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GRADE 12
Physical Science: Paper 1 (Physics)
2021

Time: 3 hours
Examiner: K van Schoor

Marks: 200
Moderator: K McNeil

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY:

1. This paper consists of 18 pages, make sure that your paper is complete.
2. Answer ALL the questions in the answer book provided.
3. Read the questions carefully.
4. Start each question on a new page.
5. Use the data and formulae provided 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.

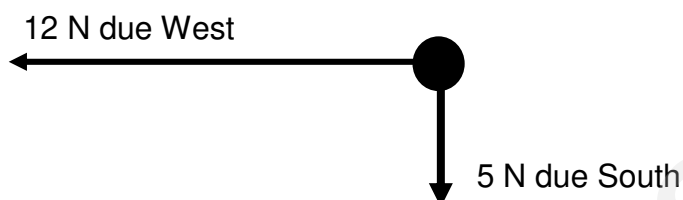
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Acknowledgements – some questions and pictures were adapted from the following sources: IEB, CIE

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

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

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



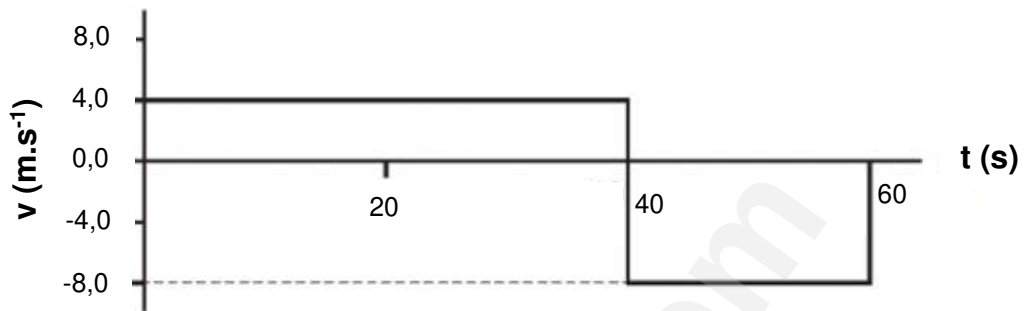
Choose the correct option for the resultant of the two forces from the table below:

	Magnitude (N)	Direction
A	13	67,4° South of West
B	17	22,6° South of West
C	13	67,4° West of South
D	13	22,6° West of South

1.2. Joao throws a ball vertically upwards. Which one of the following combinations of arrows accurately indicates the direction of the net force, acceleration and velocity of the ball when it is halfway up after leaving the hand?

	F_{net}	a	v
A	↑	↓	↑
B	↓	↓	↓
C	↑	↑	↑
D	↓	↓	↑

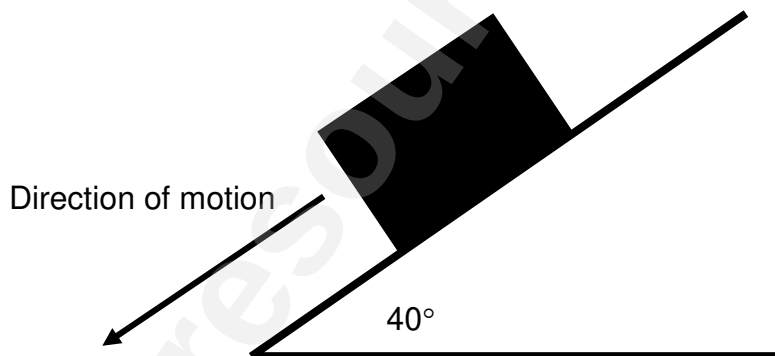
- 1.3. A bicycle travels along a straight horizontal road. The velocity vs time graph for its motion is shown below.



What is the distance travelled and the magnitude of the average velocity of the bicycle after 60 s?

