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GRADE 12
Physical Science: Paper 1 (Physics)
2020

Time: 3 hours
Examiner: K van Schoor

Marks: 200
Moderator: S Govender/M Naidoo

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY:

1. This paper consists of 17 pages and a laminated data sheet. Make sure that your paper is complete.
2. Answer ALL the questions.
3. Read the questions carefully.
4. Start each question on a new page.
5. Use the data and formulae whenever necessary.
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, answers should be expressed as TWO decimal places and not be left as fractions.
9. It is in your own interest to write legibly and to present your work neatly.

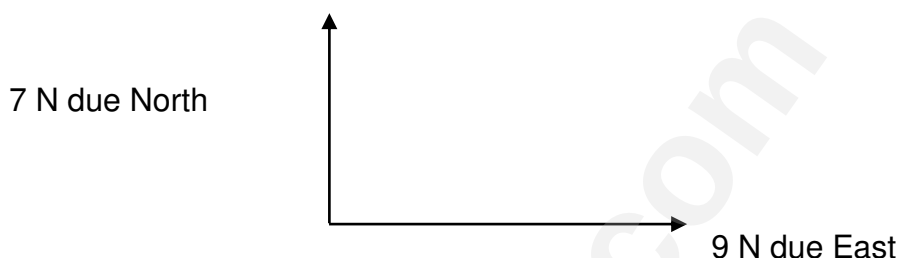
Exam number:

Acknowledgements – some questions and pictures were adapted from the following sources:
CIE 2019, Beaulieu 2019, IEBT 2018, St Stithians 2019, quizizz.com, SJC 2014, IEB 2018, Physics today.

Question 1: Multiple Choice Questions**[20]**

Answer these questions on the multiple choice grid in the front flap of your answer booklet. Place a cross over the correct letter on the grid.

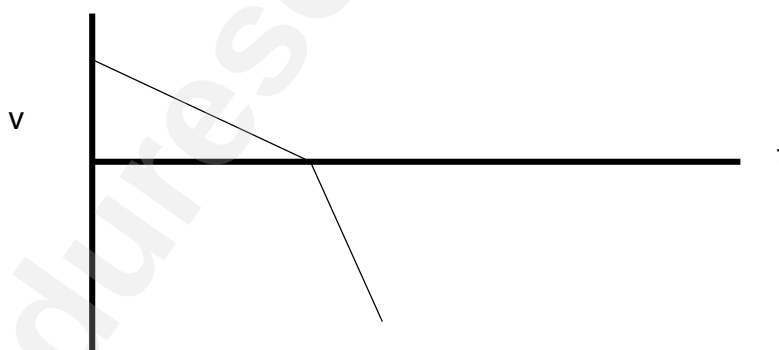
1.1. Two forces acts on an object as shown below:



Choose the correct options for the resultant of the two forces from the table below:

	Magnitude (N)	Direction
A	11	52° South of East
B	16	38° South of East
C	11	52° North of East
D	11	52° East of North

1.2. Consider the velocity vs time graph of a car initially travelling East below:



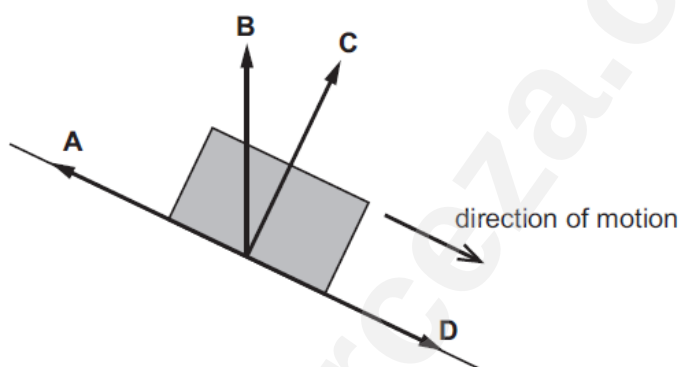
Which one of the statements below correctly describes the motion of the car?

- A The car slows down, stops and then speeds up in an westerly direction
- B The car slows down at a faster rate after stopping
- C The car speeds up in an easterly direction and then speeds up more in a westerly direction
- D The acceleration of the car is directed East before stopping and West after stopping.

