NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION MARCH 2017

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages, an Answer Sheet of 1 page and an Examination Data Sheet of 2 pages (i–ii). Please make sure that your question paper is complete.
2. Answer ALL the questions.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. Start each question on a new page.
6. Show your working in all calculations.
7. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
8. Where appropriate, express answers to TWO decimal places.
9. It is in your own interest to write legibly and present your work neatly.

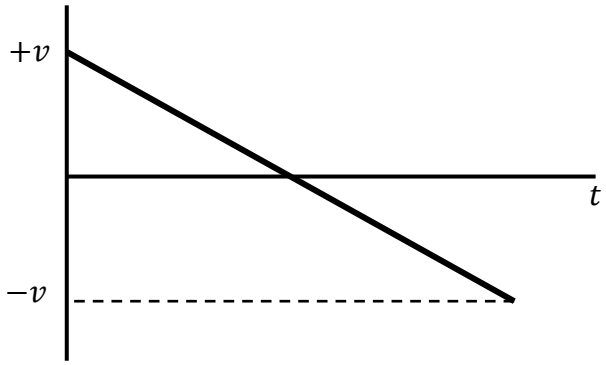
QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice Answer Sheet on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

1.1 Which group of quantities contains only vectors?

A acceleration, momentum, speed
B velocity, weight, electric field
C energy, momentum, velocity
D work, electric field, acceleration

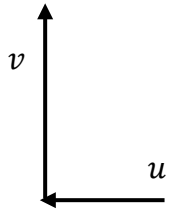
1.2 The velocity vs time graph for a moving object is sketched below. Upwards is taken as positive.



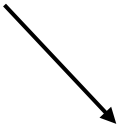
The motion of the object can be described as:

A the object is travelling downwards throughout its motion
B the object is travelling with a constant velocity throughout its motion
C the object's speed is decreasing throughout its motion
D the object is travelling with a constant acceleration throughout its motion

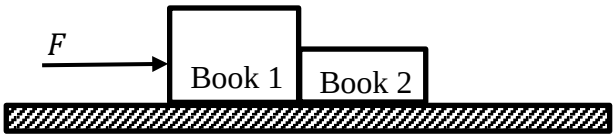
1.3 An orange ball is travelling along a smooth surface with an initial velocity u, when it is struck by another ball. After the collision, the orange ball is travelling with a speed v, which is greater in magnitude than u, in the direction shown below.



Which vector best indicates the direction of the acceleration of the orange ball during this collision?

A 
B 
C 
D 

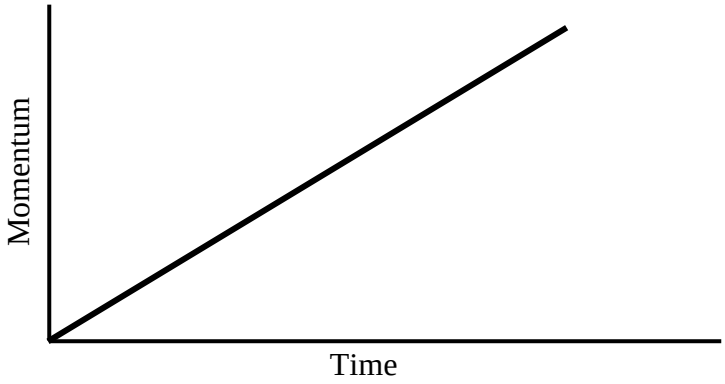
1.4 Peter pushes two books on a frictionless surface with a force F as shown in the diagram.



