

PHYSICAL SCIENCES: PAPER I

Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
 - a question paper of 16 pages;
 - a yellow Answer Sheet of 2 pages (i – ii); and
 - a green Data and Formulae booklet of 4 pages (i – iv).

Please make sure that your question paper is complete.

2. Remove the Data Booklet and Answer Sheet from the middle of this question paper.
Write your examination number on the yellow Answer Sheet.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Sheet provided on the inside cover of your Answer Book. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	B	<input checked="" type="checkbox"/>	D
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Here the answer C has been marked.

6. Start each question on a new page.
7. Show your working in all calculations.
8. Where appropriate take your answers to 2 decimal places.
9. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
10. It is in your own interest to write legibly and to set your work out neatly.
11. Please hand in this question paper.

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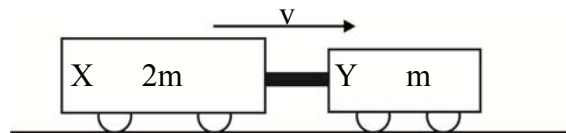
QUESTION 1 MULTIPLE CHOICE

Answer these questions on the Multiple Choice Answer Sheet on the front inside cover of your Answer Book. Make a cross (X) on the letter of the response which you consider to be the most correct.

1.1 Two identical bodies fall from different heights in a vacuum. When at a height of 1 m above the ground both bodies have the same

- A momentum
- B kinetic energy
- C velocity
- D acceleration

1.2 Two trolleys, X and Y, of masses $2m$ and m respectively, move to the right across a horizontal frictionless surface with a speed v . They are joined by means of a compressed spring. When the spring is released, the trolleys are pushed apart.



The magnitude of the change in momentum of trolley X is p . The magnitude of the change in momentum of trolley Y is:

- A $\frac{p}{2}$
- B $\frac{p}{3}$
- C p
- D $2p$

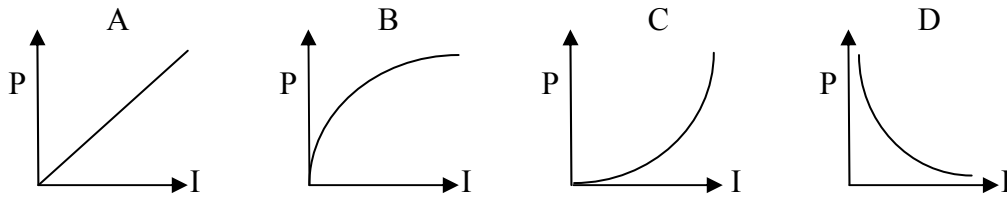
1.3 Which one of the following energy sources is described correctly?

	Energy source	Renewable	Reliable
A	Solar	Yes	No
B	Wind	Yes	Yes
C	Coal	Yes	Yes
D	Hydro	No	Yes

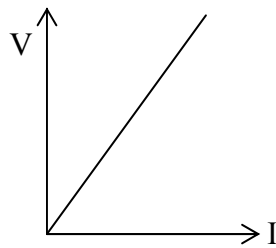
1.4 What name is given to an electronic device which allows electric current to flow through it in only one direction?

- A capacitor
- B switch
- C resistor
- D diode

1.5 Which one of the following graphs best represents the relationship between electrical power (P) and current (I) for a resistor of constant resistance?

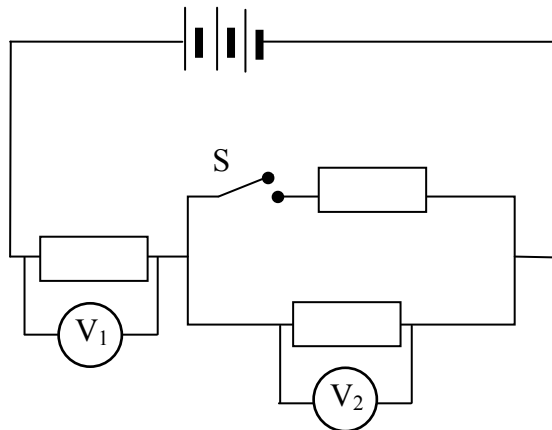


1.6 The graph shown below represents the relationship between the potential difference across a conductor and the current through the conductor. What physical quantity is represented by the area under the graph?