- 1.3. Kelsey drops a soccer ball from a height h above the ground and it strikes the ground at a speed v . From what height must she drop the ball to double the speed at which it strikes the ground?
(Air friction can be ignored)

A $2h$
B $3h$
C $4h$
D $5h$

- 1.4. A body slides down a slope as shown.
Which of the forces labelled A, B, C or D shows the direction of the Newton 3 reaction force of the friction on the block?



- 1.5. An elastic collision occurs between two bodies X and Y. The mass of body X is m and the mass of body Y is $4m$. Body X travels at v to the right before the collision and with a speed $\frac{3v}{5}$ to the left after the collision. Body Y is stationary before the collision.



What is the kinetic energy of body Y after the collision?

A $\frac{1}{5}mv^2$ B $\frac{16}{50}mv^2$ C $\frac{34}{50}mv^2$ D $\frac{8}{50}mv^2$

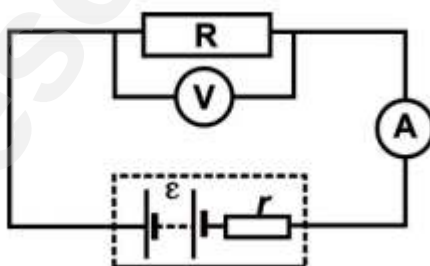
- 1.6. A body moving at a constant velocity has kinetic energy E , as well as momentum p . If the velocity of the body is doubled, which one of the following correctly gives the magnitudes of both kinetic energy and momentum?

	Kinetic Energy	Momentum
A	$2E$	$2p$
B	$4E$	$4p$
C	$4E$	$2p$
D	$2E$	$4p$

- 1.7. Planet K exerts a force of F on the star, Sirius. The Sun has half the mass of Sirius and is 5 times closer to planet K. In terms of F , what force does Planet K exert on the Sun?

- A $\frac{1}{10} F$ B $\frac{2}{25} F$
 C $\frac{25}{2} F$ D $50 F$

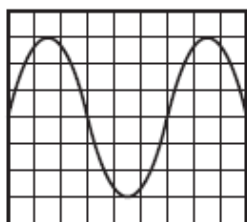
- 1.8. A battery with emf ($\mathcal{E}$) and internal resistance (r) is connected to resistor R as shown in the diagram below. The internal resistance r is equal to the resistance of resistor R . ($r = R$)
 The ammeter reads 3,0 A.



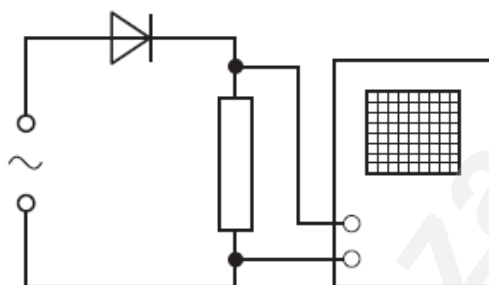
A second resistor with the same resistance is now connected in series with resistor R .
 What is the reading on the ammeter when the second resistor is connected in series?

- A 1,0 A
 B 1,5 A
 C 2,0 A
 D 3,0 A

- 1.9. An AC source is connected to an oscilloscope and produces the trace as shown.

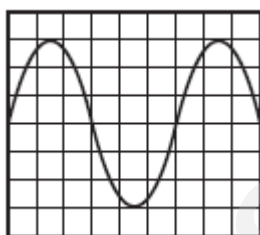


A diode is now connected in series to the circuit.

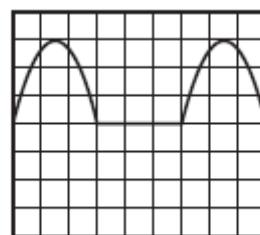


Which of the following diagrams shows the new trace on the screen?

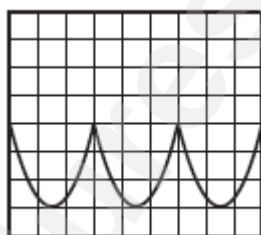
A



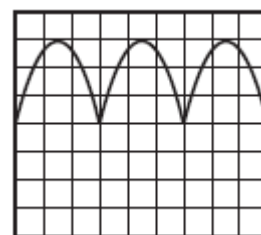
B



C



D



- 1.10. Which one of the statements below about the photo electric effect is **false**?