The force that Book 1 exerts on Book 2 is X. The force that Book 2 exerts on Book 1 is Y. The magnitude of force X compared to force Y is:

A $X = Y$
B $X > Y$
C $X < Y$
D Depends on the acceleration of the system

1.5 The momentum of a car vs time is illustrated in the graph below.



The gradient of the graph represents:

A the velocity of the car
B the resultant force on the car
C the kinetic energy of the car
D the rate of change of velocity of the car

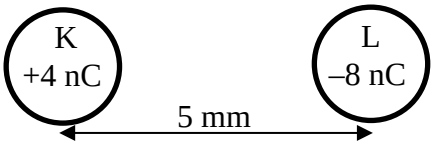
1.6 A ball thrown vertically upwards with an initial velocity v_i reaches a maximum height y. The velocity of the ball when it is halfway up is:

A $\frac{v_i}{2}$
B $\sqrt{v_i - 2gy}$
C $\frac{1}{\sqrt{2}} v_i$
D gy

1.7 An object has a weight of 88,20 N on the Earth. The gravitational field strength on the Moon is 1,64 $m \cdot s^{-2}$. What are the weight and the mass of the object when on the Moon?

	Weight (N)	**Mass (kg)**
A	14,76	1,5
B	14,76	9,0
C	88,20	1,5
D	88,20	9,0

1.8 A metal sphere K has a charge of +4 nC and an identical sphere L has a charge of –8 nC. When the spheres are 5 mm apart, sphere K exerts a force ***F*** on sphere L.



The spheres are then touched together and then replaced in their original position 5 mm apart. What is the magnitude of the force that sphere K now exerts on sphere L?

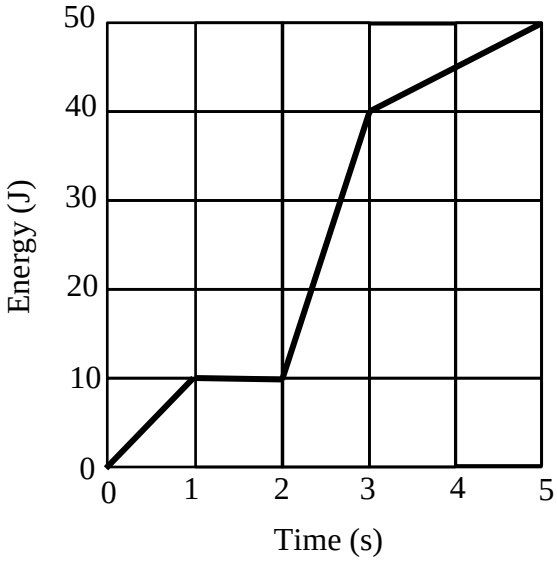
A $\frac{1}{8}\boldsymbol{F}$

B $\frac{1}{4}\boldsymbol{F}$

C $\frac{1}{2}\boldsymbol{F}$

D $\boldsymbol{F}$

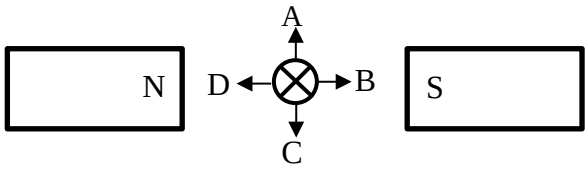
1.9 An electrical generator is started at time zero. The total electrical energy generated during the first 5 s is shown in the graph on the right.



During which time interval during these 5 s is the maximum electrical power generated?

A 0–1 s
B 1–2 s
C 2–3 s
D 3–5 s

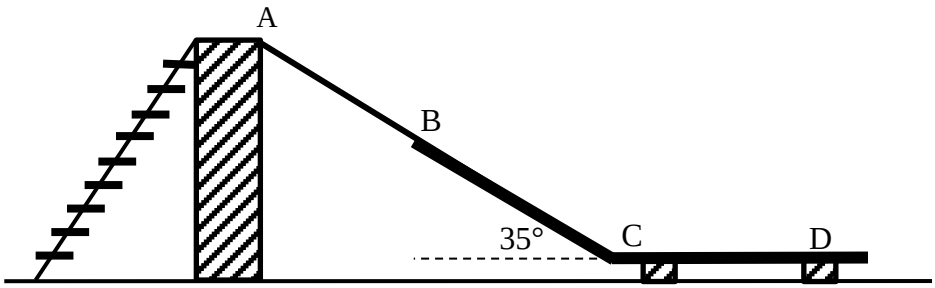
1.10 A conductor carries a current perpendicularly into the page between the poles of two magnets as shown in the diagram. In what direction will the conductor experience a force?