- A resistance
- B capacitance
- C work
- D power

1.7 In the circuit shown below the resistances of the battery, switch and connecting wires can be ignored. Both voltmeters have high resistances. The resistors are identical.



How do the readings on V_1 and V_2 change when the switch (S) is closed?

	V_1	V_2
A	Increase	Decrease
B	Decrease	Increase
C	No change	Increase
D	No change	Decrease

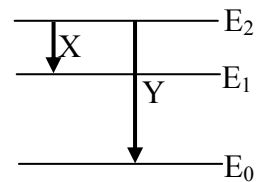
1.8 Which form of electromagnetic radiation has the greatest penetrating ability?

- A microwaves
- B X-rays
- C gamma rays
- D ultra violet

1.9 Light of a certain frequency causes electrons to be emitted from the surface of a metal. Which **one** of the following changes to the light source will increase the number of electrons emitted per second from the surface of the metal? Using light with a greater ...

- A frequency
- B intensity
- C wavelength
- D energy

1.10 The diagram represents transitions of electrons in the energy levels in a certain atom. Which one of the following statements is true concerning the emission of photons associated with transitions X and Y?



The photon associated with X has a greater ...

- A frequency than the photon associated with Y.
- B wavelength than the photon associated with Y.
- C energy than the photon associated with Y.
- D intensity than the photon associated with Y.

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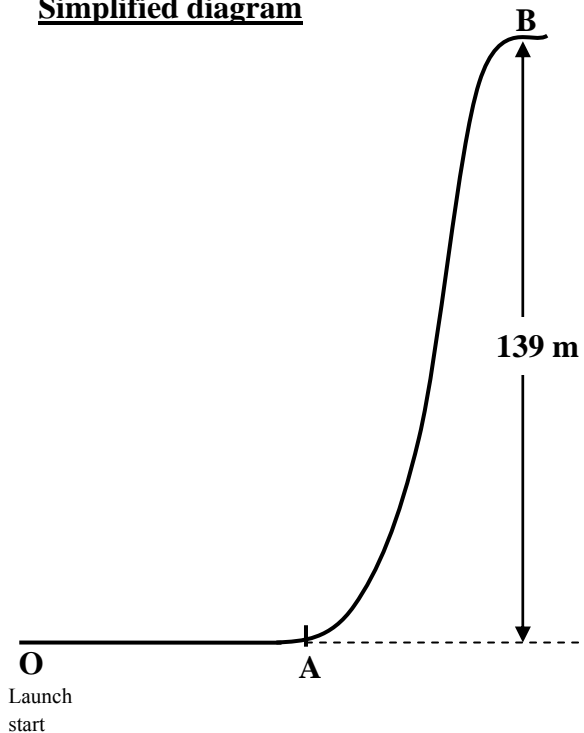
QUESTION 2 WORLD'S HIGHEST ROLLER COASTER

Kingda Ka in the United States is the world's tallest roller coaster. A motor pulls a cable attached to the train, accelerating it at $16,3 \text{ m}\cdot\text{s}^{-2}$ from rest at point O to $57,2 \text{ m}\cdot\text{s}^{-1}$ along a horizontal track. At the end of the launch track (A) the train climbs the main tower reaching B at a vertical height of 139 m above the bottom of the track.



[<www.schitzpopinov.com>]

Simplified diagram



- 2.1 Calculate the time taken for the train to reach a speed of $57,2 \text{ m}\cdot\text{s}^{-1}$ during the horizontal launch from O to A. (4)
- 2.2 Over what horizontal distance does this acceleration take place? (4)
- 2.3 If the mass of the Kingda Ka train and riders is 8 500 kg then how much work is done by the net force on the train to accelerate it from rest to $57,2 \text{ m}\cdot\text{s}^{-1}$? (4)
- 2.4 Would the work done by the cable on the train during the horizontal launch from rest to $57,2 \text{ m}\cdot\text{s}^{-1}$ be *greater than, less than or equal to* the value calculated in Question 2.3? Explain. (3)
- 2.5 The Kingda Ka uses a launch motor which is capable of producing $1,5 \times 10^7 \text{ W}$. What percentage of this power is used in accelerating the train from rest to $57,2 \text{ m}\cdot\text{s}^{-1}$? (5)
- 2.6 The speed of the 8 500 kg train as it reaches the top of the 139 m tower (B) is $8 \text{ m}\cdot\text{s}^{-1}$.
 - 2.6.1 What is *mechanical energy*? (2)
 - 2.6.2 Calculate the total mechanical energy of the train at B, the top of the tower, relative to A, the bottom of the tower. (5)