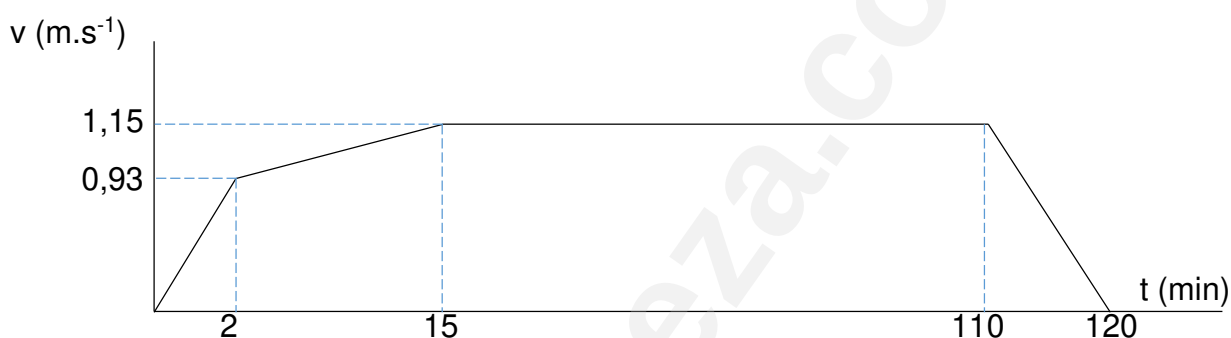
- A Electrons are always emitted instantaneously if the wavelength is high enough.
- B Electrons are always emitted instantaneously if the frequency is high enough
- C Electrons are always emitted when the incident energy is higher than the work function.
- D The kinetic energy of the emitted electrons is dependent of the incident frequency.

Question 2: Swimmer in motion**[21]**

- 2.1. According to Guinness world records, the longest distance ever swum without fins in the open sea is 225 km by Veljko Rogosic.

Distinguish between *speed* and *velocity*. (3)

- 2.2. The graph (not to scale) below shows the velocity vs time of Veljko for the first 2 hours until he stopped at a rubber duck to get some refreshments.



- 2.2.1. Use the graph to determine the displacement (in meters) during the first 15 minutes. (4)
- 2.2.2. Determine the magnitude of the average velocity for Veljko during the first 15 minutes. (2)
- 2.2.3. Define *acceleration*. (2)
- 2.2.4. Determine the magnitude of the acceleration of Veljko during the first 2 minutes. (3)
- 2.2.5. Use features of the graph to describe the difference in his acceleration during the first 2 minutes and the next 13 minutes. (No calculation necessary) (2)
- 2.2.6. Draw a sketch graph of the displacement vs time for Veljko's swim during the first 2 hours. Only the time intervals need to be shown. (5)

**Question 3: Cricket****[21]**

Taheer throws a cricket ball vertically upwards while waiting for a match to start and Kearsen decides to design a scientific investigation around this.

He uses light gates to determine the initial velocity, u , of the ball and investigated how the initial velocity affects the maximum height the ball reaches. (note $u = v_i$)

Ruth suggests that their results should help them to confirm the value of gravitational acceleration.

They used a video camera to determine the maximum height reached by the ball.

- 3.1. State the instantaneous velocity and the acceleration of the ball at the point where it reaches the maximum height. (2)

Their results are shown in the table below.

Initial velocity (m.s^{-1})	u^2	Maximum height reached (m)
8	64	4
11	121	6
17	289	15
23	529	27
29	841	42
30	900	46

- 3.2. Consider the second column in their table.

- 3.2.1. Give the unit for this column. (1)

- 3.2.2. Use an equation of motion to write a simplified equation showing the relationship between the square of the initial velocity, u^2 , and the maximum height reached. (2)

- 3.3. On the graph grid provided in your answer booklet's back page, plot a graph of the maximum height reached vs the square of the initial velocity. Include a line of best fit. (6)

- 3.4. Use your graph to determine the gradient of the line of best fit. Show the values you used on the graph. (4)