	Distance (m)	Average velocity (m.s ⁻¹)
A	320,0	8,1
B	0,0	5,3
C	320,0	0,0
D	320,0	5,3

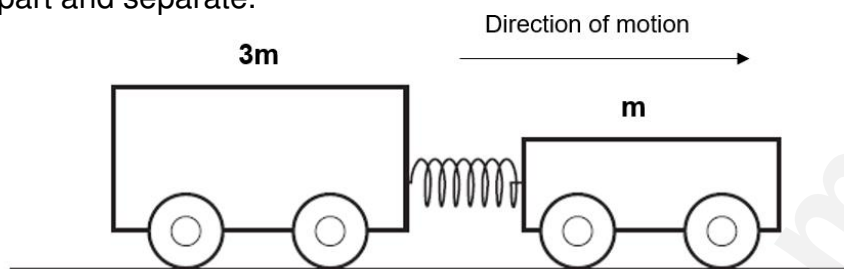
- 1.4. A block of mass, m slides down a rough slope at a constant velocity as shown.



Which one of the following expressions can be used to calculate the magnitude of the force that the surface exerts perpendicular to the block?

- A $mg \sin 40^\circ$
- B $mg \cos 40^\circ$
- C $mg - mg \sin 40^\circ$
- D $mg + mg \sin 40^\circ$

- 1.5. Two trolleys of masses $3m$ and m are moving to the right across a horizontal frictionless surface. The speed of the trolleys is v and they are joined by means of a compressed spring. When the spring is released, the trolleys are pushed apart and separate.



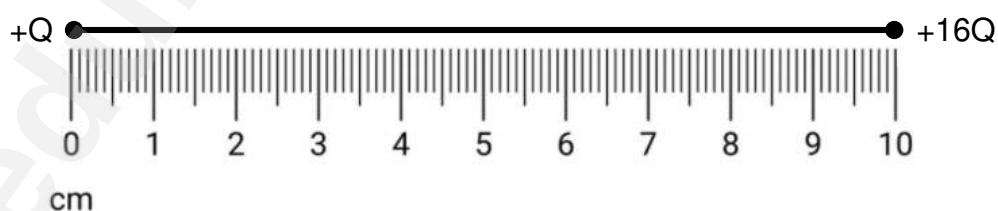
The magnitude of the change in momentum of the trolley with mass $3m$ is X . What is the magnitude of the change of momentum of the trolley with mass m ?

- A $3X$
- B $4X$
- C X
- D $\frac{1}{3}X$

- 1.6. The table shows data from a high-jump competition. Which athlete jumps the highest?

	Weight of athlete (N)	Increase in gravitational energy (J)
A	600	1320
B	700	1610
C	800	1760
D	900	1800

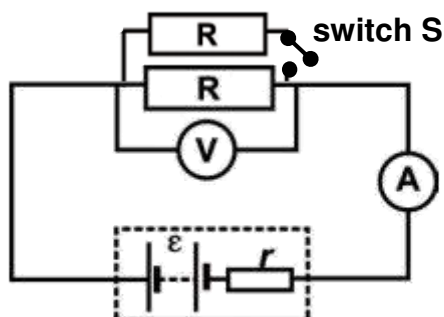
- 1.7. Two point charges of $+Q$ and $+16Q$ are placed 10 cm apart as shown below. A ruler is used to determine the distance between the two charges.



At which position between $+Q$ and $+16Q$ is the magnitude of the electric field strength zero?

- A At 2 cm from $+Q$
- B At 4 cm from $+Q$
- C At 5 cm from $+Q$
- D At 6 cm from $+Q$

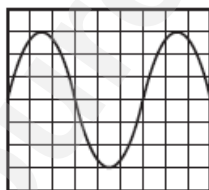
- 1.8. A battery with emf (ε) and internal resistance (r) is connected to two resistors of resistance R as shown in the diagram below.