- 2.6.3 Calculate the work done against friction in moving the train from A to B (from the bottom to the top of the tower). The train is moving at $57,2 \text{ m}\cdot\text{s}^{-1}$ at the bottom of the tower (A). (3)
- 2.6.4 Dirt on the track increases the magnitude of the frictional force between A and B. What problem may be encountered by the train when climbing the tower towards B if there is dirt on the track? Explain your answer using principles of physics. (3)

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QUESTION 3 SAFETY ON THE KINGDA KA ROLLER COASTER

- 3.1 Kingda Ka's over-the-shoulder restraint system consists of a thick, rigid lap bar and two thin, elastic over-the-shoulder restraints, as shown in the picture below.



[<<http://en.wikipedia.org>>]

- 3.1.1 Define *net force* in terms of momentum. (2)
- 3.1.2 How does using **elastic** material for the over-the-shoulder restraint reduce the risk of injury when the train comes to a sudden halt? Explain your answer with reference to a suitable physics formula. (3)
- 3.1.3 The chairs on the Kingda Ka are designed with a high back rest which supports the head. Explain why this is an important safety feature, especially during the period of sudden horizontal acceleration from rest. (4)
- 3.2 Read the following extract adapted from <www.heraldnet.com>.

Rider bird strike closes Kingda Ka roller coaster

A boy is recovering after he was hit in the face by a bird while riding a roller coaster at an amusement park in New Jersey. The collision occurred as the Kingda Ka coaster was returning to the station at $24 \text{ m}\cdot\text{s}^{-1}$. The boy was taken to a hospital for treatment of minor injuries to his face.

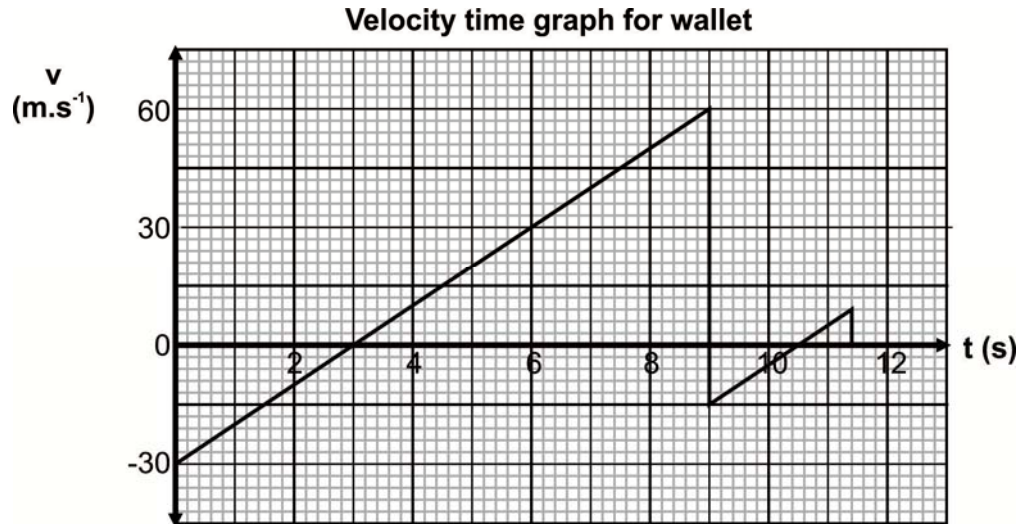
The bird (mass 80 g) was flying horizontally at $6 \text{ m}\cdot\text{s}^{-1}$ when it hit the boy. Its speed was changed to $24 \text{ m}\cdot\text{s}^{-1}$ in the opposite direction during the collision which lasted $0,05 \text{ s}$. The bird died as a result of the collision.