[20]

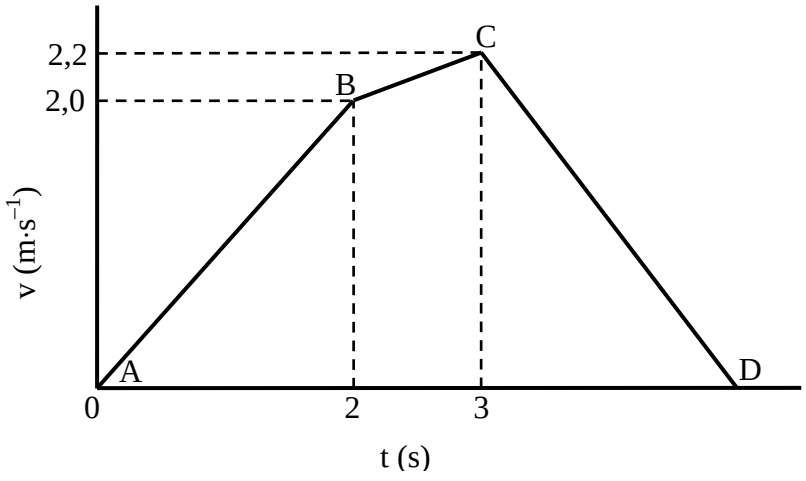
QUESTION 2 KINEMATICS

A slide in a playground has a structure as shown in the diagram below.



Children climb up the stairs and slide down starting at point A. The surface AB is smooth, while the surface BD has been covered so that there is friction present along BD.

A boy of mass 30 kg slides down the slide. The magnitude of the boy's velocity is represented on the velocity-time graph shown.



2.1 Define *velocity*. (2)

2.2 Define *acceleration*. (2)

2.3 Calculate the magnitude of the boy's acceleration while sliding on slope BC. (3)

2.4 Draw a labelled, free-body diagram of the boy while sliding on BC. (3)

2.5 Calculate the magnitude of the frictional force acting on the boy while sliding on slope BC. (5)

2.6 Calculate the length of the slide ABC. (4)

The boy slows down on the flat surface CD at 1,1 $m \cdot s^{-2}$.

2.7 Calculate the time taken from C for the boy to stop. (3)

2.8 What is the minimum length of CD required to ensure the boy comes to rest and does not slide over the edge at D? (3)

[25]

QUESTION 3 KINEMATICS

A group of students decided to measure the acceleration due to gravity. They carried out an experiment by dropping a small steel ball (mass 10 g) from different heights and measured the time taken (*t*) for the ball to fall through the particular height (*h*).

The results are recorded in the table below:

***h* (m)**	***t* (s)**	**t^2 (s^2)**
0,4	0,27	0,07
0,7	0,40	0,16
1,2	0,47	0,22
1,7	0,60	0,36
2,1	0,64	0,41
2,5	0,72	0,52

The students decided to plot *h* vs t^2.

3.1 Why is it necessary to plot *h* vs t^2 rather than *h* vs *t*? (3)

3.2 Use the data in the table to plot a graph of h (y-axis) vs t^2 (x-axis) on the graph paper provided on the **Answer Sheet**. (6)

3.3 Calculate the gradient of the graph. Indicate the values you used for this calculation on your graph. (4)

3.4 Write an equation of motion that describes the relationship between h and t^2. (2)

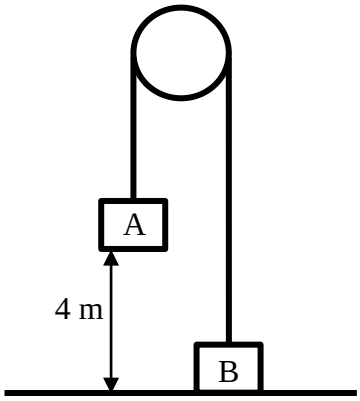
3.5 Use your answer from Question 3.4 and your knowledge that the equation $y = mx + c$ describes a straight line to determine the acceleration due to gravity. (2)

3.6 The students repeated the experiment with a ball of twice the mass. Describe the graph of *h* vs t^2 for the heavier mass in comparison with the graph plotted for the 10 g ball. Briefly explain your answer. (2)

[19]

QUESTION 4 NEWTON'S LAWS

Two identical blocks A and B are connected by a light, inextensible string that passes over a frictionless pulley as shown in the diagram. Each block has a mass of 2 kg. Initially block B is resting on the ground while block A is 4 m above the ground.



