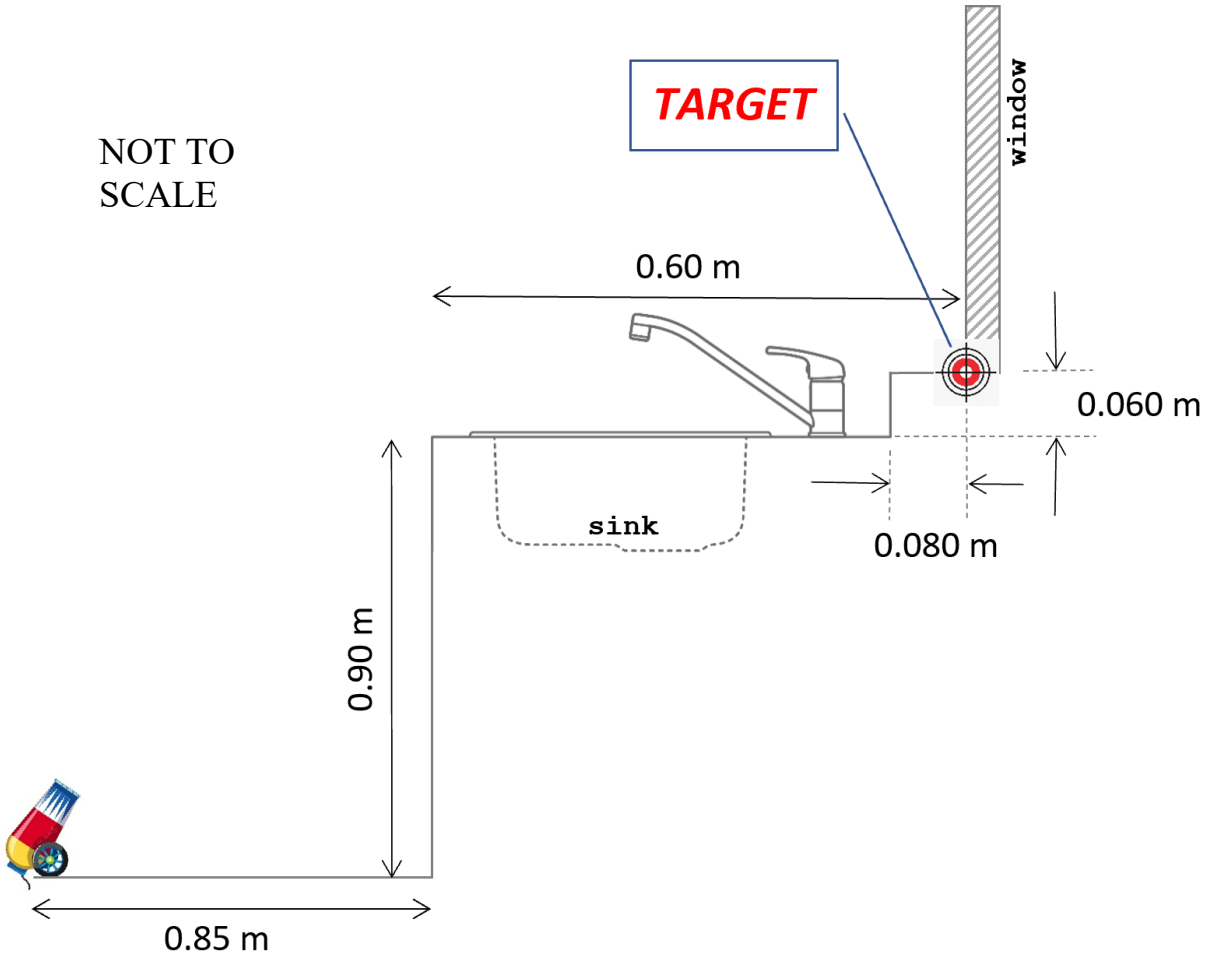
Student Number

ANSWER THIS QUESTION ON A NEW PAGE

Question 24 (5 marks)

Mr Johnston sees one of his children on the floor, playing with a 'cannon' toy, trying to get the projectile to hit a target on a windowsill behind the kitchen sink. Amazingly, the child hits the target first time!

A diagram of the scenario is shown below.



