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THEODOR HERZL HIGH SCHOOL
PHYSICAL SCIENCES PAPER 1
GRADE 12

JUNE 2023
Examiner: CO
Moderator: JS

Time: 3 hours
Total: 200 marks

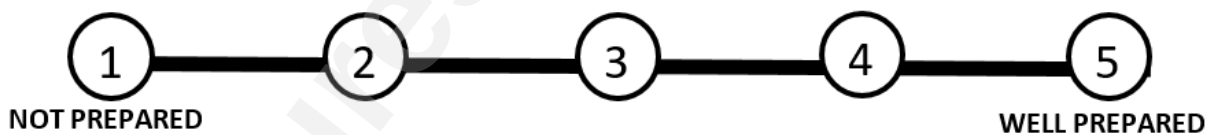
INSTRUCTIONS:

- Complete page 1 before starting the paper and after you have finished writing each question fill in the expected mark on the bottom of this page.
- The question paper consists of 8 questions.
- Answer all the questions on this paper.
- A non-programmable calculator may be used.
- All relevant data and formulas can be found at the end of the question paper.
- Round all final answers off to two (2) decimal places where necessary.

Name & Surname: _____

Before you start:	Before %	Expected %	Actual %
What percentage are you aiming to achieve for this assessment?			

How prepared do you feel for this assessment?

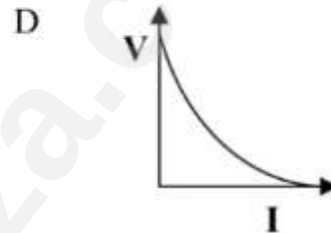
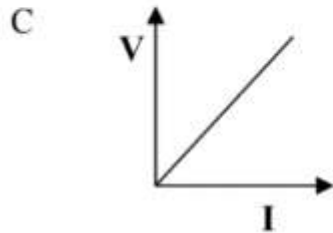
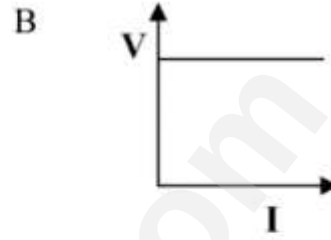
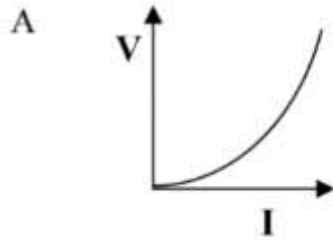


	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Total
Learner (expected mark)									
Teacher (actual mark)									

QUESTION 1

Answer this question by writing the letter of the correct answer below the question number in the table on page 5, below question 1.10.

- 1.1 Which one of the following graphs best represents the relationship between the potential difference (V) across an ohmic conductor and the current (I) in the conductor at constant temperature?



- 1.2 You are given 2 metal balls with masses m kg and $2m$ kg, with a force of $0,005\text{N}$ between them, and a distance r apart. If the mass of one of the balls is doubled and the distance between their centres is tripled, the new force measured between them will be N.

- A 0,0011
- B 0,0022
- C 0,0033
- D 0,0044

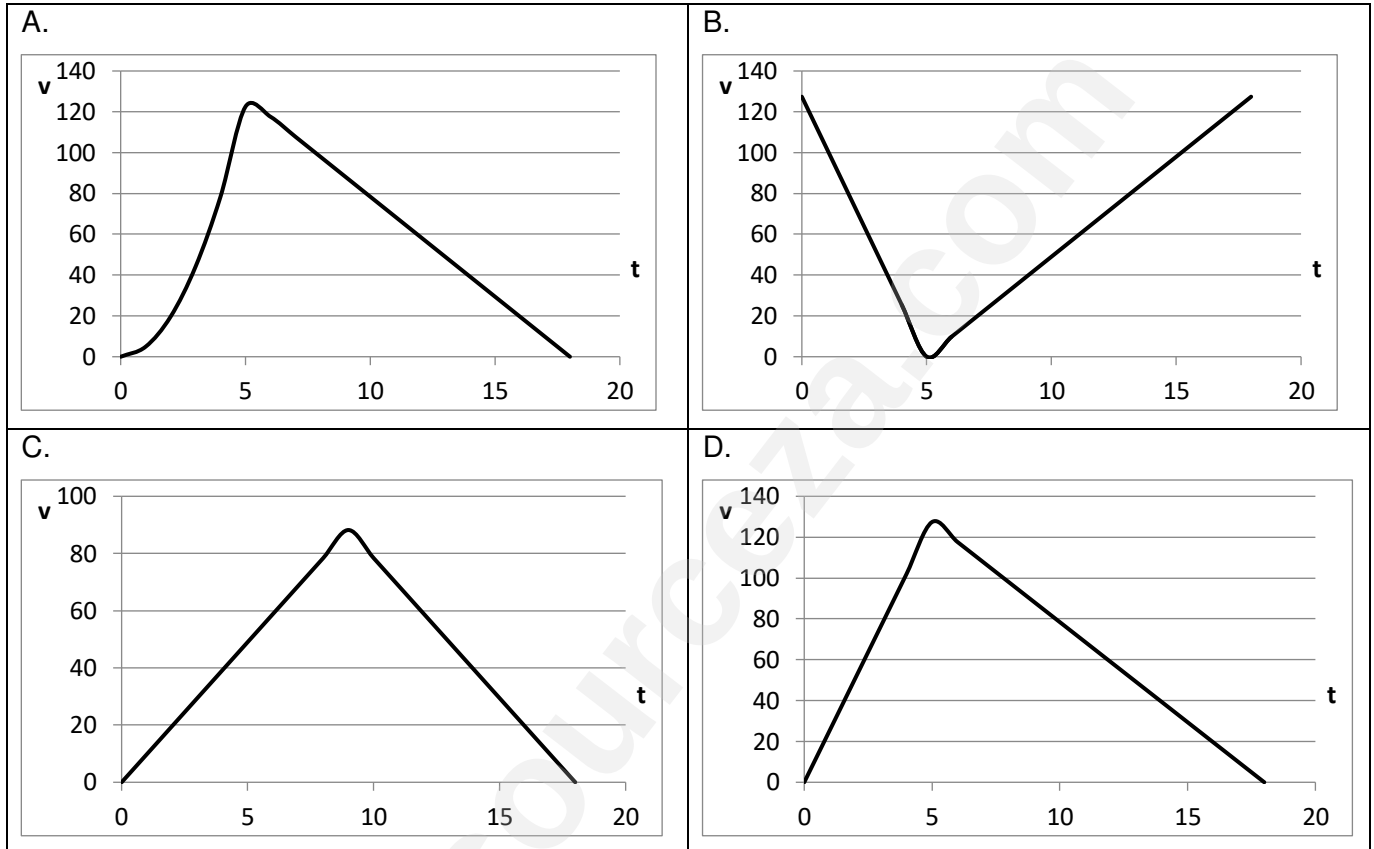
- 1.3 Given: spheres with charges q_1 and q_2 , a distance d apart. A graph of electrostatic force between the charged spheres vs. the charge on ONE of the spheres will be a ...