A block of mass 1 kg is placed on block A. The system accelerates as a result.

4.1 Draw a labelled free-body diagram of the forces acting on block B after it has left the ground and while it is accelerating upwards. The relative sizes of the forces must be clear. (3)

4.2 State *Newton's second law of motion*. (2)

4.3 Calculate the magnitude of the acceleration of the system. (5)

4.4 Calculate the tension in the string joining block A and block B while the blocks are accelerating. (2)

Block A hits the floor with a speed of 3,96 $m \cdot s^{-1}$ and comes to rest almost immediately.

4.5 Determine the resultant force acting on block B just after block A has reached the floor. (2)

4.6 Define *mechanical energy*. (2)

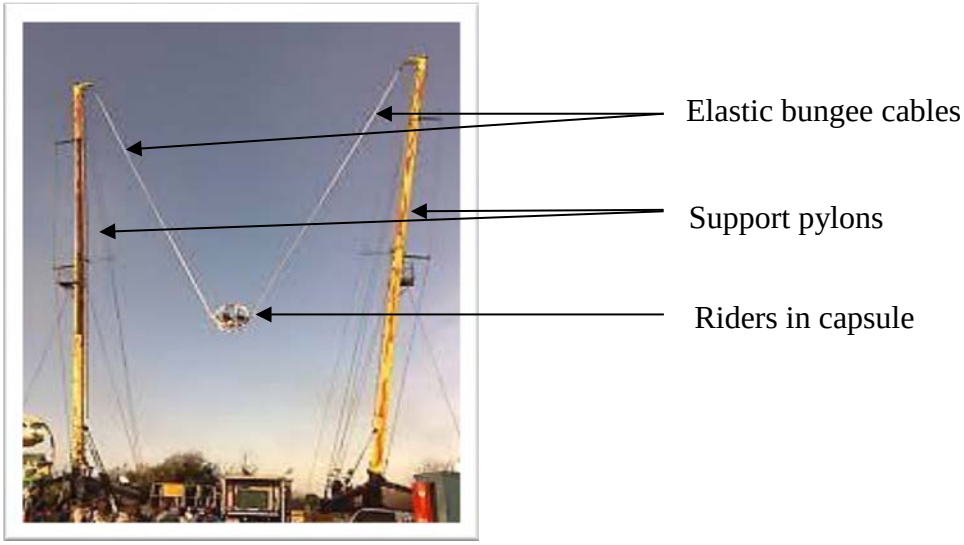
4.7 Explain why the conservation of mechanical energy may be used to calculate the maximum height reached by block B. (2)

4.8 Use the principle of conservation of mechanical energy to calculate the maximum height from the ground reached by block B. (4)

[22]

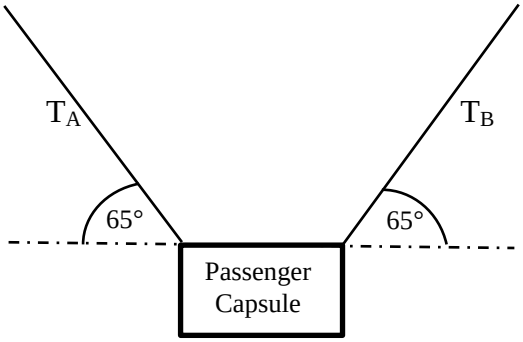
QUESTION 5 FORCE, WORK, ENERGY AND POWER

A reverse bungee is a thrill ride where passengers are strapped into a capsule and are shot into the air by using a pair of strong bungee cords (thick, elastic cables with negligible mass).



[Source: <www.teoc.ws>]

Consider the cables at the bottom of the bungee, i.e. at the lowest point. The cables exert a maximum tension at this point of 7 000 N per cable and the cables are angled at 65° to the horizontal at this point. (See the diagram below.)