Mr Johnston measures the time for the projectile, from launch to target, as 0.66 s.

(a) State where in its trajectory the projectile is experiencing a maximum acceleration. Justify your answer. (Assume no air resistance and a uniform gravitational field.) **2**

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Question 24 continues on page 24

Student Number

Question 24 (continued)

(b) Show, with calculations, that the projectile was launched at a 65° elevation. **3**

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End of Question 24

Student Number

ANSWER THIS QUESTION ON A NEW PAGE

Question 25 (5 marks)

In 1905, Albert Einstein published his special theory of relativity.

(a) State the TWO postulates of Einstein's special theory of relativity. **2**

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(b) The length of a spaceship is measured by an outside observer to be 3.57 m as the spaceship passes with a speed of 0.850*c*. Calculate the speed the spaceship would be moving relative to the outside observer if its measured length was 2.50 m. **3**

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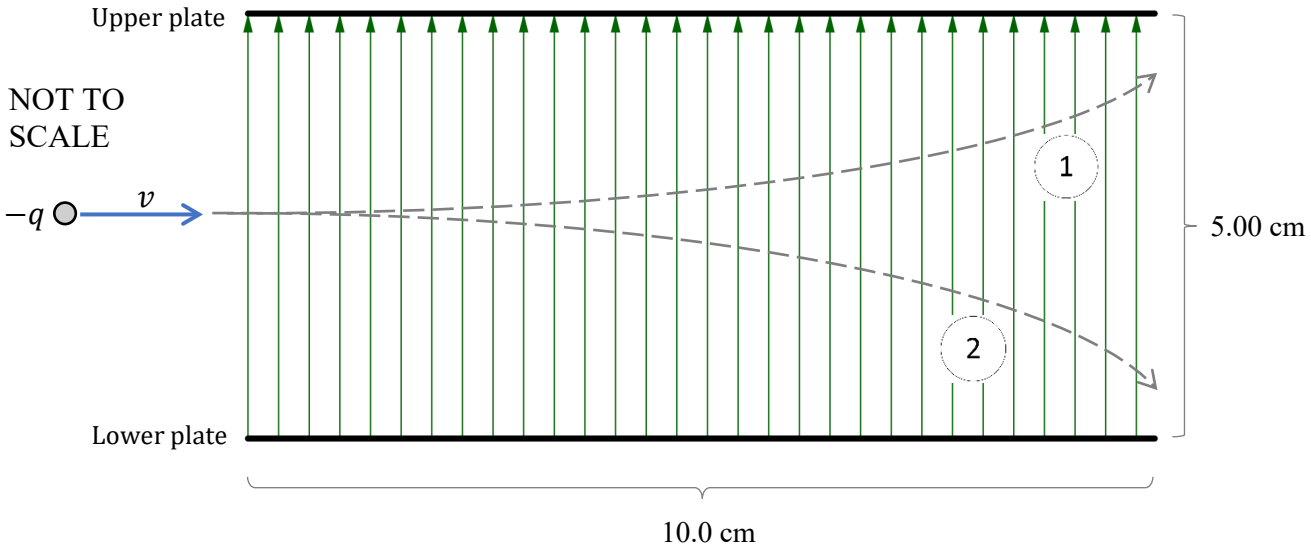
Student Number

ANSWER THIS QUESTION ON A NEW PAGE

Question 26 (8 marks)

The electric field between parallel plates is represented by vectors in the diagram below.

The plates are 5.00 cm apart and 10.0 cm in length. The electric field strength is $560\ \text{N C}^{-1}$.



(a) State which of the plates (either UPPER or LOWER) is the positively-charged plate. **1**

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(b) A charged particle, $-q = -0.80\ \mu\text{C}$, enters midway between the plates, initially travelling perpendicular to the electric field. Its velocity is $6.50 \times 10^5\ \text{m s}^{-1}$ (right).

i. Refer to the diagram. Predict which path – either (1) or (2) – the charge will follow. **1**

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ii. Calculate the force due to the electric field on the charged particle. **2**

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Question 26 continues on page 27

Student Number

Question 26 (continued)

iii. The mass of the charged particle is 5.00×10^{-16} kg.