- A hyperbolic graph with the Force axis as asymptote.
- B straight line with gradient equal to 9×10^9
- C straight line with gradient equal to $9 \times 10^9 \times q_1 \times q_2$
- D straight line with gradient equal to $9 \times 10^9 \times q_1 \div d^2$

- 1.4 The front of a modern car is designed to crumple in case of a head-on collision. The chance of serious injuries to the passenger is reduced because the...
- A net force acting on the passenger is reduced, since the rate of change in momentum is decreased.
 - B net force acting on the passenger is reduced, since the rate of change in momentum is increased.
 - C net force acting on the passenger is reduced, since the change in the momentum is reduced.
 - D net force acting on the passenger is reduced, since the contact time for the car to stop decreases.
- 1.5 Which one of the following physical quantities is a measure of the inertia of an object?
- A Momentum.
 - B Mass.
 - C Acceleration.
 - D Energy.
- 1.6 Two bodies undergo an ELASTIC collision. Which ONE of the following combinations of momentum and kinetic energy of the system is CORRECT?

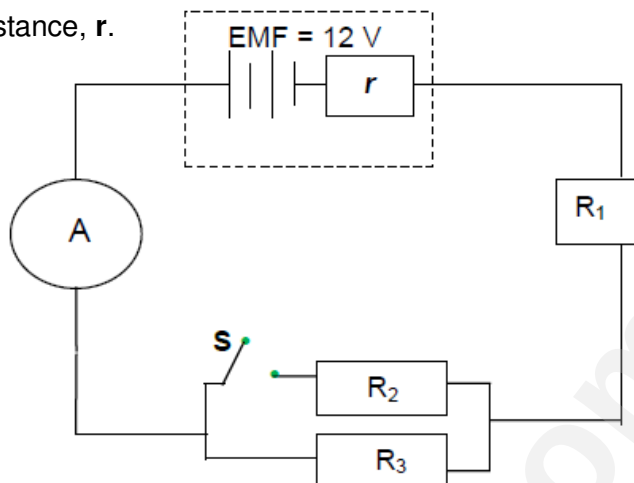
	Momentum	Kinetic Energy
A.	Not conserved	Not conserved
B.	Not conserved	Conserved
C.	Conserved	Not conserved
D.	Conserved	Conserved

- 1.7 A spaceship accelerates with a constant acceleration vertically upwards from rest. Five seconds after launching it runs out of fuel and reaches its maximum height 13 seconds later. If upwards is taken as the positive direction, which ONE of the following velocity-time graphs best represents this scenario?



- 1.8 When light of a certain wavelength is incident on a metal surface, no electrons are ejected. Which ONE of the following changes may result in electrons being ejected from the metal surface?
- A Increase the intensity of the light.
 - B Use light with a much shorter wavelength.
 - C Use light with a much longer wavelength.
 - D Increase the surface area of the metal.

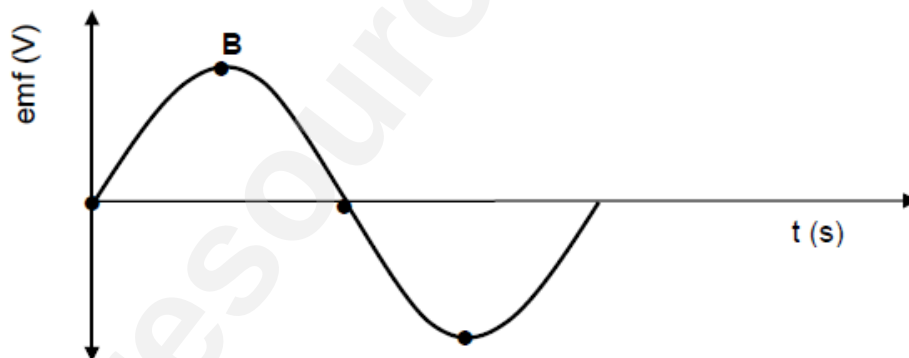
- 1.9 The circuit diagram below contains a combination of resistors R_1 , R_2 and R_3 . The battery has an EMF of 12 V and an unknown resistance, r .



When switch S is CLOSED, the voltage over the battery will...

