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PHYSICAL SCIENCES: PAPER I

Time: 3 hours

200 marks

Examiner: K Mari

Moderator: C vd Venter

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

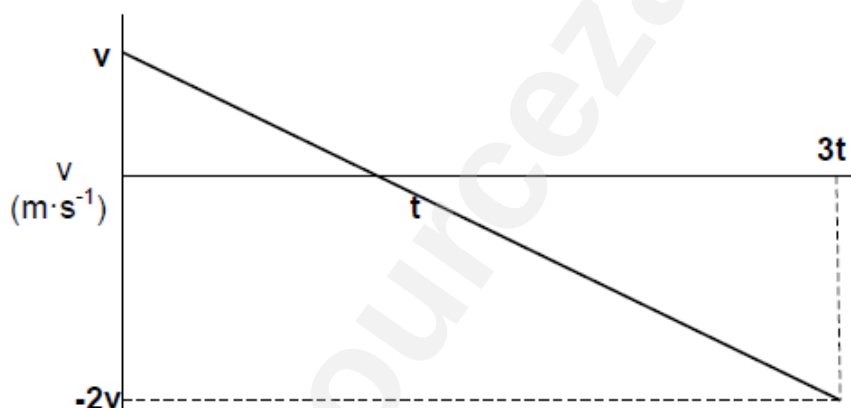
1. This question paper consists of 15 pages, and a Data Sheet of 2 pages. Please check that your question paper is complete.
 2. Read the questions carefully.
 3. Answer ALL the questions.
 4. Start each question on a new page.
 5. Number your answers as the questions are numbered.
 6. Use the data and formulae whenever necessary.
 7. Show your working in all calculations.
 8. Units need not be included in the working calculations, but appropriate units should be shown in the answer.
 9. Answers must be expressed in decimal format, not left as proper fractions.
 10. Where appropriate, express answers to TWO decimal places.
 11. It is in your own interest to write legibly and to present your work neatly.
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QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice grid 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.

Multiple Choice

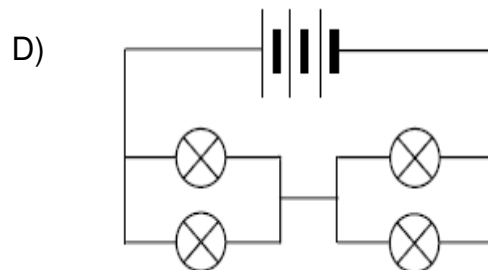
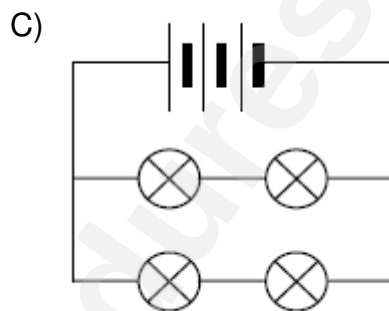
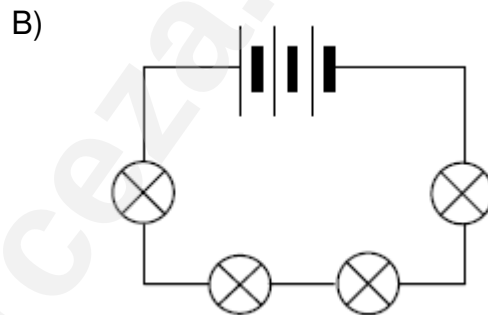
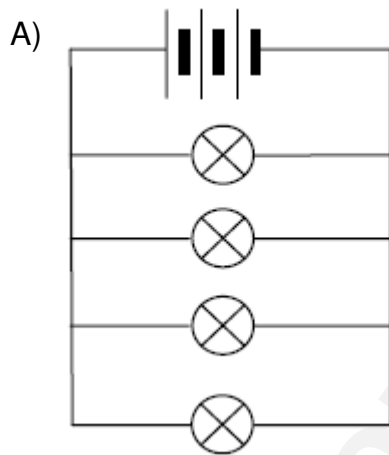
- 1.1 Which one of the following consists of two scalar quantities?
- A) mass and gravitational acceleration
 - B) acceleration and force
 - C) displacement and velocity
 - D) time and speed
- 1.2 The velocity versus time graph below represents the movement of an object under the influence of gravitational force.