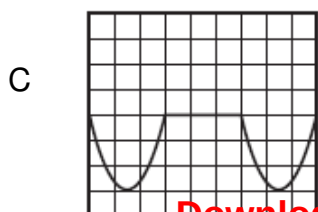
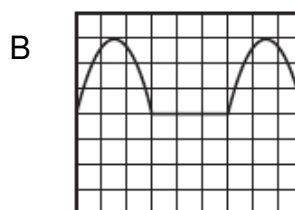
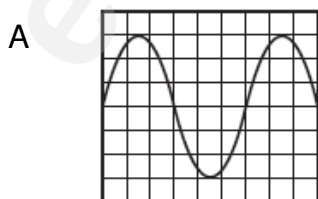
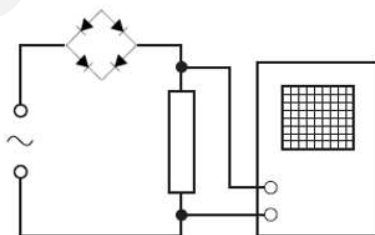
How will the readings on the voltmeter and the ammeter be affected when switch S is **closed**?

	Voltmeter reading	Ammeter reading
A	decreases	increases
B	increases	decreases
C	decreases	decreases
D	increases	increases

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



A bridge rectifier is now connected in series to the circuit. Which of the following diagrams shows the new trace on the screen?

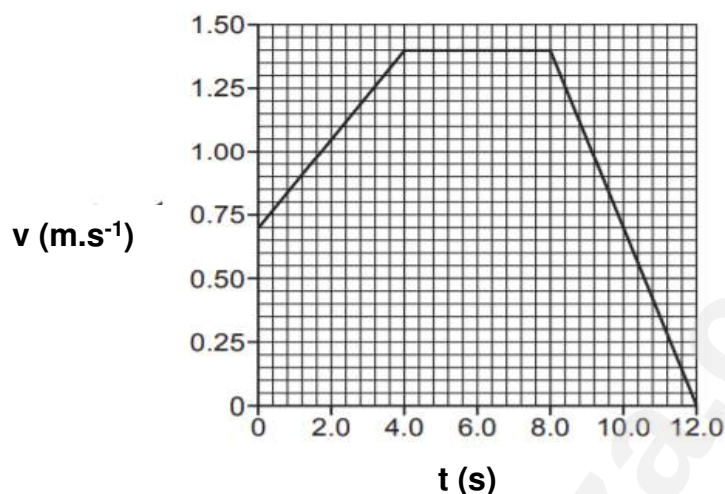


1.10. Light of wavelength 3500 nm is incident on metal A and B with respective work functions of 0,5 eV and 0,4 eV. Which one of the following statements is true?

- A Metal A will emit more photoelectrons than metal B.
- B Metal B will emit more photoelectrons than metal A.
- C Both metals will emit the same amount of electrons.
- D Electrons emitted from metal A will move away faster.

Question 2: In motion**[24]**

- 2.1. The variation with time t of the velocity of a go-kart, initially travelling **West** is shown below.



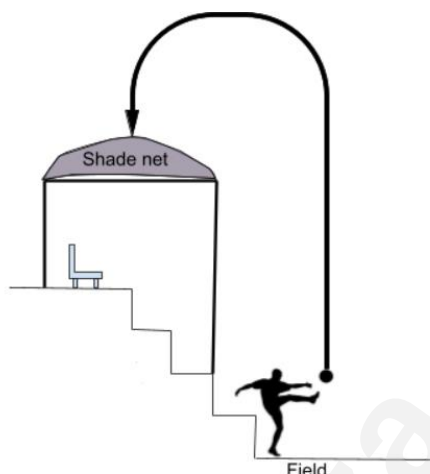
CIE 2021

- 2.1.1. State the initial velocity of the go-kart. (2)
- 2.1.2. Define *acceleration*. (2)
- 2.1.3. Determine the acceleration of the go-kart between 8 and 12 seconds. (3)
- 2.1.4. Use the graph to determine how far the go-kart moved during the 12 seconds. (4)
- 2.1.5. Draw sketch graphs (showing only the times) of:
- The displacement vs time for the 12 seconds. (4)
 - The acceleration vs time for the 12 seconds. (3)
- 2.2. In a pro go-kart, Presharin completes a 2 km race. The kart starts from rest and accelerates at $2,1 \text{ m.s}^{-2}$ until reaching its top speed of $75,6 \text{ km.h}^{-1}$. Presharin maintains this speed to complete the race. How long does it take him to complete the 2 km race? (6)