- A ...remain the same.
- B ...increase.
- C ...decrease.
- D ...be unknown as there is insufficient information.

- 1.10 The coils of an AC generator make one complete rotation. The resulting graph for the output emf is shown below.



The position **B** on the graph is obtained when the plane of the coil is at an angle of ... to the magnetic field.

- A 0°
- B 60°
- C 90°
- D 120°

Multiple choice answers:

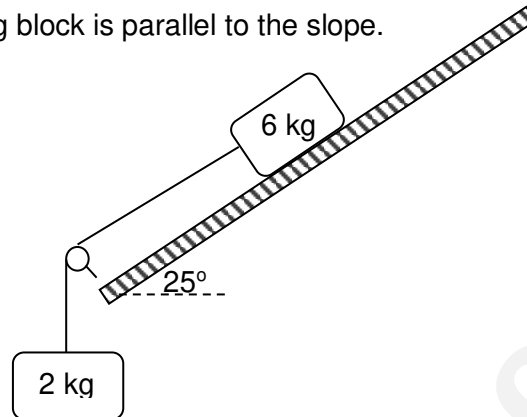
1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	Total

QUESTION 2

Newton laws

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- 2.1 A block of mass 6 kg, on an inclined ramp, is connected to another block of mass 2 kg by means of a light inextensible string that is hanging over a frictionless pulley. The 6 kg block accelerates down the ramp. The ramp is inclined at an angle 25° with the horizontal as shown in the diagram below. Assume that the cable on the 6 kg block is parallel to the slope.



The coefficient of kinetic friction between the 6 kg block and the surface of the ramp is 0,5. Ignore the effects of air friction.

- 2.1.1 NAME the force(s) responsible for the acceleration of the 6 kg block down the incline. (3)
- 2.1.2 State Newton's second law of motion in words. (2)
- 2.1.3 Draw a labelled free-body diagram indicating ALL the forces acting along the plane of motion. (2)
- 2.1.4 Calculate the tension in the connecting string. (6)

- 2.2 Thandi and Sue are wearing ice skates on an ice rink. Thandi has a mass of 50kg. They push off from each other and Thandi accelerates at a rate of $4,5 \text{ m.s}^{-2}$ to the right, but Sue only accelerates at a rate of $3,2 \text{ m.s}^{-2}$ to the left. Ignore friction.

- 2.2.1 State Newton's third law of motion in words. (2)



- 2.2.2 Identify two force pairs from the scenario. (2)

- 2.2.3 Calculate Sue's mass. (3)

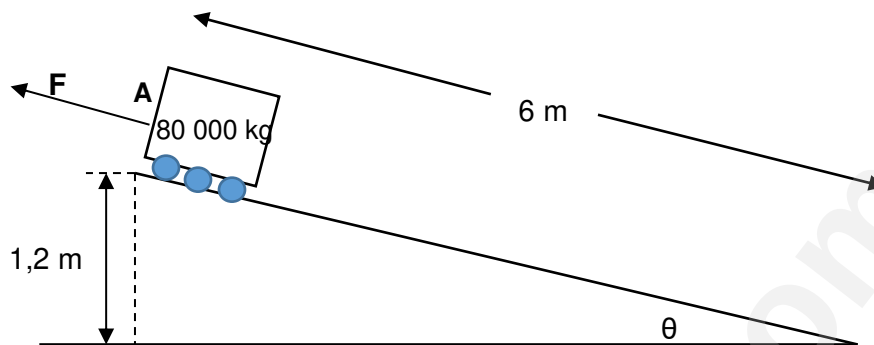
- 2.2.4 If friction is not ignored, who would most likely move the furthest, Thandi or Sue? (1)

- 2.2.5 Explain your answer to 2.2.4. (2)

QUESTION 3

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An 80 000 kg train locomotive (A) moves down a rough inclined plane at constant velocity, as shown in the diagram below. The plane is inclined at an angle θ to the ground. The coefficient of kinetic friction μ_k between the locomotive and the inclined surface is 0,2041. Ignore air resistance and any other energy losses.



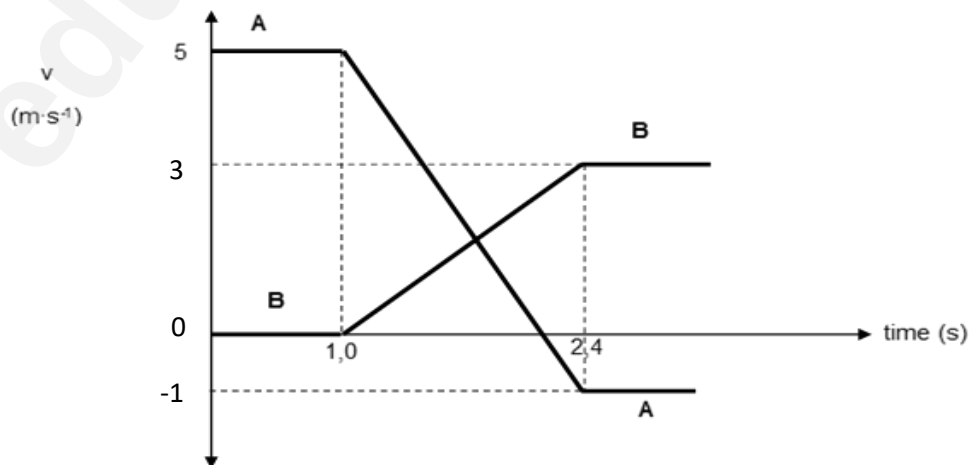
3.1 Calculate the angle θ . (2)

3.2 Write down the *work-energy theorem* IN WORDS. (2)

3.3 Calculate the work done by friction. (4)

The locomotive (A) is now moving horizontally in an easterly direction at $5 \text{ m}\cdot\text{s}^{-1}$. It collides with another locomotive B of unknown mass which is initially at rest on a straight level track.