- 3.2.1 Define *relative velocity*. (2)
- 3.2.2 What is the velocity of the bird relative to the boy immediately before the collision? (2)
- 3.2.3 Calculate the magnitude of the force exerted by the bird on the boy. (5)
- 3.2.4 Explain why the bird died but the boy only suffered minor injuries as a result of the collision. (4)

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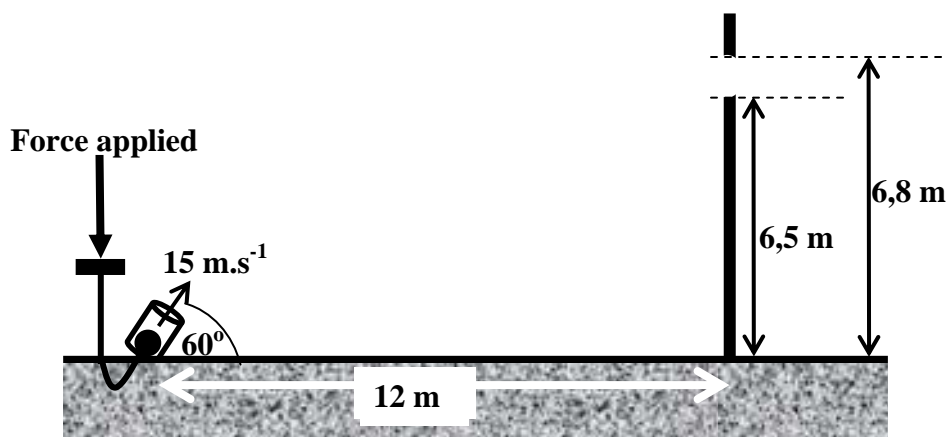
QUESTION 4 PROJECTILE MOTION

4.1 Whilst ascending the vertical tower of the Kingda Ka a wallet falls out of a rider's pocket. The simplified velocity-time graph representing the vertical motion of the wallet is represented below. Down has been taken as the positive direction. Air resistance can be ignored.



- 4.1.1 What was the magnitude of the vertical velocity of the train at the instant the wallet left the rider's pocket? (1)
- 4.1.2 Using information from the graph, calculate the height of the wallet above the ground at the instant it was released. (4)
- 4.1.3 How many times did the wallet bounce before coming to rest? (2)
- 4.1.4 Draw a displacement vs. time sketch graph to represent the change in position of the wallet with time. Use the release point as the frame of reference. No numerical values need to be shown but the axes should be labelled with the physical quantities plotted. (4)

4.2 A game challenges the ability of contestants to shoot a small ball through a hole in a vertical wall. The contestants launch the ball from a tube on the ground. They are able to vary the speed and the angle at which the ball is launched. The diagram below represents John's attempt. Ignore the effects of air resistance.