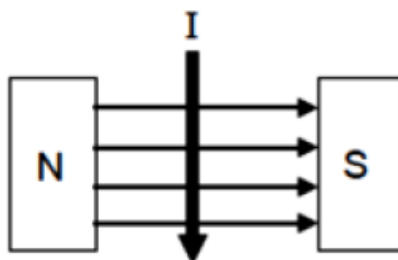
The magnitude of the displacement of the object in time $3t$ is ...

- A) vt
 - B) zero
 - C) $-vt$
 - D) $\frac{3}{2} vt$
- 1.3 A jogger runs at $8 \text{ km} \cdot \text{h}^{-1}$ on a horizontal road, then uphill at $6 \text{ km} \cdot \text{h}^{-1}$, then turns around and runs back along the same road, going at $12 \text{ km} \cdot \text{h}^{-1}$ downhill and ending at $8 \text{ km} \cdot \text{h}^{-1}$ on the horizontal road. If he runs for 2 hours, how far did he run.
- A) 8 km
 - B) 6 km
 - C) 16 km
 - D) 9 km
- 1.4 When a snowflake falls, it quickly reaches a terminal velocity. This happens because:
- A) there is no net force on the snowflake.
 - B) the mass of the snowflake is too small for gravity to have any effect.
 - C) the snowflake has no weight.
 - D) the frictional force is greater than the weight of the snowflake.

- 1.5 What quantity represents the rate of change of momentum?
- A) Impulse B) Net Force
C) Net Work D) Acceleration
- 1.6 Mars has twice the mass of Mercury and is 4 times further away from the Sun. The ratio of the gravitational force from the Sun on Mercury to the gravitational force from the Sun on Mars is:
- A) 0,5: 1 B) 2: 1
C) 8: 1 D) 32: 1
- 1.7 A set of identical light bulbs are connected as shown in the circuit diagrams below. The internal resistance of the battery is negligible. In which ONE of these circuits will the light bulbs glow the brightest?



- 1.8 In the sketch below, a conductor carrying conventional current, I , is placed in a magnetic field.



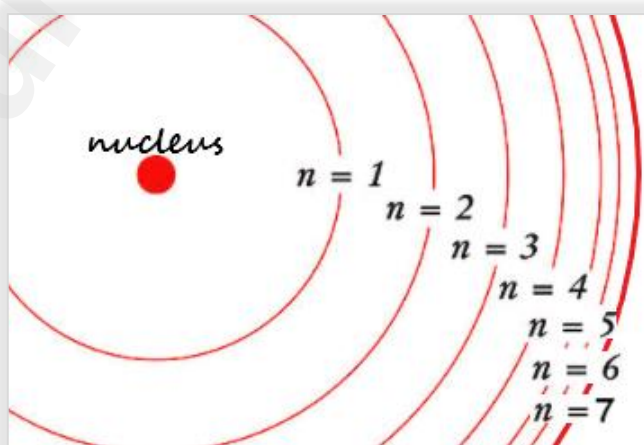
Which ONE of the following best describes the direction of the magnetic force experienced by the conductor?

- A) Parallel to the direction of the magnetic field
- B) Opposite to the direction of the magnetic field
- C) Into the page perpendicular to the direction of the magnetic field
- D) Out of the page perpendicular to the direction of the magnetic field

- 1.9 What causes bright lines on an emission spectrum?

- A) Electrons jumping to higher energy levels when absorbing light.
- B) Protons jumping to higher energy levels when absorbing light.
- C) Electrons falling to lower energy levels when releasing light.
- D) Protons falling to lower energy levels when releasing light.

- 1.10 Which transition most likely represents an electron **absorbing** red light?