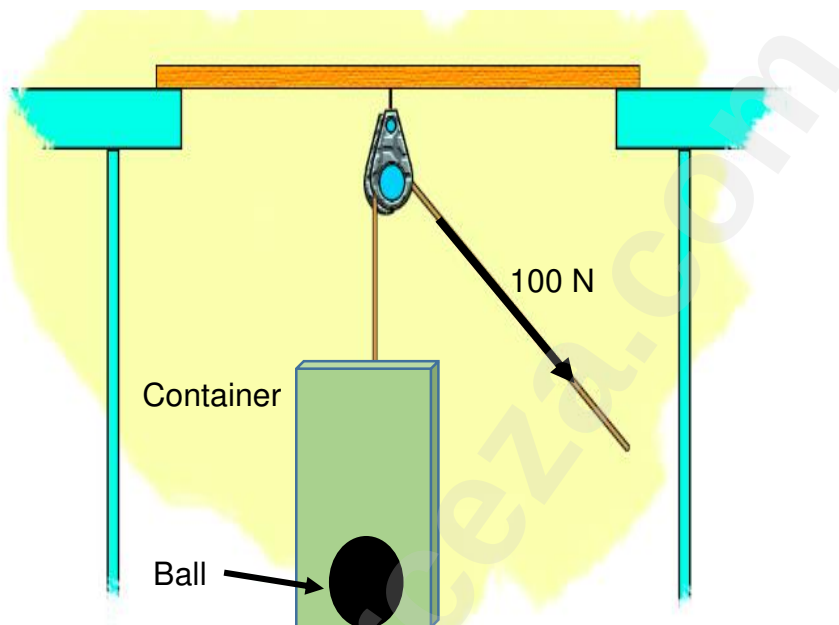
- 3.5. Write the equation stated in 3.2.2. in the form $y = mx + c$ and use this equation to state the quantity given by the gradient of your graph. (2)

- 3.6. Determine the acceleration due to gravity using your answers to 3.5 and the gradient. (2)

- 3.7. State a possible reason, referring to the forces acting on the ball, for the difference in your answer and the known value of gravitational acceleration. (2)

Question 4: Newton's Laws**[22]**

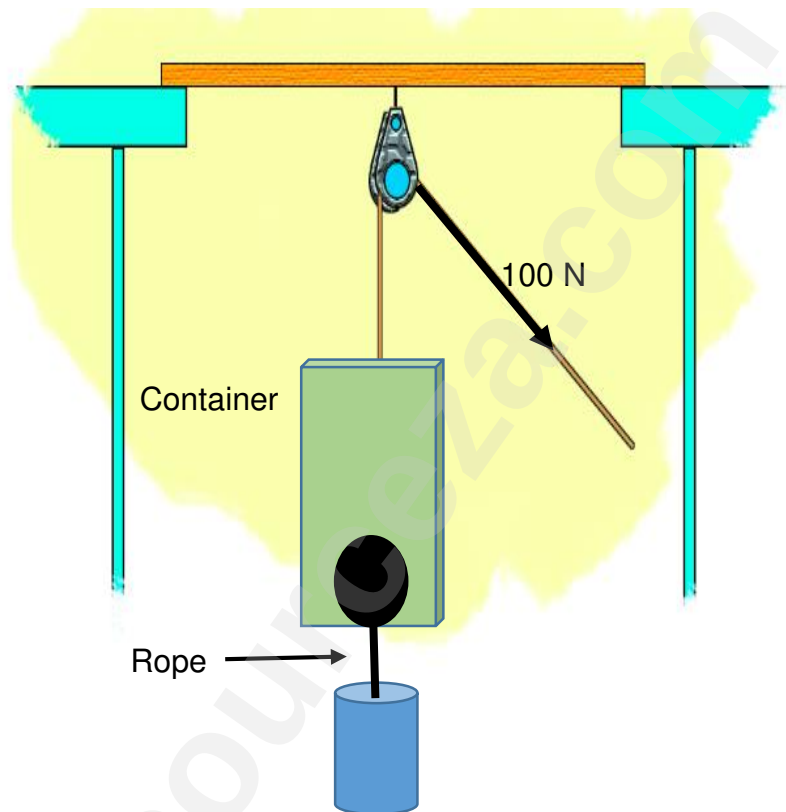
While in lockdown Amo decides to design a new ride for Gold Reef City to use. This would shoot a person up in the air using a pulley system similar to that of a lift. The diagram below shows the design of the model he builds using a ball to simulate the person and a container to simulate the lift.



The empty container has a mass of 6,4 kg and the ball a mass of 580 g.