The graph below shows the variation of the velocities with time of the two locomotives before, during and after the collision.



Ignore frictional forces between the locomotive and the track before, during and after the collision.

- 3.4 Write down the *principle of conservation of linear momentum* in words. (2)
- 3.5 Write down the magnitude and direction of the velocity of locomotive A after the collision. (2)
- 3.6 Calculate the change in momentum of A between 1,0 s and 2,4 s. (4)
- 3.7 Calculate the magnitude of the net force experienced by A between 1,0 s and 2,4 s. (3)
- 3.8 Calculate the distance travelled by B between 1,0 s and 2,4 s. (4)
- 3.9 Calculate the mass of B. (5)

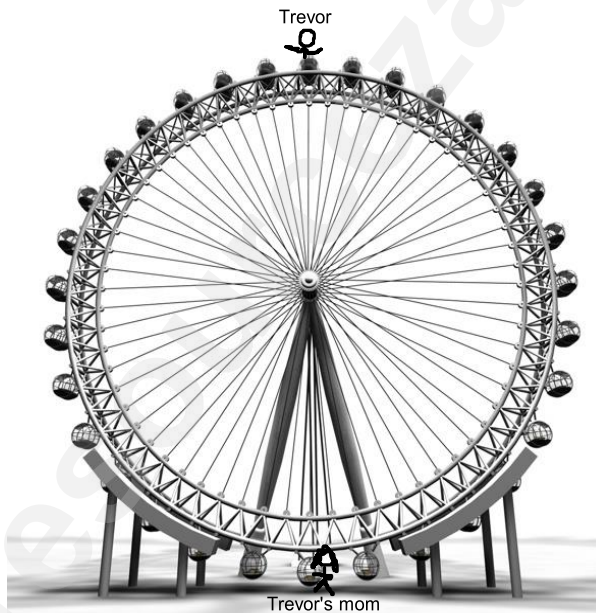
[28]

QUESTION 4

4.1 Explain the term *free fall*.

(2)

4.2 The High Roller in Los Angeles, USA, is the world's tallest Ferris wheel. Trevor, a tourist from South Africa, decides to take a ride on the High Roller Ferris wheel. When Trevor reaches the top of the Ferris wheel, he is so amazed by the view that he drops his ice cream cone. The ice cream cone falls vertically downwards, and 5,7 seconds later it strikes Trevor's mother's foot where she is standing directly beneath the Ferris wheel. The effects of air resistance can be ignored for all calculations.

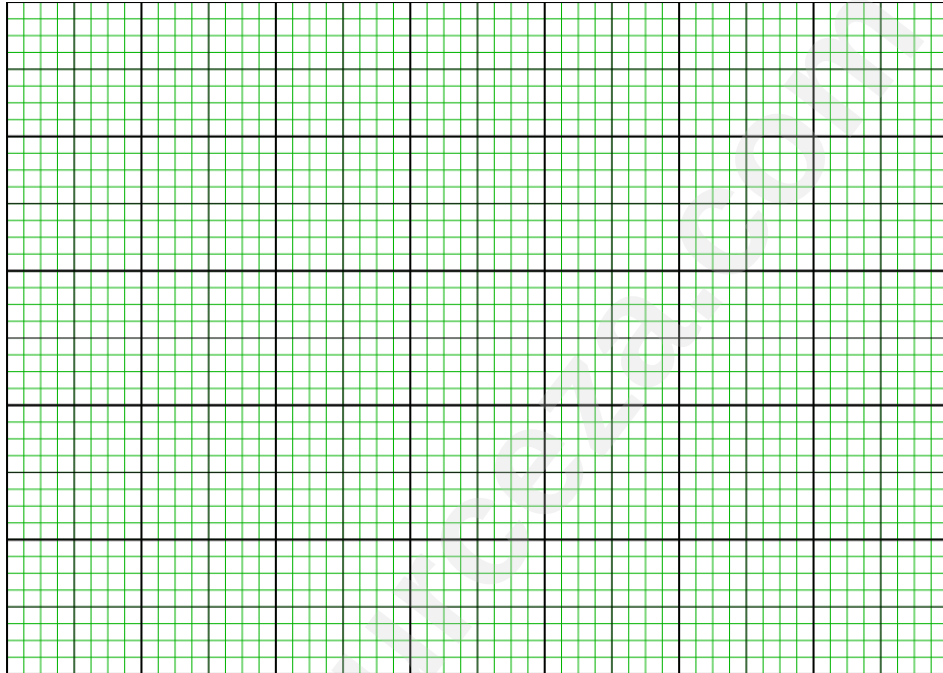


Adapted from <http://getdrawings.com/ferris-wheel-drawing#ferris-wheel-drawing-7.jpg>

4.2.1 Calculate the velocity with which the ice cream cone strikes Trevor's mother's foot.

(3)

- 4.2.2 Sketch the velocity-time graph for the motion of the ice cream cone. Take downward as the positive direction and indicate the following on your graph:
- Initial velocity of the ice cream cone.
 - Final velocity of the ice cream cone.
 - Time at which the ice cream cone strikes Trevor's mother.
- (4)



- 4.2.3 Calculate the height of the High Roller Ferris wheel. (4)

- 4.2.4 In real life, the High Roller Ferris wheel is 158,5m tall. Why is there a difference between the actual height and your answer in 4.2.3? (Note: there are **no** rounding errors). (1)