Given the particle DOES NOT collide with either of the plates (i.e. it exits the field), calculate the work done on the particle due to the electric field. **4**

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End of Question 26

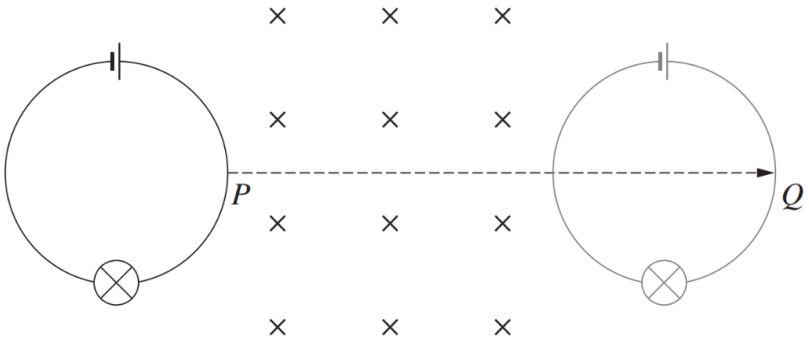
Student Number

ANSWER THIS QUESTION ON A NEW PAGE

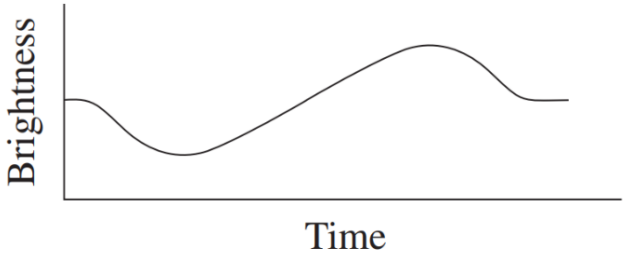
Question 27 (5 marks)

A circular loop of wire is connected to a battery and light globe.

The entire apparatus is moved from *P* to *Q* along the path shown, at constant velocity and through a region of uniform magnetic field.



A graph, with a sketch representing the brightness of the globe as the apparatus moves from *P* to *Q*, is shown below.



With explicit reference to the graph, and using your knowledge of the relevant physics, explain why the brightness of the globe changes in the way it does. **5**

- *You are encouraged to re-sketch the diagrams and/or graph, and refer to them in your response.*

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Student Number

ANSWER THIS QUESTION ON A NEW PAGE

Question 28 (13 marks)

(a) Outline how observations of the photoelectric effect were inconsistent with predictions based on a classical wave interpretation of light. **4**

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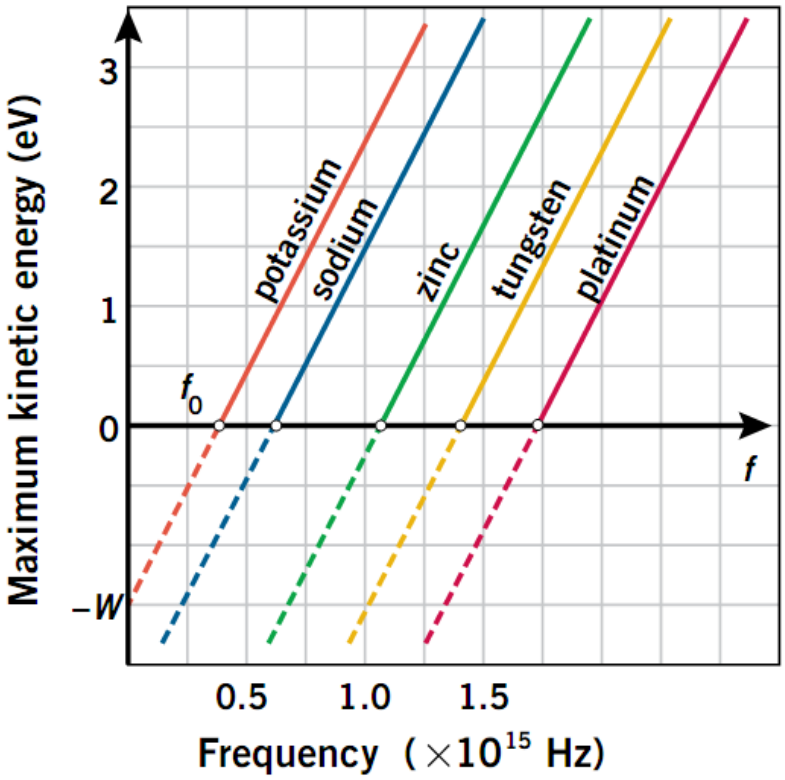
Question 28 continues on page 30

Student Number

Question 28 (continued)

(b) The graph below represents the maximum kinetic energies of photoelectrons when cathodes of different metals are irradiated with various frequencies of light.