- 4.1. State *Newton's second law of motion*. (2)
- 4.2. Amo exerts a force of 100 N on the pulley used to pull the rope up.
 - 4.2.1. Draw a labelled free body diagram showing all the forces acting on the **ball** as the system accelerates upwards. Relative sizes of the forces must be shown. (3)
 - 4.2.2. Determine the weight of the container and the ball. (2)
 - 4.2.3. Determine the acceleration of the system. (3)
 - 4.2.4. State the Newton III reaction force of the weight of the ball. (2)
 - 4.2.5. Determine the magnitude of the normal force that the bottom of the container exerts on the ball. (3)

- 4.3. As the container comes to rest the ball hits the top of the container and Lufuno suggests that he should add another object to the bottom of the container to decrease the acceleration of the system. She suggests the adjustment shown in the diagram below. A rope that can withstand a tension of 20 N is used to connect a cylinder of mass 1,5 kg to the bottom of the container.



For this system, determine (showing all your calculations)

- 4.3.1. The magnitude of the acceleration of the system. (4)
- 4.3.2. Whether the rope connecting the container and the cylinder will break or not during the acceleration. (3)

Question 5: Momentum, Work and Energy**[29]**

5.1. Keabetswe (55 kg) dreams of going on a skiing holiday when lockdown is over...

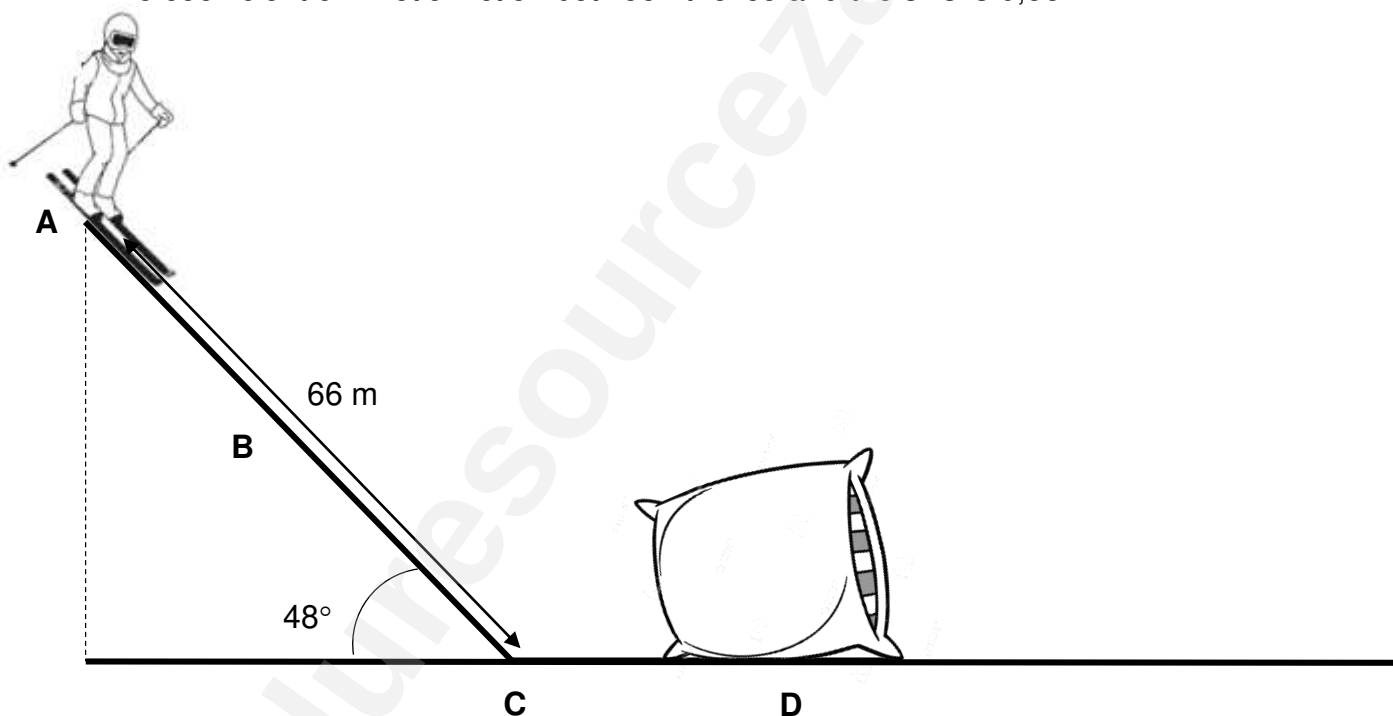
In her dream, she gets pulled up the ski slope at a constant velocity of $1,3 \text{ m}\cdot\text{s}^{-1}$ by a tow bar that exerts an average force of 120 N on her.