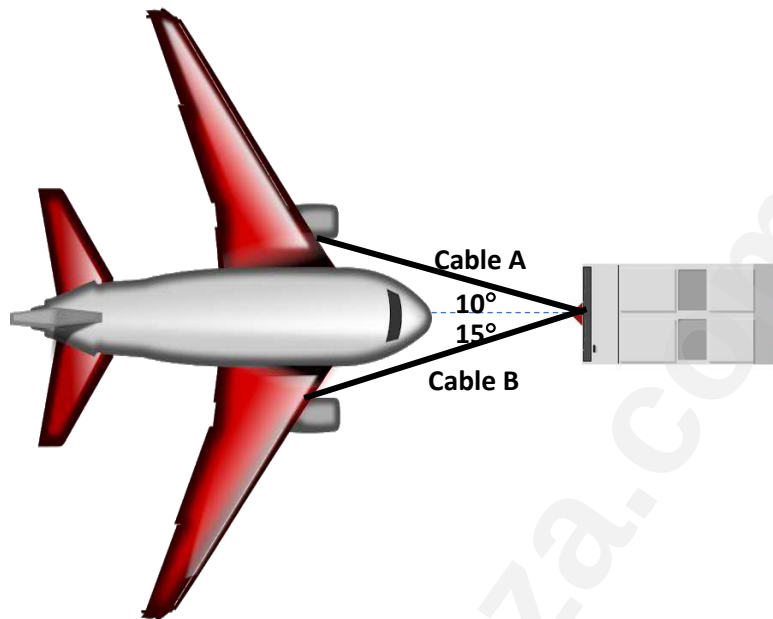


- A $n = 2 \rightarrow n = 3$
- B $n = 1 \rightarrow n = 7$
- C $n = 3 \rightarrow n = 2$
- D $n = 7 \rightarrow n = 1$

[20]

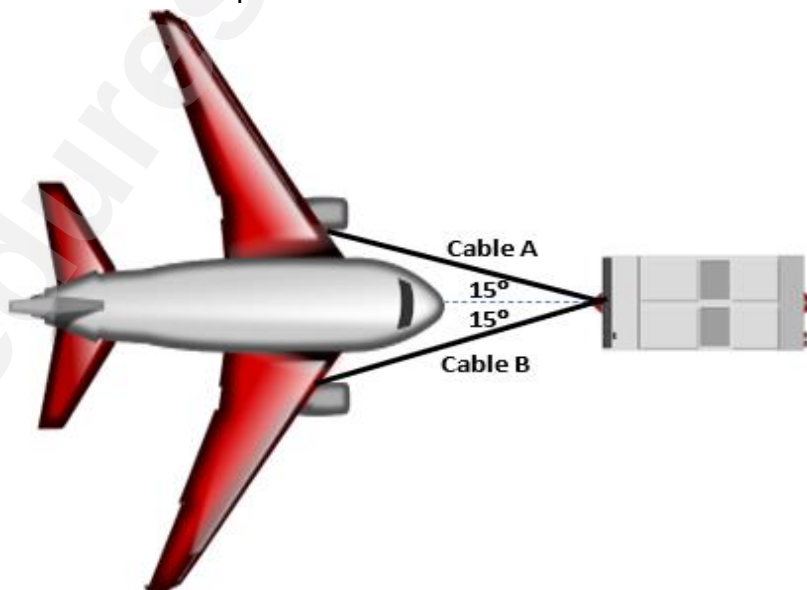
Question 2

An aeroplane is towed by a tug using two cables as shown in the diagram below. The tension in cable A is 180 000 N and the tension in cable B is 150 000 N.



- 2.1 Calculate the components in the direction of the motion of cable A and cable B. (4)
- 2.2 Define the term *resultant vector*. (2)
- 2.3 The aeroplane moves to the right with a constant velocity, calculate the frictional force. (3)

In a different scenario Cable A is moved further away from the aeroplane such that it makes an angle of 15° with the line of motion. Assume that the frictional force is the same as question 2.3 and the plane is at rest.



- 2.4 Explain using a suitable formula if the aeroplane will continue to move with a constant velocity. (4)
- [13]**

Question 3

An aeroplane, initially at rest undergoes a constant acceleration of $2,3 \text{ m.s}^{-2}$ down the runway for 28 s before it lifts off.

3.1 Define the term *distance*. (2)

3.2 What is the distance the plane travels during a normal take-off? (4)

During a take-off procedure, the pilot of the same plane notices that an emergency warning light comes on 13 s after he had started accelerating down the runway. The pilot decides to abort the take-off. His reaction time is 1,5 s (i.e. it takes 1,5 s to apply the brakes at which time the acceleration is zero).