Question 3 : Let's kick**[17]**

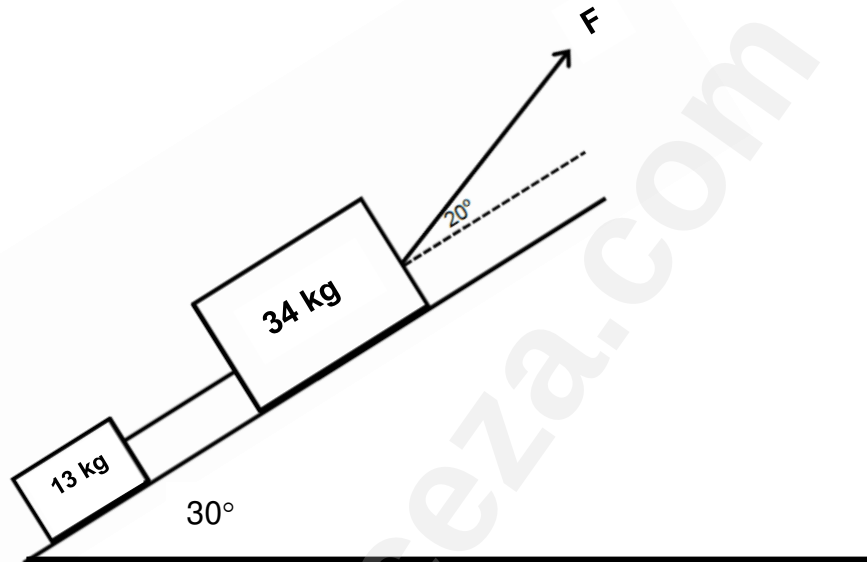
Tumi kicks a soccer ball high into the air during break. The ball goes up **vertically**, reaches its maximum height and lands on a shade net on its way down. Air friction is negligible.



- 3.1. State ONE difference between *distance* and *displacement*. (2)
- 3.2. The ball is kicked so that it leaves Tumi's foot with a velocity of 11 m.s^{-1} . Calculate the distance between his foot and the maximum height reached by the ball. (3)
- 3.3. The ball hits the shade net 2,10 seconds after being kicked. Show by calculation that the magnitude of the velocity of the ball as it hits the shade net is $9,58 \text{ m.s}^{-1}$. (3)
- 3.4. As the ball hits the net, the net sags 0,6 m before launching the ball back into the air. (The ball has a mass of 0,45 kg)
 - 3.4.1. Draw a fully labelled free body diagram showing all the forces acting on the ball at the point where the sag is the greatest. (2)
 - 3.4.2. Calculate the acceleration of the ball while falling down into the net. (From the moment it hits the net to the point where the sag is the greatest) (3)
 - 3.4.3. Calculate the magnitude of the force the **shade net** exerts on the ball. (4)

Question 4: Newton's Laws**[20]**

Two blocks of masses 13 kg and 34 kg are joined together by a light inextensible rope. The blocks are pulled up a rough slope inclined at 30° . The force F acting at an angle of 20° to the surface as shown causes the blocks to move up the slope at a **constant velocity**.



4.1. Draw a labelled free body diagram showing all the forces acting on the 34 kg block while moving up the slope. (5)

4.2. Define *frictional force*. (2)

The coefficient of kinetic friction between the surface and the blocks is 0,4 as it moves up the slope with a constant velocity.