5.1.1. Calculate the output power of the tow bar's motor. (3)

5.1.2. The motor is rated 200 W. Determine the percentage efficiency of the motor pulling her up the slope. (2)

Once at the top, she can start skiing. She skis from the top of the slope, inclined at 48° as shown in the diagram below. The slope is 66 m long. (The mass of the gear and skis can be ignored)

The coefficient of kinetic friction between the ice and the skis is 0,58.



5.2. Define *potential energy*. (2)

5.3. Determine her potential energy at the top of the slope as she is about to ski down. (Position A) (4)

5.4. Draw a free body diagram showing all the forces acting on Kea as she is skiing down the slope. (Position B) (3)

- 5.5. Determine the magnitude of the maximum frictional force acting on her while she is skiing down the slope. (3)
- 5.6. Use energy principles to determine her speed as she reaches the bottom of the slope. (Position C) (4)

At the bottom of the slope the ice is so slippery that frictional force can be ignored. Keabetswe skies horizontally and just as she gets scared about her high speed, she collides with a giant fluffy pillow (at position D) with a mass of 23 kg and they slide further together.

- 5.7. State the *law of conservation of linear momentum*. (2)
- 5.8. Calculate the speed of Keabetswe and the pillow after the collision. (3)
- 5.9. Explain how the pillow prevented her from getting hurt during the collision. Use a relevant equation to support your answer. (3)

Question 6: Fields**[25]**

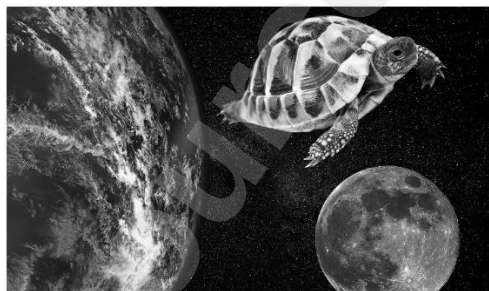
In 1968, the race was on between the USA and the Soviet Union to get a man on the Moon. The Russians launched the Zond 5 spaceship with a capsule carrying samples of soil and seeds, some worms and two steppe tortoises. These tortoises were the first living creatures able to survive this journey to the Moon but they lost 5 % of their body mass during this trip due to muscle and bone degeneration.



6.1.1. The Zond 5 had a total mass of 5 375 kg.

- a) State Newton's *Law of Universal Gravitation*. (2)
- b) Determine the magnitude of the gravitational force acting on the Zond 5 when it was 953 km above the Earth's surface. (The radius of the Earth is 6 371 km and the mass of the Earth is $6,0 \times 10^{24}$ kg.) (4)

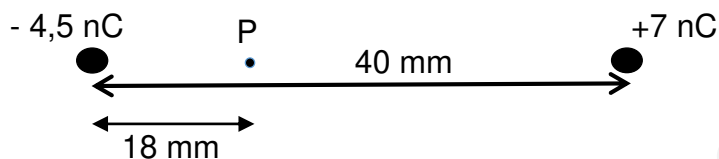
6.1.2. The smallest tortoise had a mass of 340 g when leaving the Earth and lost 5% of this mass by the time she reached the Moon.



The Earth has a mass of 81 times that of the Moon and is 4 times larger than the Moon.

- a) What would the gravitational field strength of the Moon be? (3)
- b) What would the mass of the small tortoise be on the surface of the Moon? (2)

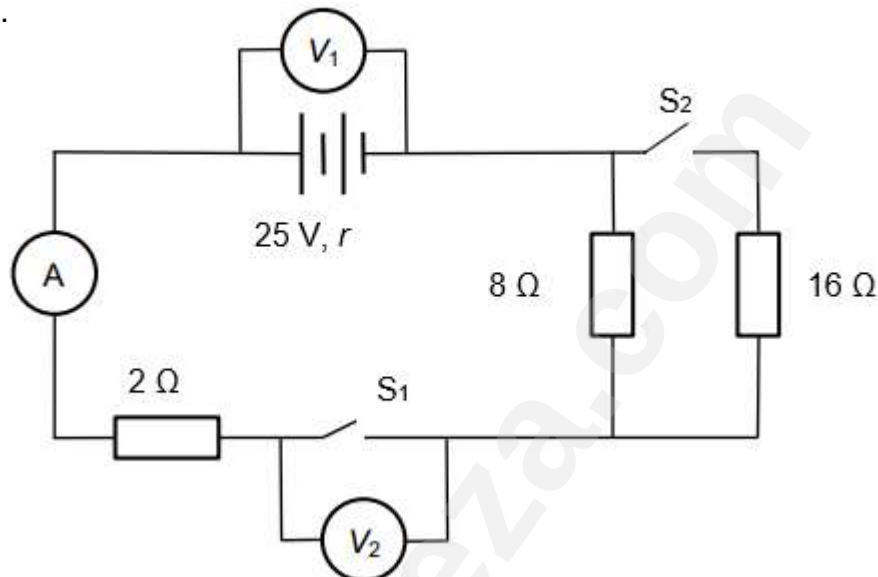
- 6.2. Two small conducting spheres which carry charges of $-4,5 \text{ nC}$ and $+7 \text{ nC}$ are placed a distance of 40 mm apart as shown in the diagram below.