T_A: The tension exerted by cable A

T_B: The tension exerted by cable B

5.1 Calculate the total upward force that the bungee cables exert on the passenger capsule at this point. (3)

5.2 Define *resultant vector*. (2)

5.3 Calculate the mass of a capsule if it experiences a net force of 4 000 N upwards at this point as it is released. (5)

At a height of 25 m above the release point, a different capsule of mass 320 kg has a speed of 19 $m \cdot s^{-1}$.

5.4 State the *work-energy theorem*. (2)

5.5 Calculate the work done by the net force on the capsule to get the capsule to this point. (3)

5.6 Calculate the increase in mechanical energy of the capsule at this point. (5)

5.7 Calculate the **average applied force** that the cables exerted on the capsule to accelerate it to the speed of 19 $m \cdot s^{-1}$. (4)

5.8 Calculate the maximum height from the release position that the capsule will reach if the cable exerts no further force on the capsule, i.e. the capsule is free to move upwards from the 25 m position. (4)

5.9 Sketch a position vs time graph for the upward motion of the capsule from its release position to its maximum height. Show on the graph the height 25 m and the maximum height reached. (4)

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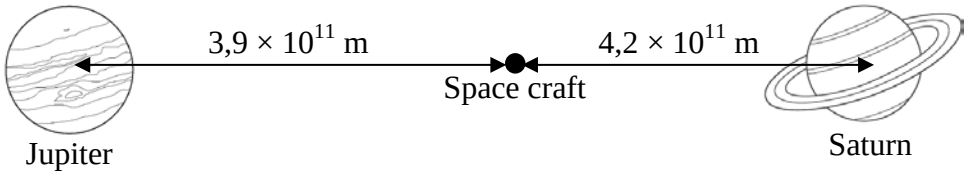
QUESTION 6 FIELDS

6.1 A spacecraft on a mission to explore the outer solar system was between Jupiter and Saturn at the distances shown on the diagram.

The mass of Jupiter is $1,9 \times 10^{27}$ kg and the mass of Saturn is $5,7 \times 10^{26}$ kg.



[Source: images of Jupiter and Saturn available at <http://www.windows2universe.org/coloring_book/>]

6.1.1 State *Newton's Law of Universal Gravitation.* (2)

The mass of the spacecraft is $2,2 \times 10^3$ kg.

6.1.2 Calculate the magnitude of the force that Jupiter exerts on the spacecraft at the position shown. (3)

6.1.3 Calculate the magnitude of the acceleration experienced by the spacecraft at the position shown. (6)

6.2 A small metal sphere has a charge of +5 nC. The electric field is measured to have a magnitude of 312 500 $N \cdot C^{-1}$ at an unknown distance from the charge.

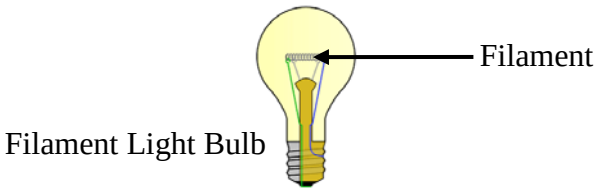
6.2.1 Define *electric field.* (2)

6.2.2 Calculate the distance from the charge where the electric field strength was measured. (3)

[16]

QUESTION 7 ELECTRIC CIRCUITS

7.1 Older torches have bulbs that are filament light bulbs.



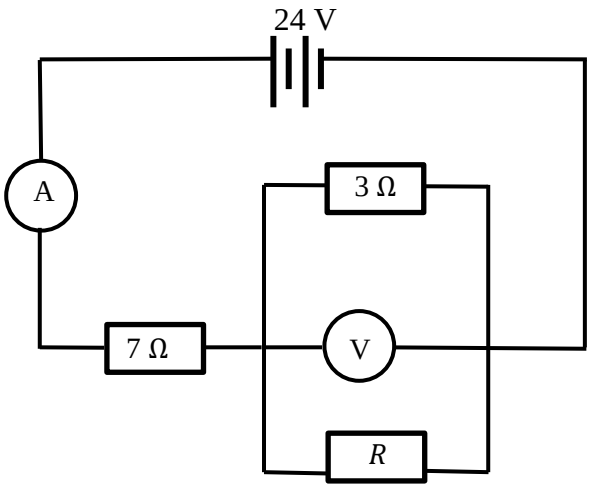
[Source: Image from <http://caitboo.com/?p=230>]