4.3. Calculate the frictional force acting on the 13 kg block as it moves up the slope. (3)

4.4. Determine the magnitude of the tension force in the rope between the two blocks. (4)

4.5. Calculate the magnitude of the force F causing the blocks to move up the slope. (6)

Question 5: Momentum, Work and Energy

[29]

- 5.1. A beach ball is dropped from the roof of Mall of Africa. The ball falls vertically and reaches a constant velocity (terminal velocity).

(Adapted from CIE 2021)

- 5.1.1. Can an object reach terminal velocity in an isolated system? (1)
- 5.1.2. State and explain the variation in the magnitude of the acceleration of the ball during the time interval from when the ball is dropped until it reaches terminal velocity. (3)

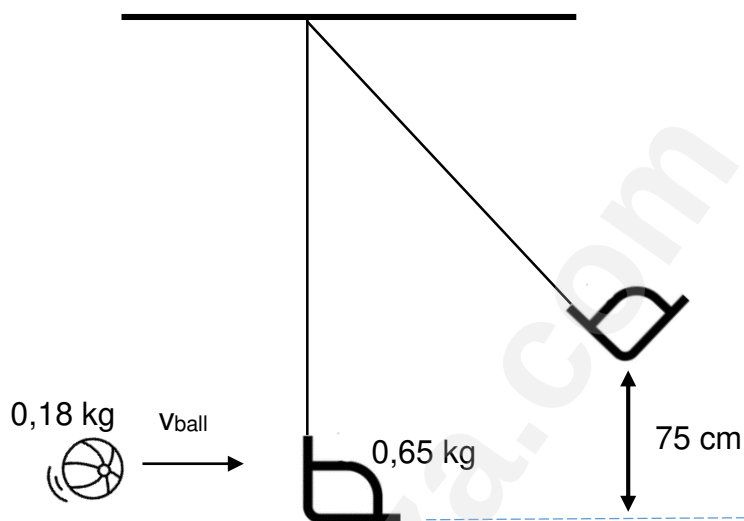
The ball hits the ground with a speed of 16 m.s^{-1} and kinetic energy of 23 J.

- 5.1.3. Define *kinetic energy*. (2)
- 5.1.4. Show by calculation that the mass of the ball is 180 g. (3)

The gravitational potential energy of the ball decreases by 60 J as it falls from the roof to the ground.

- 5.1.5. Calculate the height of the roof above the ground. (3)
- 5.1.6. Use the *Law of Conservation of Energy* to determine the average frictional force acting on the ball as it falls from the roof to the ground. (4)

- 5.2. The ball (0,18 kg) lands on the kid's playground where Neliswa kicks the ball towards a stationary swing seat of mass 0,65 kg. The ball collides with the swing and rebounds with a velocity of $2,62 \text{ m.s}^{-1}$. The swing moves up through a vertical height of 75 cm. (**Frictional forces are negligible**)



- 5.2.1. State the *principle of conservation of mechanical energy*. (2)
- 5.2.2. Calculate the speed of the swing immediately after the ball collided with the swing. (3)
- 5.2.3. Calculate the velocity of the ball, v_{ball} just before it collides with the swing. (4)
- 5.3. Using his golfing experience, Kuda suggests that Neliswa could have given the ball a greater speed by following through (keeping her foot on the ball for longer) while kicking the ball.
- 5.3.1. Is Kuda correct? (1)
- 5.3.2. Explain your answer using an appropriate equation. (3)

Question 6: Fields and graphing**[28]**

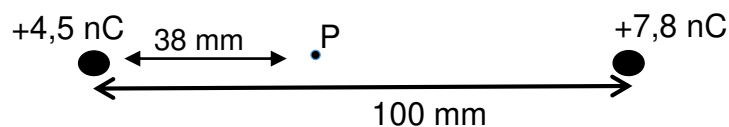
- 6.1. Space X wants to determine the size of Mars's gravitational field. They send probes that record the gravitational force (F) due to Mars on the probe at different distances (r) away from the planet.