- 4.2.5 Trevor's brother, Vuyo (1.8 m tall) is standing next to Trevor's mother. Vuyo throws a ball vertically upwards with an initial speed of 25 m.s^{-1} . Will the ball reach the top of the High Roller Ferris wheel? Explain your reasoning. (2)

- 4.2.6 On the ball's return, Vuyo does not catch it, instead he allows it to bounce once before catching it. The ball reaches a maximum height of 3 m after the bounce and thereafter Vuyo catches it. Draw a **labelled** position vs time graph (not to scale) of the complete motion of the ball. Indicate all given and calculated positions and times on the graph. The time of contact with the ground is negligible. (Take the upward direction as positive and the ground as reference point). (4)

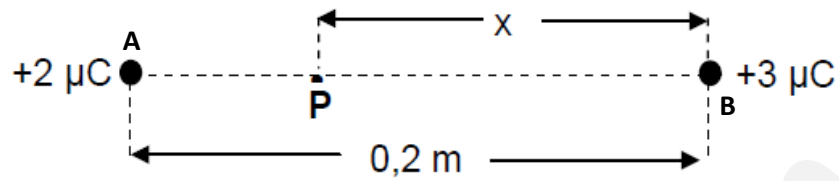


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QUESTION 5

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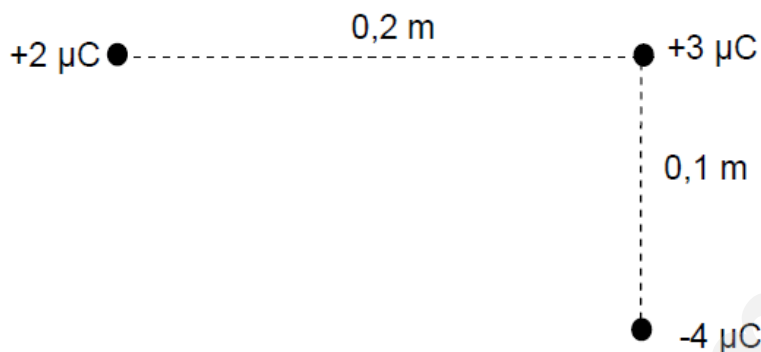
Two point charges, A of $+2\ \mu\text{C}$ and B of $+3\ \mu\text{C}$, are placed a distance of $0,2\ \text{m}$ apart. P is a point on the line joining the two charges, a distance of $X\ \text{m}$ from the $3\ \mu\text{C}$ charge such that the net electric field at point P is zero.



5.1 Define the *electric field at a point*. (2)

5.2 Calculate the distance X . (7)

- 5.3 A $-4\text{ }\mu\text{C}$ charge is now placed at a distance of $0,1\text{ m}$ from the $+3\text{ }\mu\text{C}$ charge as shown in the sketch below.



Calculate the magnitude of the electrostatic force experienced by the $+3\text{ }\mu\text{C}$ charge due to the presence of the other two charges.

(5)

- 5.4 If the $+2\text{ }\mu\text{C}$ (**A**) and $+3\text{ }\mu\text{C}$ (**B**) charges are brought together to touch and then separated again:

5.4.1 Calculate the new charge on each after separation.

(3)

5.4.2 Calculate the number of electrons that moved from the one charge to the other.

(3)

5.4.3 In which direction did the electrons move? Write **A** to **B** or **B** to **A**.

(1)

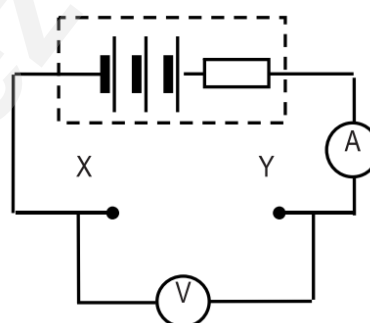
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QUESTION 6

A student uses two resistors R_1 and R_2 in an experiment to verify the expression for the total resistance of resistors connected in parallel. She connects first R_1 alone, then R_2 alone, and then R_1 and R_2 in parallel between X and Y as shown in the circuit diagram. For each connection she records the reading on the ammeter A and the voltmeter V.

Her results are given in the table:

Meter readings	R_1	R_2	R_1 and R_2 combined
Ammeter A	1,5	0,86	2
Voltmeter V	9	10,32	8



6.1 Use the readings to calculate the resistance of R_1 , R_2 and the parallel combination by using Ohm's law.

(4)

R_1

R_2

Parallel

6.2 Show by calculation that the resistance of the parallel combination is in agreement with the theoretical value in 6.1.

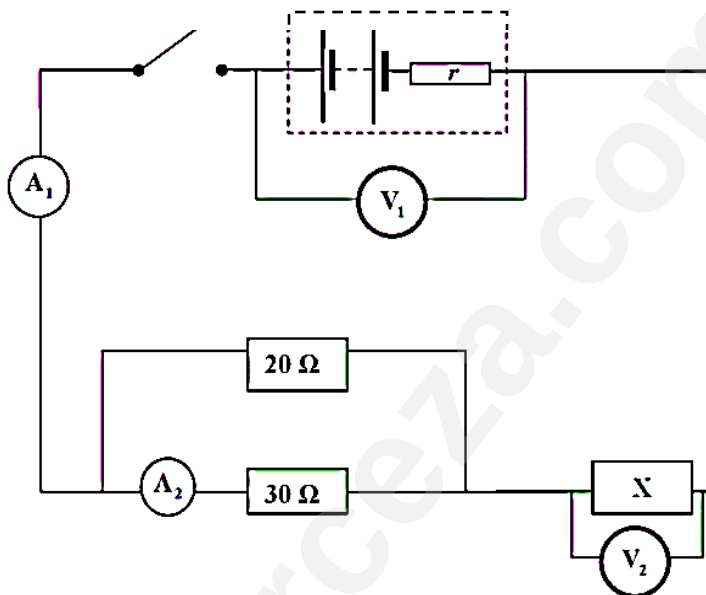
(3)

6.3 The learner wants to verify the ammeter reading for R_1 alone, by determining the current through resistor R_1 when it is connected in series. She decides to heat water with the resistor, by submerging it in a small insulated cup with 100 ml of water. She then measures the energy dissipated by the resistor into the water, by recording temperature changes in the water. She Googles to find that 1 ml of water needs 4,182 J (1 calorie) to raise its temperature by 1°C . The experiment was conducted 3 times, and the temperature increased by 1°C after: 30 seconds, 31 seconds and 29,5 seconds.