3.3 Calculate the speed reached by the plane in the 13 s. (3)

3.4 Calculate the total distance travelled just before the pilot applies the brakes. (5)

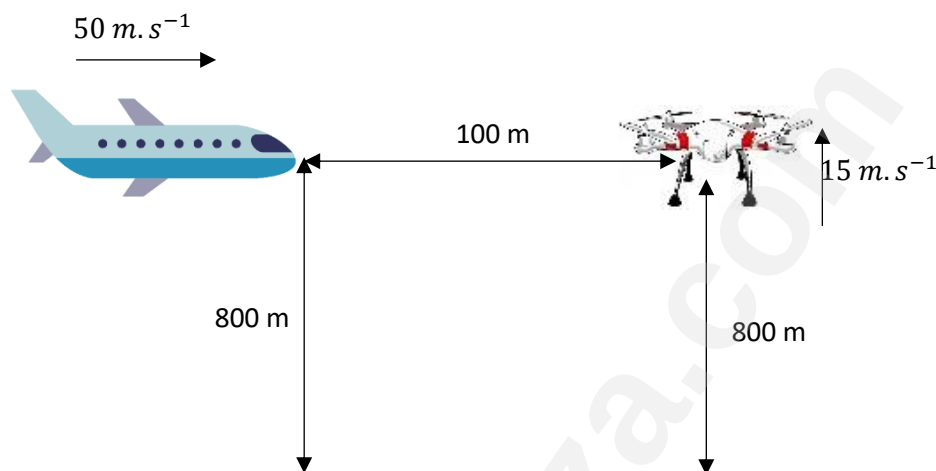
3.5 What must the acceleration of the plane be if it must come to a halt at the extreme end of the runway? The total length of the runway is 1 km. (5)

3.6 Sketch a velocity versus time graph for the entire motion of the plane.
No values are required. (4)

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Question 4

Abigail is flying her drone and she notices a model toy aeroplane approaching when her drone is moving vertically upwards with a constant speed of 15 m.s^{-1} . At this instant the drone is at a height of 800 m above the ground and the plane is moving with a horizontal speed of 50 m.s^{-1} , 800 m above the ground. The horizontal distance between the plane and the drone is 100 m.



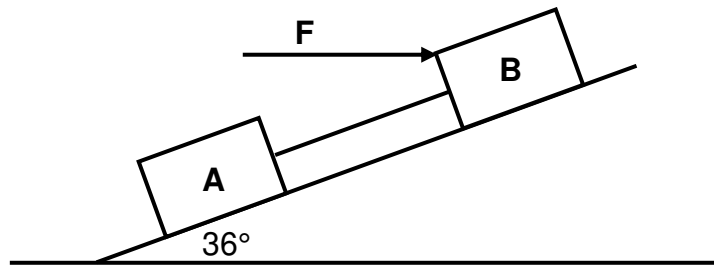
At the very same instant Abigail's remote brakes and the drone begins to free fall. Ignore the effects of air resistance.

- 4.1 Define the term *acceleration*. (2)
- 4.2 State the magnitude of the acceleration of the drone after the remote breaks. (1)
- 4.3 Calculate the maximum height above the ground reached by the drone. (4)
- 4.4 Calculate the time taken for the drone to reach its maximum height. (2)
- 4.5 Using calculations determine if the drone will collide with the plane. Ignore the length of the plane when doing this calculating. (5)

[14]

Question 5

Two blocks, **A** and **B**, are held at REST on a rough slope by a horizontal force **F**. The mass of each block is 8,5 kg and the rope connecting the two blocks is light and inextensible.



The coefficient of static friction between block **B** and the surface is 0,4 and block **A** experiences a static frictional force of 68 N. Block **B** is at the point of sliding up the slope.

- 5.1 Define *normal force*. (2)
- 5.2 Calculate the magnitude of the normal force acting on block **A**. (3)
- 5.3 State *Newton's first law*. (2)
- 5.4 Calculate the magnitude of the tension in the string. (3)
- 5.5 Draw a free-body diagram for the forces acting on block **B**. (5)
- 5.6 Calculate force **F**. (7)
- 5.7 Force **F** is now decreased. For the following questions, state only INCREASES, DECREASES, or NO EFFECT.
 - 5.7.1 How will this affect the normal force on block **B**? (2)
 - 5.7.2 How will this affect the frictional force on block **B**? (2)

[26]

Question 6

A dirt bike of mass 150 kg (including the rider) is travelling at 27 m.s^{-1} along a straight horizontal gravel road. The dirt bike then accelerates over a distance of 50 m. The 150 cc engine exerts a forward force of 3 500 N on the dirt bike and it experiences a frictional force of 850 N as it accelerates for 50 m.