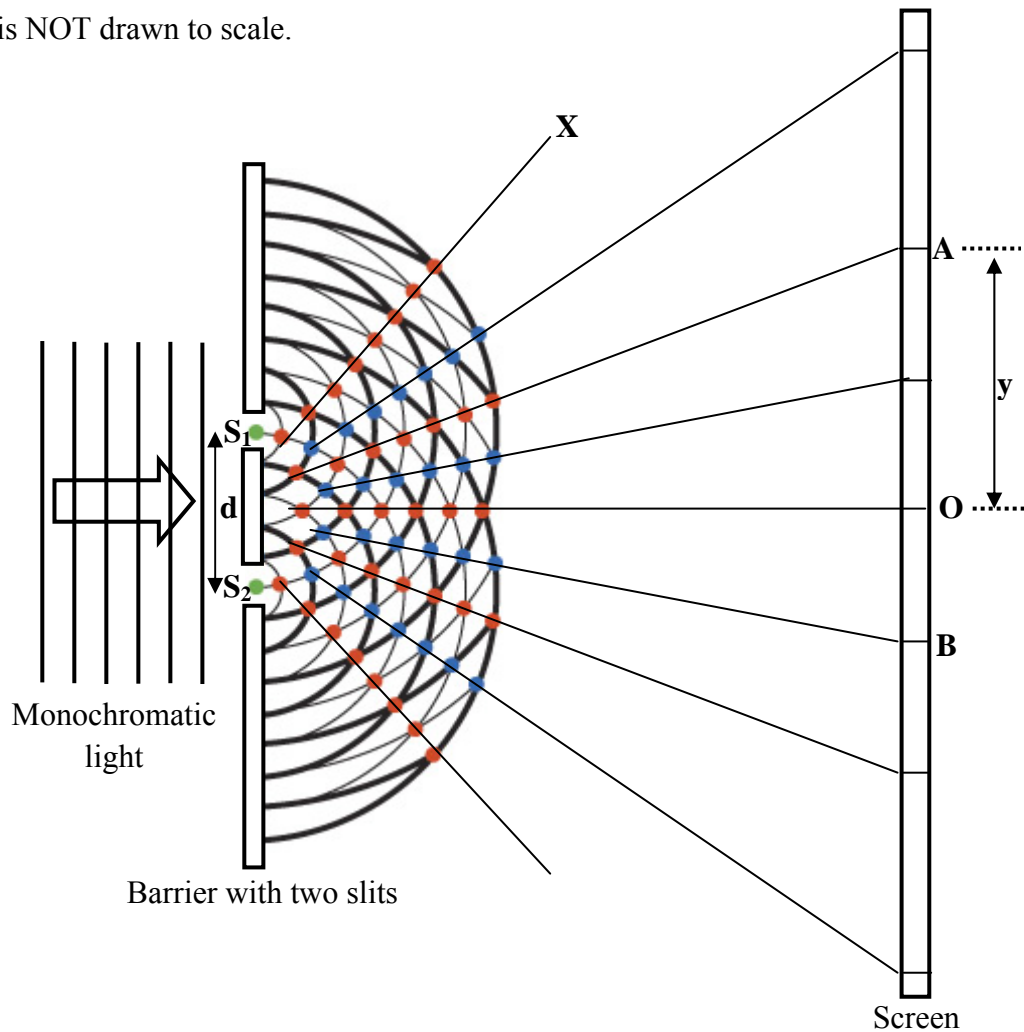
Does John's ball pass through the hole in the wall? Show all working in support of your answer.

(9)
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QUESTION 5 INTERFERENCE OF LIGHT

Monochromatic light (light of a single frequency) is passed through two narrow slits, S_1 and S_2 , separated by a distance d , as shown in the diagram below. The light undergoes diffraction at each slit. These slits act as coherent sources of light waves that interfere to produce a pattern of alternating light and dark bands on the screen.

Diagram is NOT drawn to scale.



- 5.1 Define *diffraction*. (2)
- 5.2 What type of interference takes place at position A on the screen? Explain your answer by referring to the phase relationship of the waves as they arrive at A. (2)
- 5.3 Would you expect to see a bright band or a dark band at position B on the screen? Explain your answer by referring to the phase relationship of the waves as they arrive at B and the subsequent type of interference. (3)
- 5.4 Is line X a nodal or an antinodal line? Explain your answer. (2)

- 5.5 An experiment is conducted to determine how the distance (d) between the slits affects the extent to which the bands of light spread out, as measured by the distance (y) between O and A. Monochromatic light of fixed wavelength is used and the distance between the screen and the slits is kept constant.