6.3.1 Why was the experiment repeated at least 3 times? (2)

6.3.2 Now calculate the current through the resistor by using the collected data. (3)

- 6.4 An electric circuit is set up as shown in the diagram below. The resistances of the switch, ammeters and connecting wires are negligible. The voltmeters have very high resistance. The battery has an emf (ϵ) of 12 V and has significant internal resistance (r).



The switch is CLOSED. The ammeter A_2 reads 0,2 A and the voltmeter V_2 reads 5,5 V.

- 6.4.1 Define emf.

(2)

- 6.4.2 Calculate the reading on ammeter A_1 .

(4)

- 6.4.3 Calculate the resistance of resistor X.

(3)

6.4.4 Calculate the total external resistance of the circuit. (3)

6.4.5 Calculate the internal resistance (r) of the battery. (4)

6.4.6 Resistor X is replaced by a new resistor of greater resistance than that of X.

(a) Will the reading on the voltmeter V_1 connected across the terminals of the battery INCREASE, DECREASE or REMAIN THE SAME? (1)

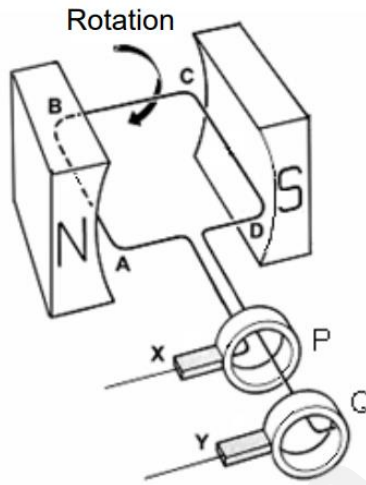
(b) Explain your answer to question (a), making reference to relevant formulae. (3)

6.4.7 Calculate the power of the $30\ \Omega$ resistor. (3)

[37]

QUESTION 7

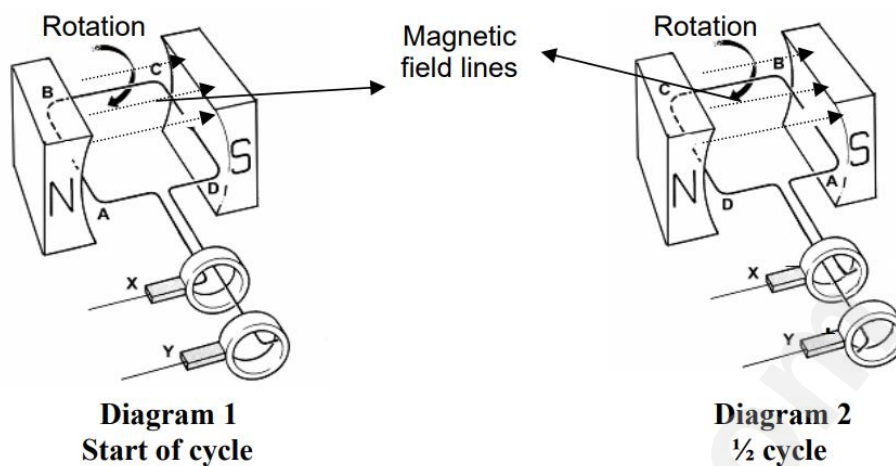
A simple generator consists of a coil turning in a magnetic field. The magnetic field is produced by permanent magnets. Refer to the diagram.



Answer the following questions:

- 7.1 When a conductor moves in a magnetic field, an emf is induced in the conductor.
What is this phenomenon called? (1)
- 7.2 What energy transfer takes place in the generator? (1)
- 7.3 Name components P and Q. (1)
- 7.4 State the law that relates emf with magnetic field strength and flux linkage. (2)
- 7.5 Mention one structural difference between this device and a DC electric motor? (1)
- 7.6 Name the law that relates the direction of induced current in a coil to the magnetic flux direction. (1)

The following diagrams show the rotation of the coil in the magnetic field.



The coil is turned mechanically in a clockwise direction, as shown in Diagram 1.