The results for $\frac{1}{r^2}$ and F are given in the table below:

$\frac{1}{r^2} \text{ (m}^{-2} \times 10^{-14}\text{)}$	$F \text{ (N} \times 10^{-4}\text{)}$
7,8	1,85
5,9	1,36
3,4	0,84
2,2	0,48
1,4	0,32
0,8	0,16

- 6.1.1. Plot a graph of F vs $\frac{1}{r^2}$. Include a line of best fit. (6)
(Graph paper is provided in your answer book on the back page.
Hint: Use your graph in landscape view)
- 6.1.2. What would the shape of the graph be if you plotted F vs r and not $\frac{1}{r^2}$? (2)
- 6.1.3. Calculate the gradient of your graph. Show the values you used on your graph. Give an appropriate unit for your gradient. (5)
- 6.1.4. The probe has a mass of 5600 kg. Use an appropriate equation **and your gradient** calculated in 6.1.3 to determine the mass of Mars. (4)

- 6.2. Two small conducting spheres which carry charges of $+4,5 \text{ nC}$ and $+7,8 \text{ nC}$ are placed a distance of 100 mm apart as shown in the diagram below.



6.2.1. **Describe** what is meant by an *electric field*. (2)

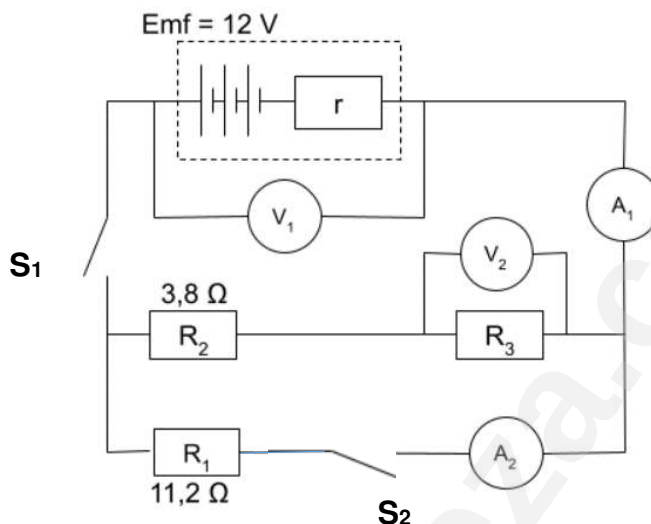
6.2.2. Along the straight line joining the two small spheres, there is a point P as indicated on the diagram.

This point is 38 mm from the $+4,5 \text{ nC}$ charge.

- a) Determine the resultant electric field strength at P. (6)
- b) An proton is placed at P.
Determine the magnitude of the net force that the proton will experience due to the electric fields. (3)

Question 7: Current Electricity**[23]**

- 7.1. In the circuit represented in the diagram below, the battery has an emf of 12 V and a significant internal resistance, r . The resistance of the ammeters is negligible.



7.1.1. **Switch S_1 is open and S_2 is closed.**

- Define *emf*. (2)
- State the reading on voltmeter V_1 . (1)
- State the reading on voltmeter V_2 . (1)

7.1.2. **Switch S_1 and S_2 is closed.**

Ammeter A_1 and A_2 have readings of 1,55 A and 0,96 A respectively.

- Calculate the reading on V_1 . (3)
- Determine the total resistance of the resistors in the external circuit. (3)
- Calculate the internal resistance, r of the battery. (3)

7.1.3. **Switch S_2 is now opened while S_1 remains closed.**

- State what happens to the reading on A_1 . Only state increase, decrease or remain the same. (1)
- State what happens to the reading on V_1 . Only state increase, decrease or remain the same. (1)
- Use an appropriate equation to explain your answer in (b) (3)

7.2. The heaters in the science block are connected in parallel to a 240 V supply. A heater has a resistance of $53\ \Omega$. The heater is left on for two hours.