- 6.2.1. Define *the magnitude of an electric field at a point*. (2)
- 6.2.2. In your answer book, draw the electric field around each of these conducting spheres. (3)
- 6.2.3. Along the straight line joining the two small spheres, there is a point P as indicated on the diagram.
This point is 18 mm from the $-4,5 \text{ nC}$ charge.
- a) Determine the resultant electric field strength at P. (6)
- b) An electron is placed at P.
Determine the resultant force that the electron will experience due to the electric field. (3)

Question 7: Current Electricity**[26]**

- 7.1. In the circuit represented in the diagram below, the battery has an emf of 25 V and a significant internal resistance, r . The resistance of the ammeter is negligible.



7.1.1. **The switch S_1 is open and S_2 is closed**

- Define *emf*. (2)
- State the reading on voltmeter V_1 . (2)
- State the reading on voltmeter V_2 . (2)

7.1.2. The switch S_1 is closed. S_2 remains closed.

- Use a suitable equation to explain **why** the reading on V_1 drops to 21 V. (3)
- Determine the total resistance of the resistors in the external circuit. (3)
- Determine the internal resistance of the battery. (4)

7.1.3. The switch S_2 is opened while S_1 remains closed. Use an appropriate equation to explain why the reading on the voltmeter, V_1 , **increases**. (3)

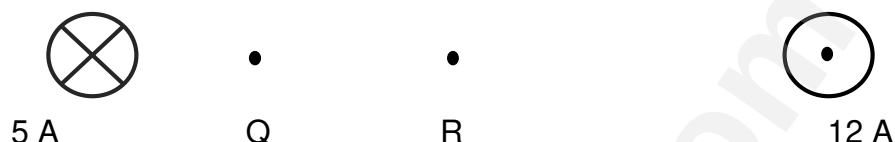
- 7.2. A hair dryer operates at a potential difference of 240 V and a current of 8,6 A. It takes Luzandi 13 minutes to completely dry her hair.

- Determine the energy used by the hairdryer in the 13 minutes. (3)
- Eskom charges energy usage at R1,88 per kWh. Calculate the cost of operating the hairdryer for the 13 minutes. (4)

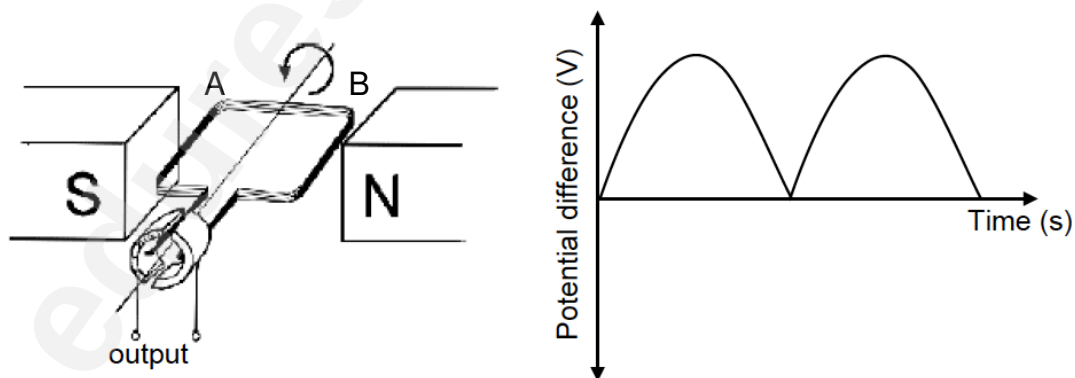
Question 8: Electrodynamics

[21]

- 8.1. Two conductors carrying currents of 5 A (into the plane of the page) and 12 A (out of the plane of the page) as shown, are placed 20 cm away from each other. The diagram is not to scale. Q and R are points in a straight line between the wires.