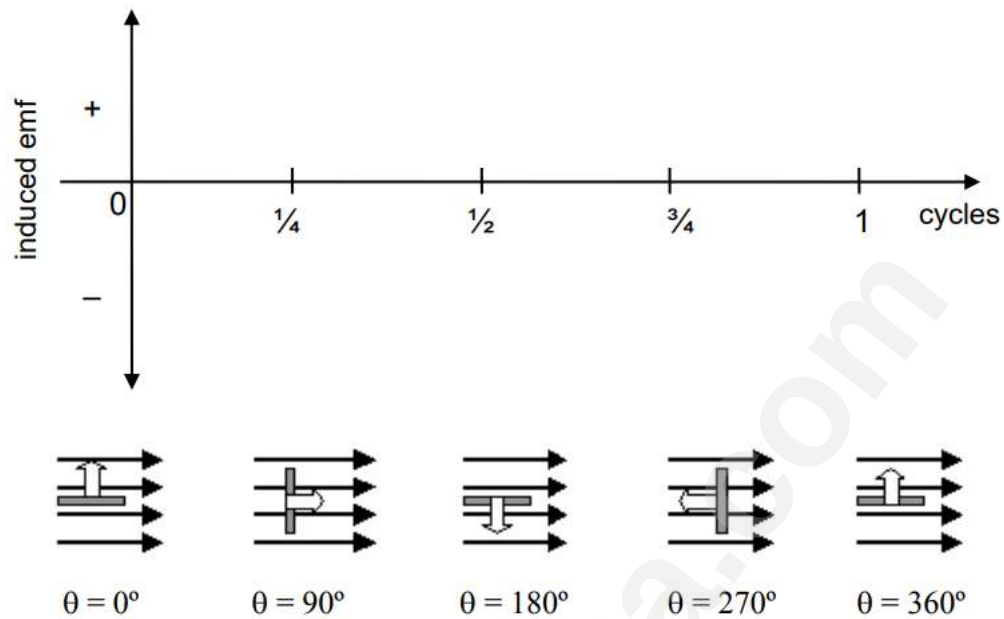
After a $\frac{1}{4}$ cycle the coil has turned through 90° .

After $\frac{1}{2}$ cycle, the coil is horizontal, as shown in Diagram 2.

7.7 The following table shows the position and motion for half a rotation of the coil, starting with AB on the left hand side, moving up. Complete the table by writing in the unshaded blocks. (3)

Position of Coil	Motion of part AB of coil	Magnitude of current (max or zero)	Direction of current (ABCD or DCBA)
Horizontal	Moving up, cutting field lines	7.7.1	7.7.2
Vertical	Parallel to field lines, moving to the right	7.7.3	

7.8 Answer the following question on the axes below



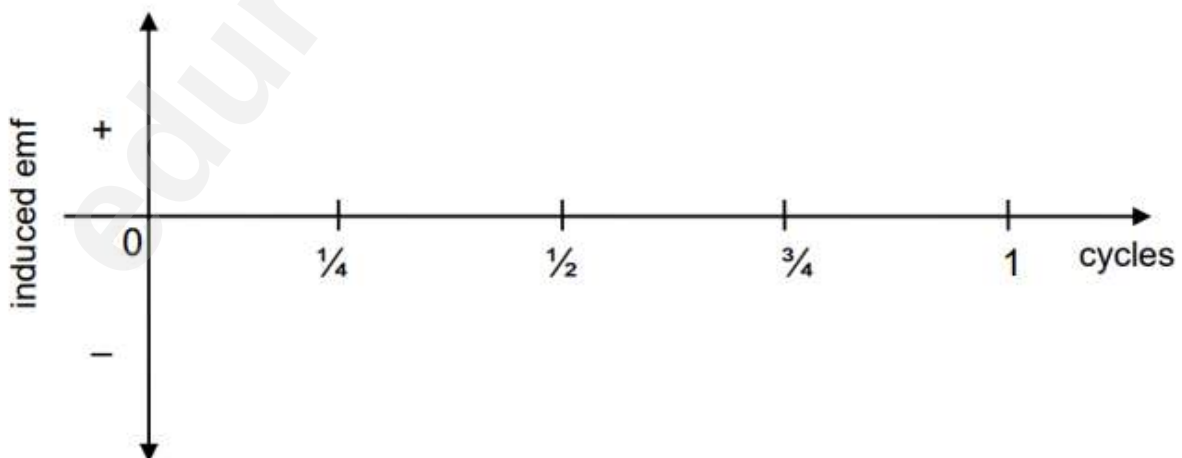
The group of black arrows indicates the direction of the magnetic field and the white block arrow indicates the direction of motion of AB of the coil. The angle θ indicates the angle through which section AB has turned.

7.8.1 Draw the graph (**use a solid curve/line** ———) of the induced emf for one complete cycle of section AB of the coil, when AB starts from the horizontal position. (3)

7.8.2 On the same axes, draw the graph (**with dotted curve/line** - - - -) of the induced emf in section AB of the coil when the coil is rotated at half its original speed. (3)

7.9 A bridge rectifier is used to rectify the emf which is then passed through an oscilloscope that can show the rectified emf as a function of cycles, on a system of axes as shown below.

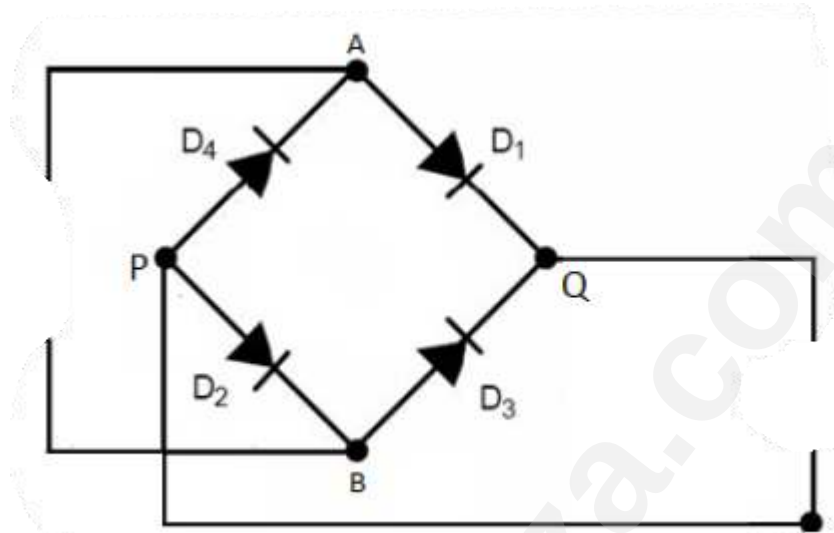
7.9.1 Draw the graph for one cycle of the rectified emf as seen on the oscilloscope. (3)



7.9.2 An incomplete bridge rectifier circuit diagram is given below. Complete the diagram by indicating the:

- the position of the input device (ID),
- the position of the oscilloscope (OS)
- the current direction before and after the oscilloscope.