7.2.1. Determine the power generated by the heater in the two hours. (3)

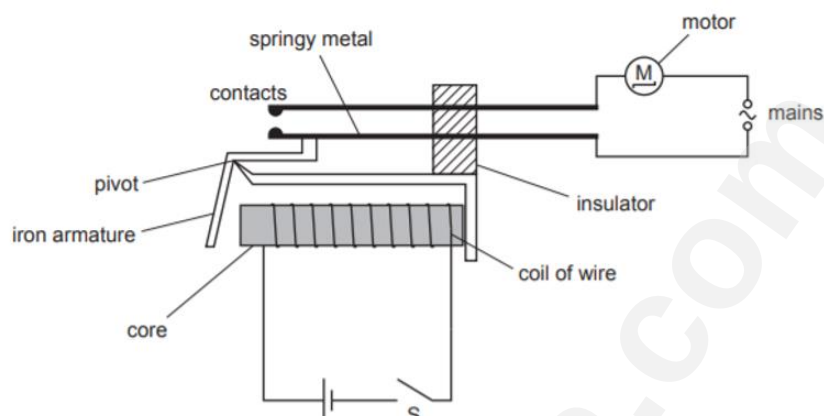
7.2.2. Eskom charges energy usage at R1,88 per kWh. Calculate the cost of operating the heater for 2 hours. (2)

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Question 8: Electrodynamics

[25]

- 8.1. The figure below shows a simple relay used to switch a mains electric motor on and off.



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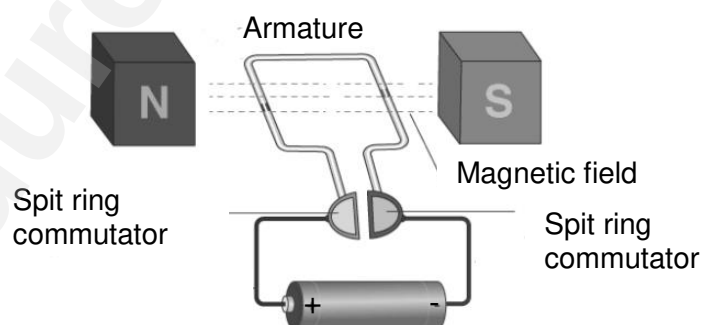
The switch S is closed.

- 8.1.1. Make a copy of only the core and coil as shown below. Draw the magnetic field formed when the switch is closed. Clearly indicate the position of the North and the South poles. (3)



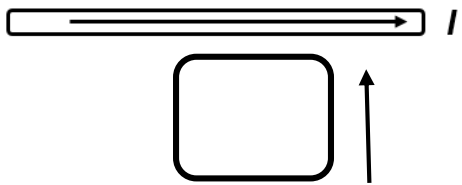
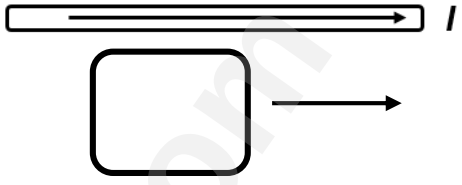
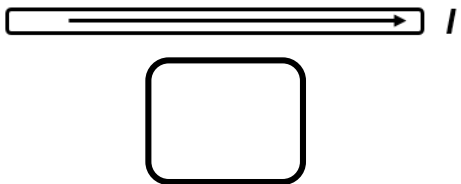
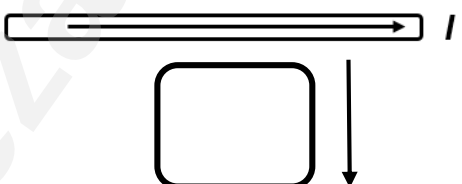
- 8.1.2. Explain how the motor turns on when the switch S is closed. (3)

- 8.2. The diagram below shows a simple version of a motor.