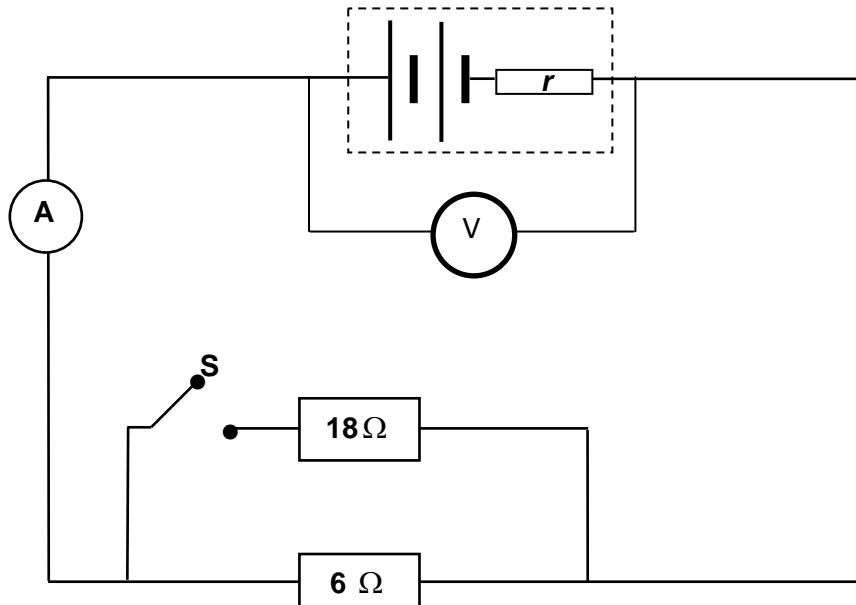
Distance (d) between the slits (mm)	Distance (y) between O and A (mm)
0,10	20
0,15	13
0,20	10
0,25	8,0
0,30	6,7
0,35	5,7
0,40	5,0

- 5.5.1 Name the independent variable in this experiment. (2)
- 5.5.2 Why is it necessary to keep the distance between the screen and the slits constant? (2)
- 5.5.3 On the graph paper provided in your Answer Sheet plot a best fit curve to represent the results of this experiment. (7)
- 5.5.4 Use your graph to determine the distance (d) between the slits for which the distance (y) between O and A is 16 mm. (2)
- 5.5.5 State a suitable conclusion for this experiment. (2)
- 5.5.6 Determine the distance (y) between O and A when the distance (d) between the slits is 1,25 mm. Show working in support of your answer. (3)
- 5.5.7 The relationship concerning the distance (d) between the slits and the distance (y) between O and A is best represented by means of a straight line graph. If the distance (y) between O and A is plotted on the y-axis state the physical quantity and its unit that must be plotted on the x-axis in order to obtain a straight line graph. (2)

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QUESTION 6 ELECTRIC CIRCUIT

A class of learners conducts experiments to determine the emf and internal resistance of a new battery. Titus and Thobile set up their circuit as shown in the diagram below. They take readings from the ammeter and the voltmeter when the switch, S, is open and when the switch, S, is closed. The resistances of the ammeter, switch and connecting wires can be ignored. The voltmeter has a very high resistance.



Results

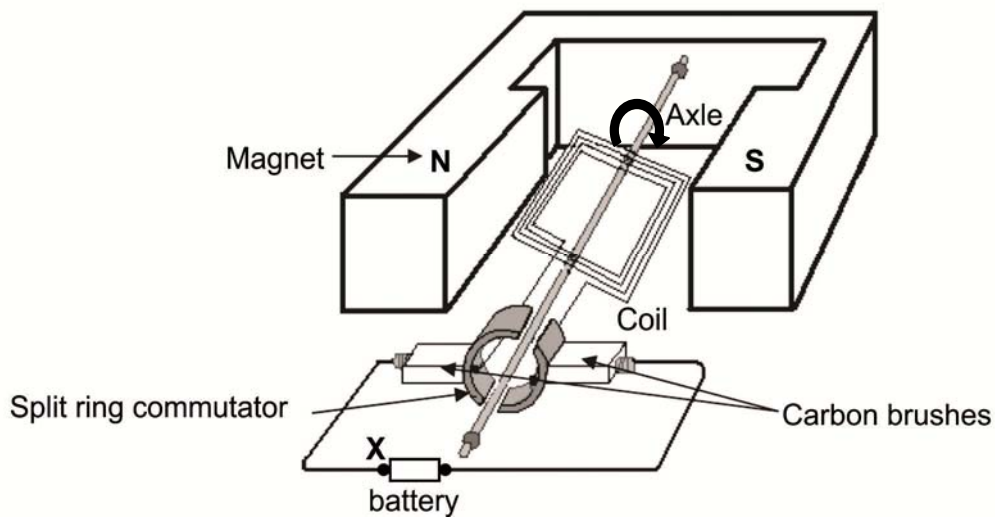
Switch	Reading on ammeter (A)	Reading on voltmeter (V)
Open	?	1,92
Closed	0,4	?