- 6.1 Define the term *work*. (2)
- 6.2 Name the force(s) which
 - 6.2.1 increases the mechanical energy of the dirt bike? (1)
 - 6.2.2 reduces mechanical energy of the dirt bike? (1)
 - 6.2.3 do zero work on the dirt bike? (2)
- 6.3 Provide a reason for your answer in question 6.2.3. (1)
- 6.4 Describe the energy conversions taking place in this system. (3)
- 6.5 State the *work-energy theorem*. (2)
- 6.6 By using energy principles, calculate the speed of the dirt bike after it has travelled the 50 m. (5)
- 6.7 State the *Law of conservation of energy*. (2)

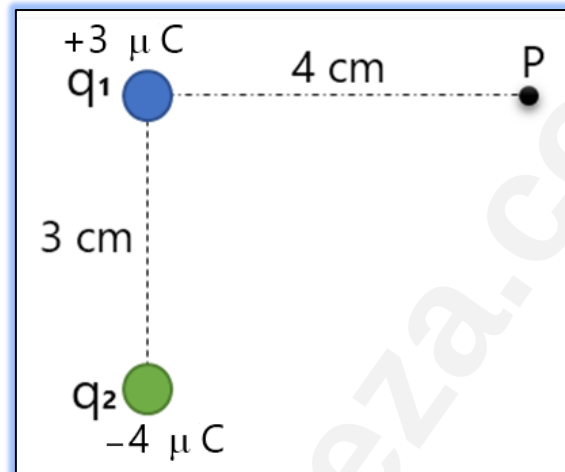
The dirt bike continues at the velocity calculated in question 6.6 until he comes to a cliff and the rider takes on the challenge to make the jump. He jumps horizontally off a 10 m high cliff.

- 6.8 Determine the magnitude of the final velocity just before the dirt bike hits the ground. Use energy principles. (6)

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Question 7

In the diagram below, q_1 has a charge of $+3 \mu\text{C}$ and is situated 3 cm above q_2 which has a charge of $-4 \mu\text{C}$. A positive point charge P is 4 cm to the right of charge q_1 .

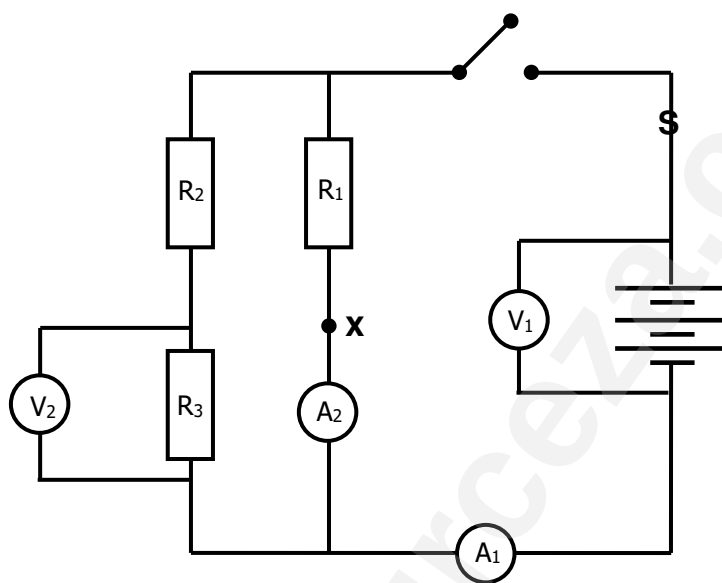


- 7.1 State *Coulomb's Law* in words. (2)
- 7.2 Calculate the magnitude of the electrostatic force of attraction between the two charges. (4)
- 7.3 P experiences the electric field produced by each of the two charges. Describe an electric field. (2)
- 7.4 Draw the electric field pattern produced by the two charges. (3)
- 7.5 Calculate the magnitude of the net electric field experienced by P . (9)

[20]

Question 8

In the circuit below the battery has an emf of 24 V and an internal resistance, r . When the switch, S , is closed, the reading on A_1 is 2 A and on A_2 is 1.5 A. R_1 and R_2 have resistances of $12\ \Omega$ and $8\ \Omega$ respectively. The internal resistance of the ammeter can be ignored while the resistances of the voltmeters are very high.