(i) Using the graph, estimate the threshold frequency for zinc. **1**

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(ii) State why the gradient of the function lines for each metal are identical. **1**

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Question 28 continues on page 31

Student Number

Question 28 (continued)

(c) The lowest frequency at which photoelectrons are emitted from a metallic cathode in a photelectric cell is 5.66×10^{14} Hz.

A student shines a blue 'laser pointer' ($f_{blue} = 6.33 \times 10^{14}$ Hz) onto the cathode.

Calculate:

(i) The energy (in joules) of the incident photons. **2**

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(ii) The work function (in joules) of the metal. **2**

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(iii) The speed of the most energetic photoelectrons. **3**

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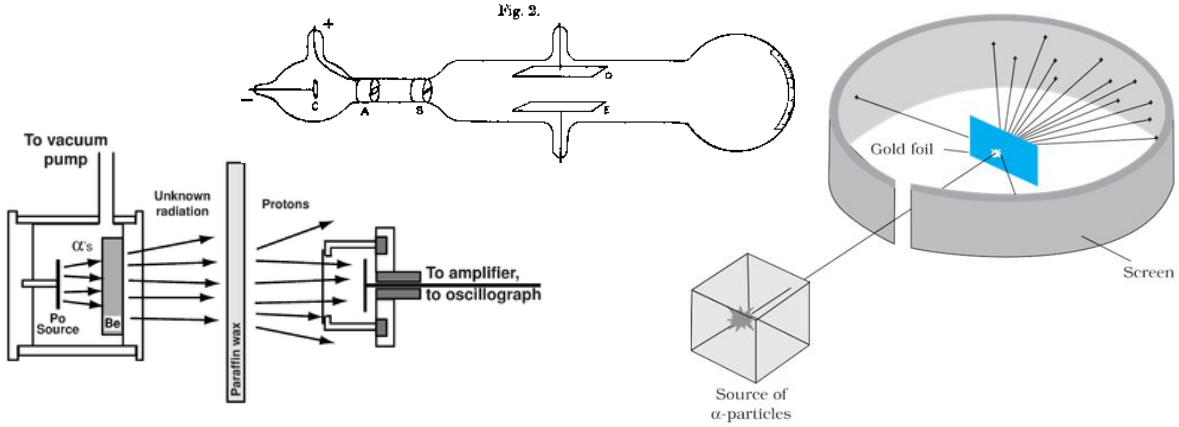
End of Question 28

Student Number

ANSWER THIS QUESTION ON A NEW PAGE

Question 29 (9 marks)

In the pursuit of the true nature of the atom, many experiments have been conducted. The measurements and observations from these experiments have often resulted in changes to the scientific model of the atom.



In the context of the development of the atomic model, referring to at least THREE experiments (and the associated changes they brought about), outline how scientific evidence has resulted in advancement of understanding.

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Student Number

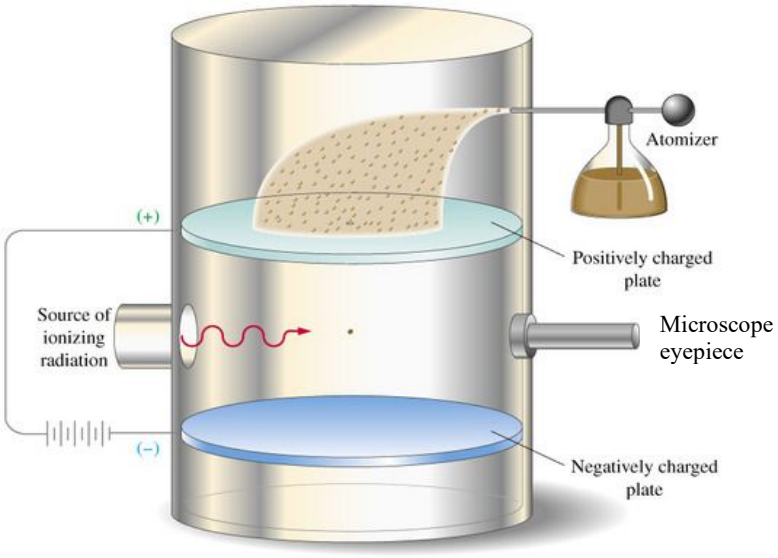
ANSWER THIS QUESTION ON A NEW PAGE

Question 30 (8 marks)