7.1.1 Is the filament light bulb an ohmic conductor? Explain your answer. (3)

7.1.2 Draw a sketch graph of V (y-axis) vs I (x-axis) for a filament light bulb. (2)

7.1.3 When used in a torch, the filament light bulb gets hot while the wires connecting the bulb to the battery do not, even though the current in both is the same. Explain the difference in temperature by making use of a relevant equation. (3)

7.2 Three resistors are connected to a 24 V battery of negligible internal resistance as shown in the diagram. The battery supplies 60 W of power to the circuit. The value of the resistance of resistor R is unknown.



7.2.1 Define *power*. (2)

7.2.2 Calculate the reading on the ammeter. (3)

7.2.3 State *Ohm's law*. (2)

7.2.4 Calculate the potential difference across the 7 Ω resistor. (3)

7.2.5 Calculate the reading on the voltmeter. (2)

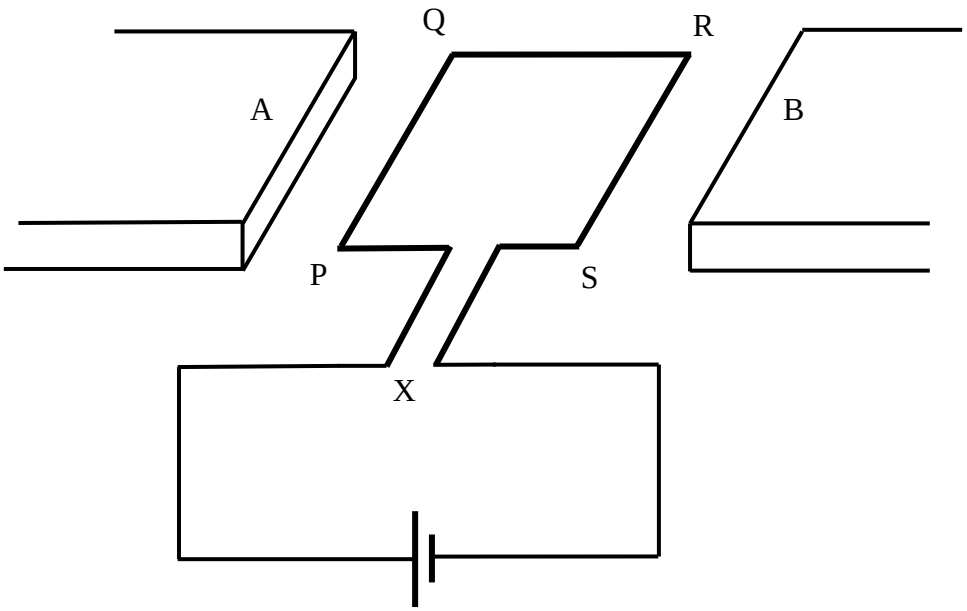
7.2.6 Determine the current flowing through resistor R. (5)

7.2.7 Hence calculate the value of the resistance of resistor R. (3)

[28]

QUESTION 8 ELECTRODYNAMICS

8.1 A student constructs an electromagnetic device as shown in the diagram. The poles of the magnets are labelled A and B.