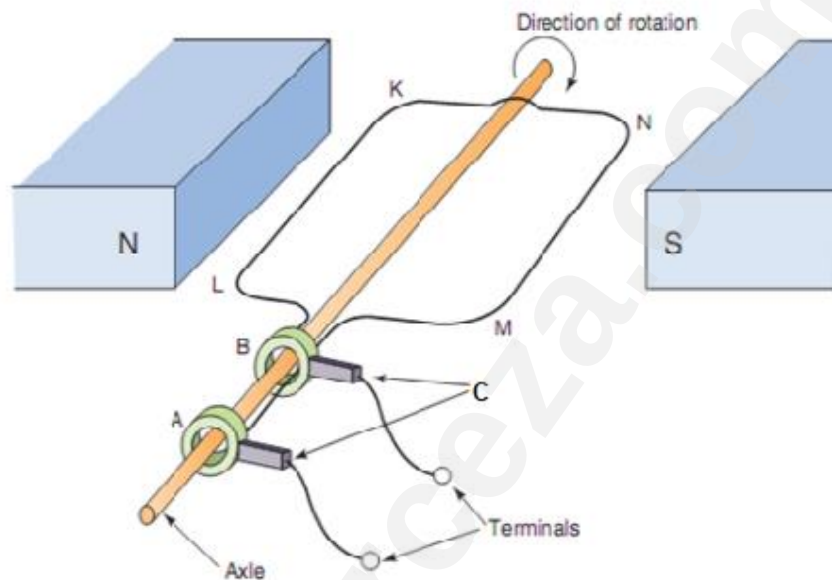
- 8.1 What is the reading on voltmeter V_1 when the switch is closed? (3)
- 8.2 What is the reading on voltmeter V_1 when the switch is open? Explain. (2)
- 8.3 Calculate the internal resistance of the battery. (4)
- 8.4 Calculate the reading on voltmeter V_2 when the switch is closed. (6)
- 8.5 Calculate the power produced in resistor R_2 when the switch is closed. (4)
- 8.6 If the circuit was broken at point X, how would the reading on voltmeter V_1 change? Explain fully. (4)

[23]

Question 9

Generators are useful appliances that supply electrical power during a power outage.

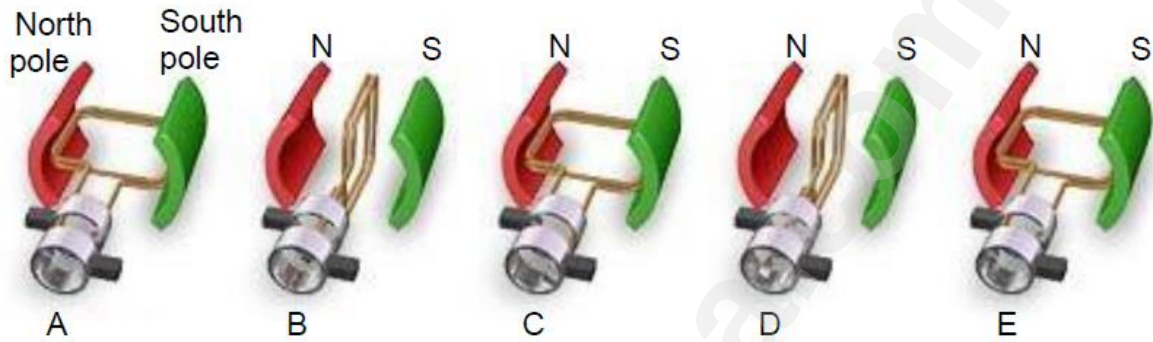
Diagram of a simple generator



<https://dc.edu.au/dot-point-summary-motors-and-generators/>

- 9.1 State the energy conversion that take place in a generator. (2)
- 9.2 Name components A and B. (1)
- 9.3 Name the components labelled C and state the function of these components. (3)
- 9.4 Explain why an emf is induced in the coil when the coil rotates. (2)
- 9.5 The coil is turned mechanically in a clockwise direction as shown in the diagram above. State the direction of the flow of the current write only LKNM or MNKL. (1)
- 9.6 State *Faraday's Law of Electromagnetic Induction*. (2)
- 9.7 A bulb is connected at the two terminals and the coil is turned faster. How does this affect the brightness of the bulb? Explain fully, with reference to relevant equation(s). (4)

- 9.8 The diagrams below illustrate a generator with a rotating coil, between magnetic poles, shown in a number of different positions labelled **A – E**. The coil is rotated clockwise at constant speed in a uniform magnetic field.