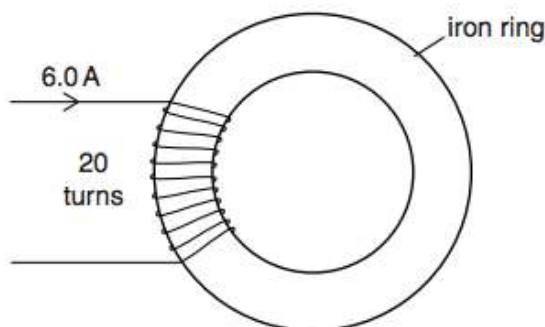


- 8.1.1. In your answer book, draw the magnetic field lines forming due to the current flowing in the 5 A conductor. (2)
- 8.1.2. At point Q, the magnetic force experienced due to the 5 A wire is equal to that experienced due to the 12 A wire. Explain how it is possible for the different currents to produce forces of the same magnitude. (2)
- 8.1.3. Point R is in the middle between the two current carrying wires. State the direction of the net magnetic force acting at point R. Only state **upwards** (to the top of the page), **downwards** (to the bottom of the page), **left**, **right**, **out of the page** or **into the page**. (2)
- 8.2. A simplified diagram of a generator and a graph of its output voltage is shown.



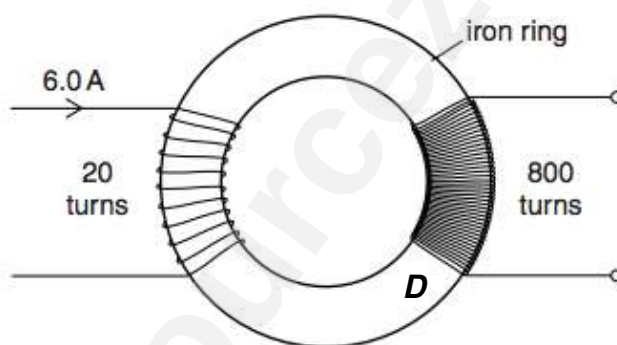
- 8.2.1. The output of this generator can be considered DC. Explain how the alternating current produced by this generator is rectified into DC. (2)
- 8.2.2. State two ways in which the output voltage of this generator can be increased? (2)

- 8.3. To create a transformer, 20 turns of wire is wound onto a ring as illustrated below.



A current of 6,0 A in the coil causes a magnetic flux of $3,8 \times 10^{-5}$ Wb in the ring.

A second coil of 800 turns is now placed on the ring together with the first coil as shown below.



When a constant direct current of 6,0 A flows in the 20 turn coil, no current is induced in the 800 turn coil.

- 8.3.1. Use *Faraday's Law of electromagnetic induction* to explain why there is no current induced in the 800 turn coil. (3)

- 8.3.2. State *Lenz's law*. (2)

The current in the 20 turn coil increases from 6,0 A.

- 8.3.3. State the polarity of the electromagnet created in the 800 turn coil, while this increase is taking place, by stating if the side labelled **D** would be the north or the south pole of the electromagnet. (2)
- 8.3.4. Determine the current induced in the 800 turn coil if an alternating current of 6,0 A was used in the 20 turn coil. (4)

Question 9: Photons and electrons**[15]**

- 9.1. UV light of frequency $9,1 \times 10^{14}$ Hz is shone onto silver metal. The work function of silver is $4,33 \times 10^{-19}$ J. Electrons are ejected from the silver metal.

9.1.1. Define the term *threshold frequency*. (2)

9.1.2. Determine the threshold frequency for silver. (3)

Now, red light is shone onto the silver and no electrons are emitted.

9.1.3. The intensity of the red light is increased.

a) Will electrons be emitted? (1)

b) Explain your answer in a. (2)

- 9.2. Light of wavelength 542 nm is emitted from a certain element when an electron transition occurs between the fifth and the second energy level.

9.2.1. Calculate the energy of the photon of light that is emitted. (3)

9.2.2. The second energy level has an energy of -2,61 eV. Calculate the energy of the fifth orbital in joules. (4)