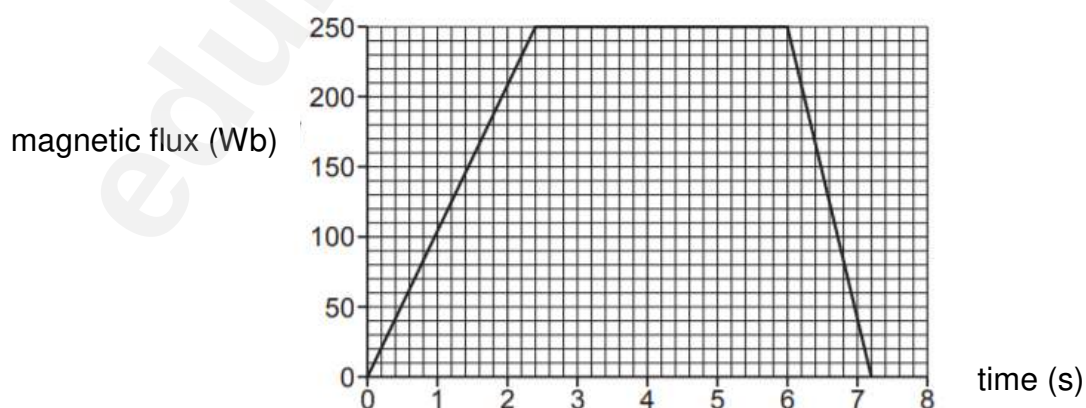


- 8.2.1. State the energy conversion that takes place in the motor. (2)
- 8.2.2. Will the armature turn clockwise or anticlockwise? (2)
- 8.2.3. State one way to **increase** the turning force of the motor. (2)

- 8.3. The table below shows 4 different scenarios in which identical loops of wire are close to a straight, current carrying conductor. The current is moving to the right.

A <i>The loop is moving upwards towards the current carrying conductor</i> 	B <i>The loop is moving towards the right</i> 
C <i>The loop is not moving</i> 	D <i>The loop is moving downwards away from the current carrying conductor</i> 

- 8.3.1. State *Lenz's Law*. (2)
- 8.3.2. In which of the scenario/s above will a current be induced? State the letter/s only. (2)
- 8.3.3. In which scenario will the current move in a clockwise direction. (2)
- 8.3.4. Use Faraday's Law to explain why you stated that a current was induced or not induced, in loop scenario **B**. (3)
- 8.4. The variation with time t of the magnetic flux in a coil is shown below.

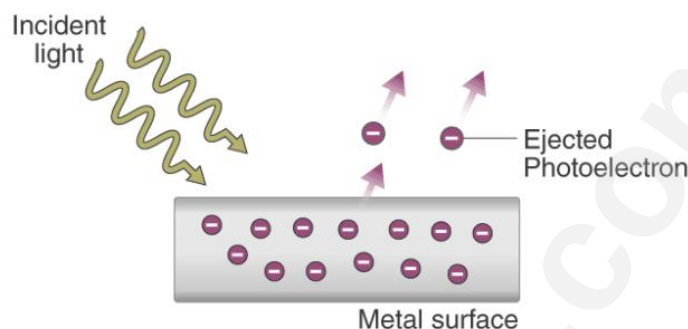


- Sketch a graph showing the variation with time of the emf induced in the coil. No exact values are needed. (4)

Question 9: Photons and electrons

[14]

- 9.1. The diagram below shows a diagrammatic presentation of the photoelectric effect.



- 9.1.1. State one observation made in the above experiment that proves the particle nature of light. (2)
- 9.1.2. The incident light has a frequency of $7,73 \times 10^{14}$ Hz and the work function of the metal surface is $3,7 \times 10^{-19}$ J.
- a) Define *work function*. (2)
- b) Determine the maximum velocity at which electrons are emitted from the metal surface. (4)
- 9.2. The energy level diagram for a particular element is drawn to scale below.



- 9.2.1. Explain how spectral lines are produced. (2)
- 9.2.2. How many spectral lines are produced by the energy levels shown? (2)
- 9.2.3. Which transition will produce the spectral line with the lowest wavelength? (2)

The End