- 6.1 Calculate the reading on the ammeter when the switch is open. (3)
- 6.2 Calculate the reading on the voltmeter when the switch is closed. (4)
- 6.3 Explain why the voltmeter reading changes when the switch is closed. (2)
- 6.4 Calculate the current through the 18 Ω resistor when the switch is closed. (4)
- 6.5 Calculate the energy dissipated in the 18 Ω resistor in 5 minutes when the switch is closed. (4)
- 6.6 Use the results of the experiment to calculate the emf and internal resistance of the battery. (7)
- 6.7 Bruce and Betty conduct the same experiment as Titus and Thobile in order to find the emf and internal resistance of the same new battery. The only difference is they use a 12 Ω resistor and a 24 Ω resistor instead of a 6 Ω resistor and an 18 Ω resistor. What impact (if any) will this have on the results they obtain for the emf and internal resistance of the battery? Justify your answer. (3)

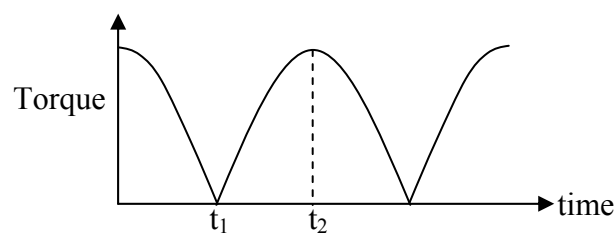
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QUESTION 7 MOTOR AND GENERATOR

7.1 The diagram below represents a simplified sketch of a DC electric motor.



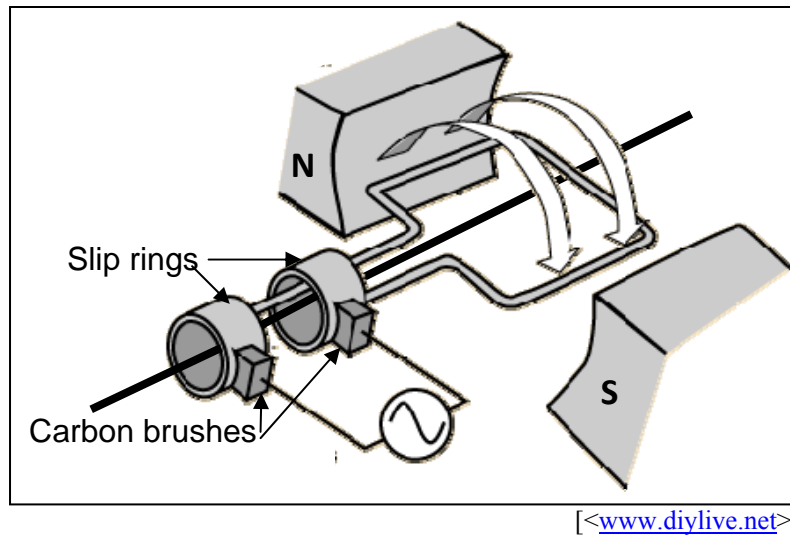
- 7.1.1 The coil rotates in a clockwise direction as indicated by the solid black arrow. What is the polarity (positive or negative) of the pole of the battery labelled X? (2)
- 7.1.2 Describe the energy conversion that takes place in the electric motor. (2)
- 7.1.3 Electric motors have had a great impact on society. Name TWO devices that use electric motors. (2)
- 7.1.4 The simplified graph below shows the changes in torque (turning force) with time for one complete cycle of rotation of the DC motor shown in the diagram.