In 1909, Robert Millikan's "oil drop" experiment provided convincing evidence for the quantisation of charge and made a measurement of the elementary charge as being 1.592×10^{-19} C.

(a) Summarise the method Millikan used in his original "oil drop" experiment and explain how this allowed a valid measurement of the elementary charge. **4 marks**

(You may choose to refer to the provided diagram in your response.)



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Question 30 continues on page 34

Student Number

Question 30 (continued)

(b) For his Science Extension project, Adrian has reproduced Millikan's experiment.

He obtained the following measurements:

Oil drop number	Charge on oil drop (x 10^{-19} C)
1	+ 4.84
2	+ 6.37
3	+ 1.59
4	+ 3.93
5	+ 8.03

Assess the accuracy of Adrian's measurements, identifying any that you believe to have substantial error. Justify your response. **2**

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(c) In a lab at Sydney University, an oil droplet became charged after having 1000 electrons removed. This droplet was then suspended (put into equilibrium) in an electric field.

The electric field strength was $250\ \mathrm{N\ C^{-1}}$.

Calculate the mass of the oil droplet. **2**

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End of Question 30

Student Number

ANSWER THIS QUESTION ON A NEW PAGE

Question 31 (5 marks)

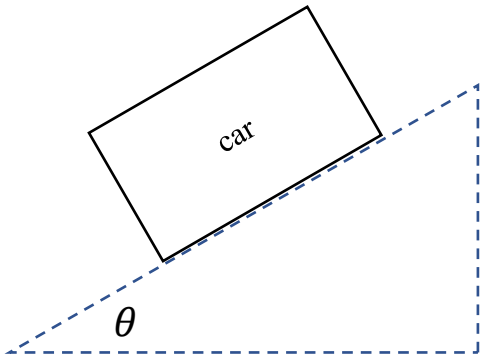
Engineers are designing a curved section of road on a motorway. They plan to make the radius of curvature 80.0 m and bank the curve at an angle of 23°.

For this type of road, government regulations require the following:

Motorists will travel at no more than 55 km/h around curved sections of road.

(a) REPLICATE the diagram below (represent the car with a box)
- Add LABELLED force vectors ('free body diagram') to represent a vehicle engaging in a <u>frictionless</u> turn on this banked corner. **2**

NOT TO SCALE



(b) With appropriate calculations, determine the speed at which a car can perform a frictionless* motion (maintaining height) around this banked, curved section of road, and assess the appropriateness of the engineers' choice of radius and banking angle. **3**