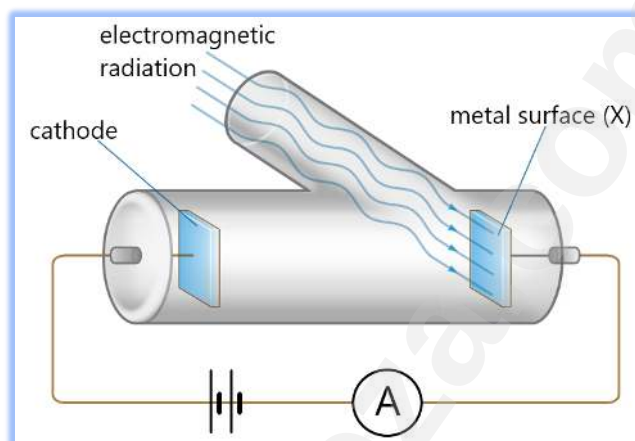


- 9.8.1 Sketch a graph to show how the induced emf of the generator varies with time. Clearly indicate positions A, B, C, D and E on the graph to correspond to the diagrams. (3)
- 9.8.2 Sketch a graph to show the magnetic flux varies with time. Clearly indicate positions A, B, C, D and E on the graph to correspond to the diagrams. (3)

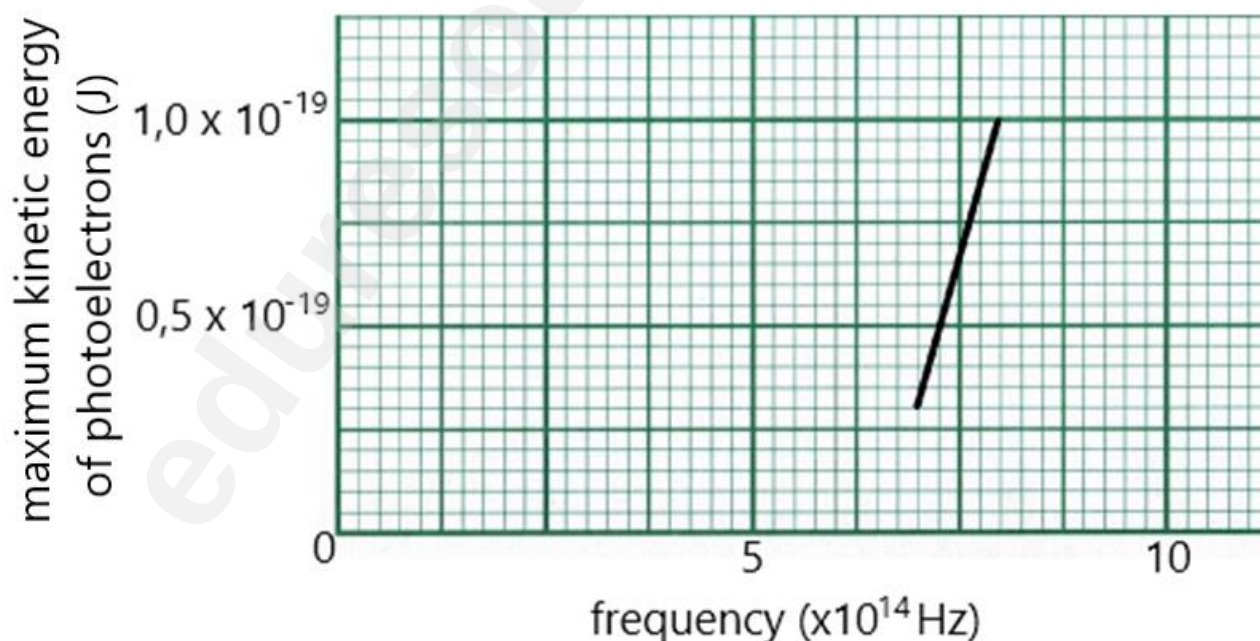
[21]

Question 10

The apparatus shown alongside is used to investigate photoelectric emission from the metal surface (**X**) when electromagnetic radiation is shone on the surface. The frequency of the electromagnetic radiation can be varied.



The maximum kinetic energy of the photoelectrons emitted from metal **X** is measured for several different frequencies of the radiation. The graph below shows how this kinetic energy varies with frequency.



10.1 Use the graph to determine the threshold frequency for metal **X**. (2)

10.2 Define the term *work function*. (2)

10.3 Calculate the work function of metal **X**. (3)

Ultraviolet light, with a photon energy of 4,95 eV, is shone on metal **X**.

10.4 Express 4,95 eV in joules (J). (2)

10.5 Calculate the wavelength of this light. (3)

10.6 Calculate the magnitude of the maximum velocity that could be reached by the photoelectrons when light of this frequency is shone on metal **X**. (3)

[15]

TOTAL: 200 MARKS