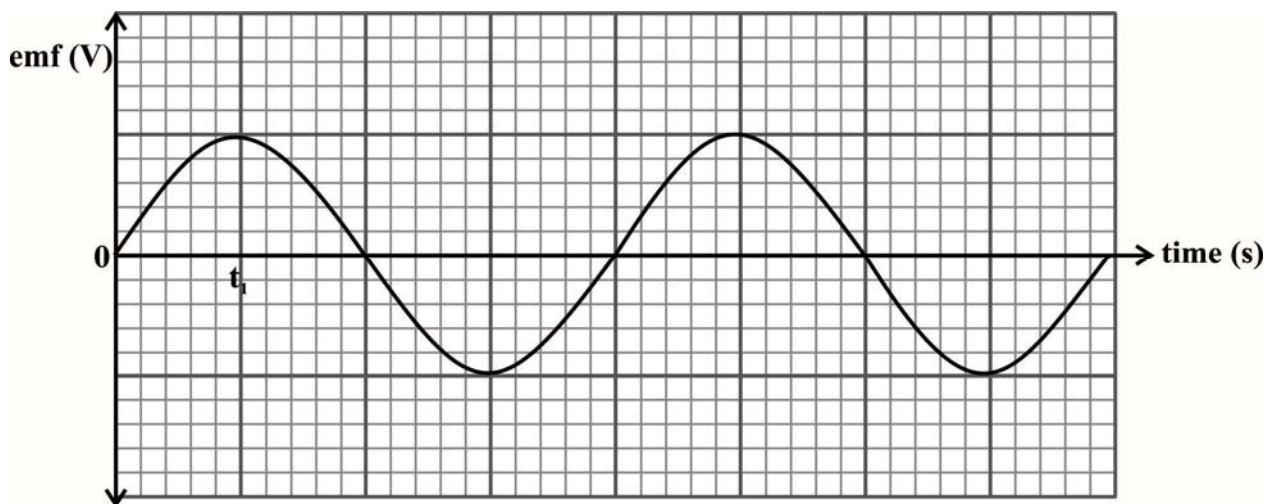
Give the orientation of the coil in the field (*vertical or horizontal*) for time

- (a) t_1
- (b) t_2 (2)
- 7.1.5 Explain why the torque (turning force) changes with time in the manner shown in the graph. (4)

7.2 The diagram below represents a simplified sketch of an AC generator.



- 7.2.1 Give TWO structural differences between the DC motor and the AC generator. (4)
- 7.2.2 State Faraday's law of electromagnetic induction. (2)
- 7.2.3 State TWO ways of increasing the magnitude of the induced emf. (2)
- 7.2.4 The simplified sketch graph below shows the changes in induced emf with time for two complete cycles of rotation of the AC generator shown in the diagram.



Give the orientation of the coil in the field (*vertical or horizontal*) for times

- (a) 0 s (1)
- (b) t_1 (1)
- (c) On the Answer Sheet draw the graph of emf against time when the speed of rotation is halved. (4)

7.2.5 Although most of South Africa's electricity is generated by coal-fired power stations, there is a nuclear power station near Koeberg in the Western Cape.

- (a) State TWO environmental advantages of the generation of electricity in nuclear power stations over coal-fired power stations. (2)
- (b) State TWO environmental disadvantages of the generation of electricity in nuclear power stations. (2)

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QUESTION 8 ELECTROMAGNETIC SPECTRUM AND THE PHOTOELECTRIC EFFECT

8.1 The following table gives information about different types of electromagnetic radiation.

Type of radiation	Typical wavelength (m)	Typical frequency (Hz)	Use	
Microwaves	3×10^{-2}	1×10^{10}	8.1.1	(1)
Ultra violet	8.1.2	6×10^{15}	To detect forged bank notes	(3)
8.1.3	1×10^{-10}	3×10^{18}	To see bones inside body	(1)

Complete the table by giving the information missing in blocks 8.1.1, 8.1.2 and 8.1.3. You must show working for 8.1.2. You do not need to re-draw the table.

8.2 8.2.1 What is the photoelectric effect? (2)

8.2.2 The work function of calcium is 2,9 eV.

(a) Calculate the work function of calcium in joules. (1)

(b) Calculate the minimum frequency of light required for the photoelectric effect to take place at the surface of calcium metal. (4)

(c) Explain why the photoelectric effect will not take place when the frequency of the incident light is lower than that calculated in Question 8.2.2 (b). (3)

(d) Calculate the maximum kinetic energy of the electrons emitted from calcium metal when ultraviolet light of frequency $6,0 \times 10^{15}$ Hz is incident on the metal surface. (4)

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Total: 200 marks