(3)

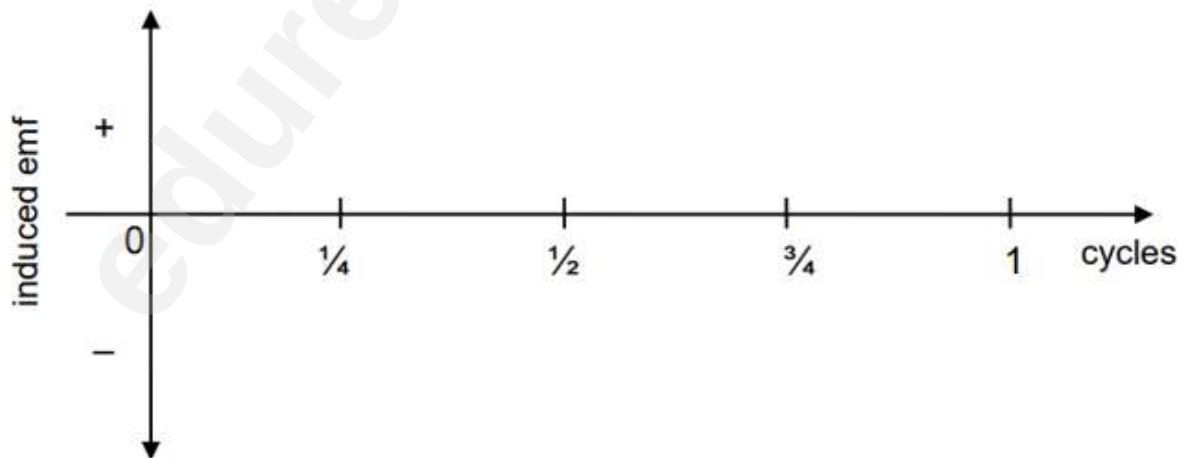


7.9.3 Name and define the components labelled D₁-D₄.

(3)

7.9.4 The component (in 7.9.3) can also be used in a half-wave rectifier circuit. Show the output of the half wave rectifier on the graph below.

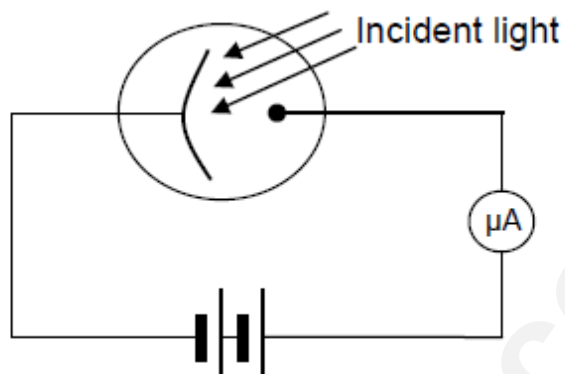
(2)



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QUESTION 8

An investigation is conducted to determine the maximum kinetic energy of ejected photoelectrons. In the first experiment a caesium cathode is used. In the second experiment a sodium cathode is used. In both experiments, the photocell is radiated by ultraviolet light from the same source. The apparatus used as well as the incomplete results of the experiment are shown below.



Metal	Work Function (in J)	Maximum Kinetic Energy of Photoelectrons (in J)
Caesium	$3,36 \times 10^{-19}$	$2,23 \times 10^{-19}$
Sodium	$3,65 \times 10^{-19}$	E_k

8.1 Define *work function of a metal*. (2)

8.2 Without doing any calculations, state which metal's photoelectrons would have the larger maximum kinetic energy. (2)

8.3.1 Use the information in the table to calculate the wavelength of ultraviolet light used in the investigation. (4)

- 8.3.2 Assuming that the ultraviolet light used in the investigation had a wavelength of $3,50 \times 10^{-7} \text{ m}$, calculate the maximum kinetic energy, E_k , of an electron ejected from the sodium metal. (4)

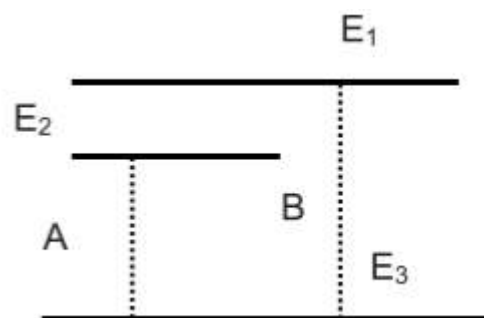
- 8.3.3 How will an **increase** in the **intensity** of the UV light affect the following? Write down only INCREASES, DECREASES or REMAINS THE SAME.

(a) The maximum kinetic energy of the photoelectrons. (1)

(b) The reading on the ammeter. (1)

(c) Explain your answer to (b). (2)

- 8.4 The bright yellow line in the spectrum of sodium actually consists of a pair of lines of wavelength 589,0 nm and 589,6 nm. These lines arise from transitions from a pair of closely spaced energy levels E_1 and E_2 to the same lower energy level E_3 as in the diagram.



- 8.4.1 Which one of these waves has the higher frequency? (2)

- 8.4.2 Which one of the transitions A or B would correspond to the wavelength 589,0 nm? Explain your answer. (3)

[21]