8.1.1 Is the electromagnetic device being used as a motor or a generator? Use energy considerations to motivate your answer. (2)

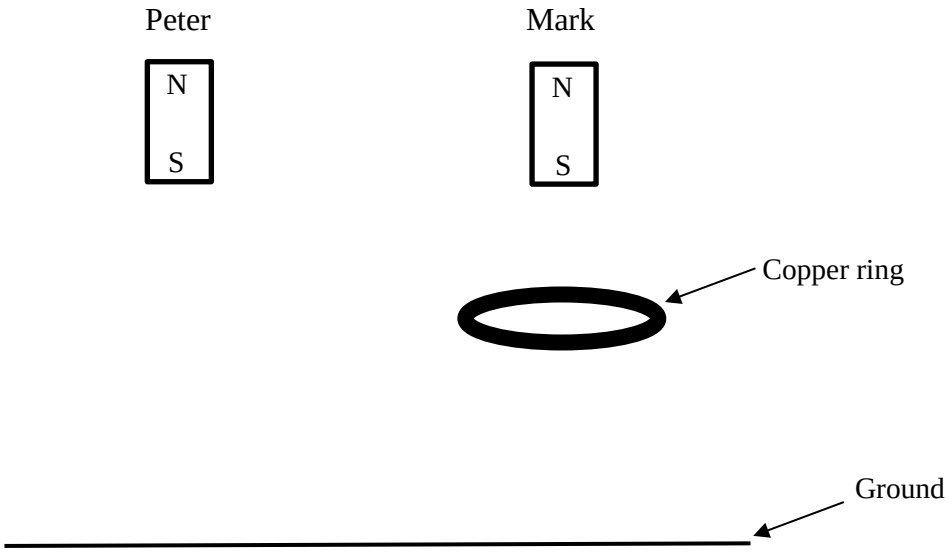
8.1.2 Is the direction of the conventional current in the coil PQRS or SRQP? (2)

8.1.3 When viewing the coil from position X, the coil rotates anticlockwise. Is the pole labelled A, north or south? (2)

8.1.4 When the coil reaches its vertical direction, state the direction of the force acting on side PQ. (2)

8.1.5 Does the coil rotate continuously in one direction? Briefly explain your answer. (3)

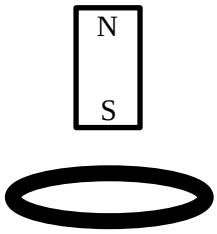
8.2 Two students, Peter and Mark, each drop a magnet from the same height. Peter simply drops the magnet, while Mark drops the magnet through a copper ring. Both students drop the magnet with the south pole facing downwards.



8.2.1 Describe the change in energy when Mark drops the magnet. (3)

8.2.2 State *Lenz's law*. (2)

The diagram below shows the copper ring with the magnet approaching.



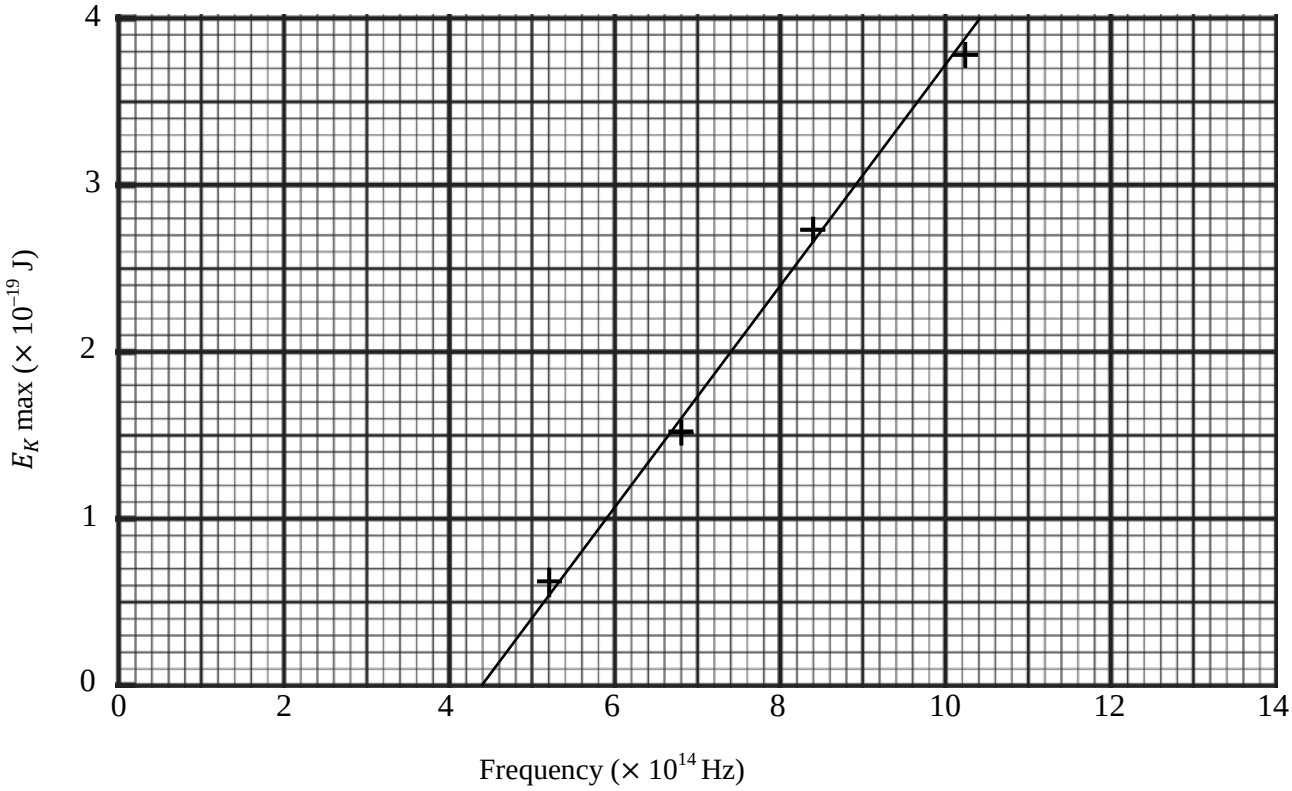
8.2.3 State the direction of the current in the copper ring (clockwise or anticlockwise). (2)