**<u>Note</u>: "Frictionless" refers to no laterial (sideways) friction between the tyres and the road.*

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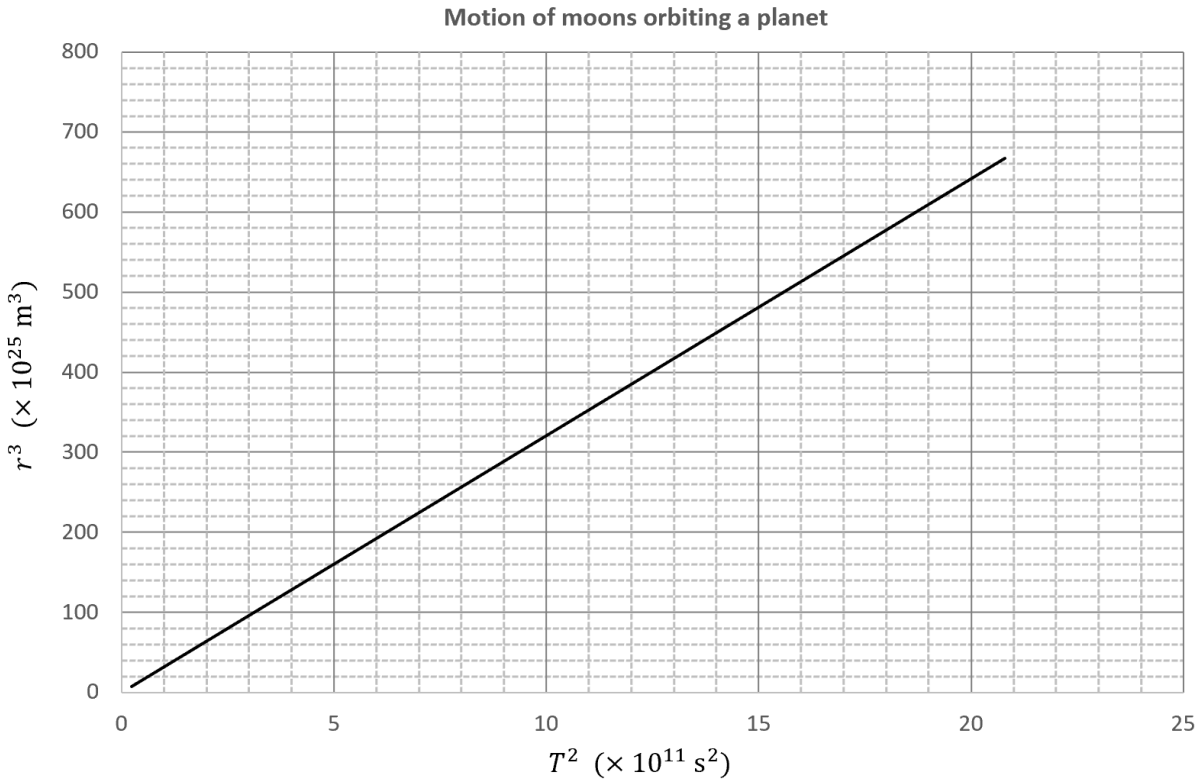
Student Number

ANSWER THIS QUESTION ON A NEW PAGE

Question 32 (7 marks)

An astronomer has measured the orbital period and average orbital radius of several moons orbiting a planet. Applying Kepler's third law, she manipulates the data and constructs a graph to obtain a linear relationship, as shown:



(a) Using the graph, calculate the mass of the planet around which these moons are orbiting. **3**

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Question 32 continues on page 37

Student Number

Question 32 (continued)

(b) The Australian Space Agency sends a research team to a distant planet, P-299d, with a radius twice that of Earth and a mass of 5.7×10^{26} kg.

i. Calculate the escape velocity on the surface of P-299d. **2**

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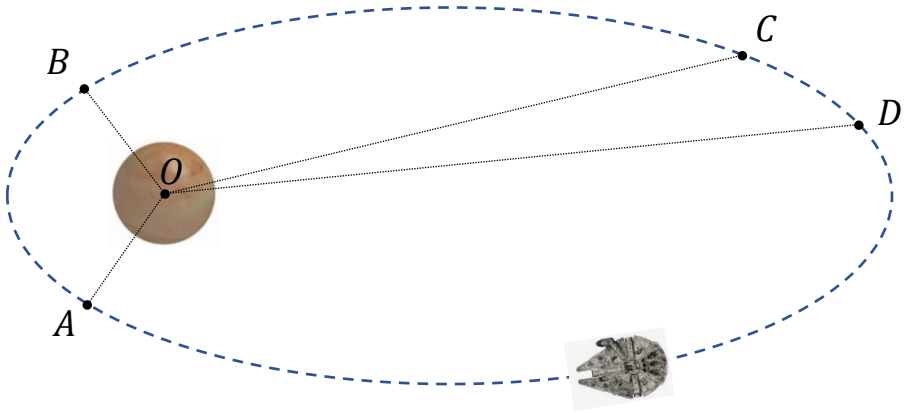
ii. At the completion of their mission, the research team leaves P-299d in their spaceship and enters an elliptical orbit around the planet, as depicted below. **2**

NOT TO SCALE



If the spaceship travels from position A to B and position C to D in equal time intervals, compare the areas of segment AOB and COD, justifying your response.

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End of Paper

Student Number

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If you choose to use this space, clearly indicate what question you are answering.

Student Number

Section II Extra writing space
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