8.2.4 Will the magnets reach the ground at the same time if dropped simultaneously? If not, whose magnet will reach the ground first? Explain your answer. (4)
[22]

QUESTION 9 PHOTONS AND ELECTRONS

In experiments to demonstrate the photoelectric effect, a beam of light with a single frequency is shone onto a clean, metal surface. The maximum kinetic energy of the ejected electrons was measured.

The experiment was repeated at different frequencies of light and the graph of maximum kinetic energy vs frequency was obtained for potassium metal.



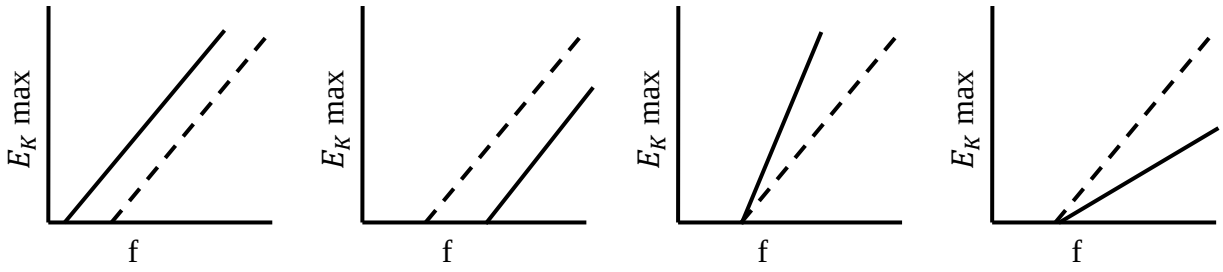
9.1 Define *threshold frequency*. (2)

9.2 Use the graph to help you determine the minimum energy needed to eject an electron from the surface of potassium. (3)

9.3 Use the graph to describe the relationship between maximum kinetic energy and the frequency of the incident light. (3)

The work function of copper is double the work function of potassium.

9.4 The experiment is repeated with copper instead of potassium. Which one of the graphs below would best represent the results for copper (———)? The graph for potassium (– – – –) has been included for comparison. Explain your choice of answer by referring to relevant features of the graph. (4)



A B C D

9.5 Light of frequency 15×10^{14} Hz is incident on the copper metal. Calculate the kinetic energy of the electrons ejected from **copper**. (4)

[16]

Total: 200 Marks