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Brescia House School

GRADE 12
PHYSICAL SCIENCE
PAPER 1
July 2021

Time: 3 Hours
Marks: 200

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 18 pages, an answer book, an answer sheet of 3 pages (i-iii) and a data sheet of 2 pages (i-ii). 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.

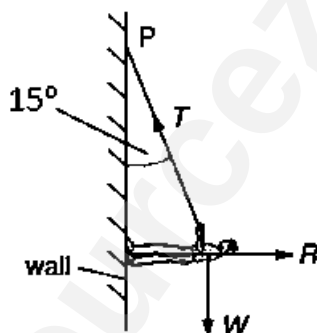
EXAMINER: S Crossman

MODERATOR: K Trenor, A Bruns

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.

- Which of the following three quantities are all vector quantities?
 A displacement, current, position
 B electric field, current, velocity
 C displacement, velocity, gravitational field
 D energy, gravitational field, displacement (2)
- A climber is supported by a rope on a vertical wall as shown in the diagram below.



The weight of the climber is W . The light inextensible rope is attached to the climber and to a fixed point, P where it makes an angle of 15° to the vertical. The reaction force R makes an angle of 90° to the wall.

The climber is in equilibrium.

How do the following forces change when the climber climbs up the wall until the rope makes an angle of 20° to the vertical?

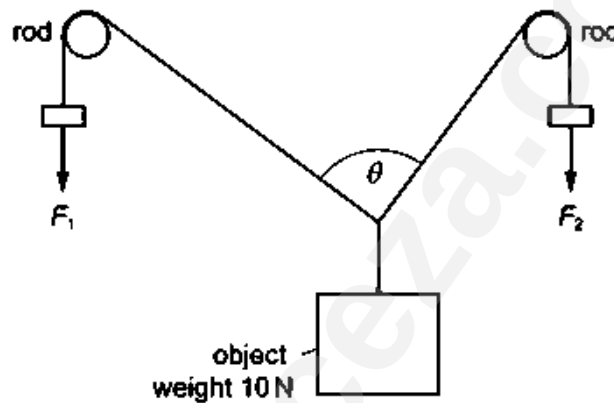
	Tension in rope (T)	Reaction force (R)
A	Increases	Increases
B	Increases	Decreases
C	Decreases	Decreases
D	Decreases	Increases

(2)

3. Which statement about an object moving in a straight horizontal line through air is correct?

- A The resultant force acting on it is zero when it accelerates.
- B The air resistance acting on it is zero when it moves at constant speed.
- C There is no resultant force acting on it when its speed is constant.
- D The only force acting on it is air resistance. (2)

4. An object hangs in equilibrium from two light inextensible cords as shown in the diagram below.



Forces F_1 and F_2 pull down on the cords. The object weighs 10 N.

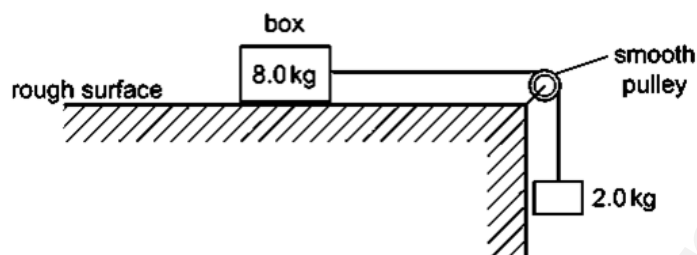
The magnitudes of F_1 and F_2 are shown in the table below.

For which of the pairs of F_1 and F_2 will the angle θ be 90° ?

	F_1	F_2
A	2,00	2,45
B	2,45	2,00
C	8,00	6,00
D	6,00	8,00

(2)

5. A box of mass $8,0 \text{ kg}$ rests on a horizontal rough surface. A light inextensible string attached to the box passes over a smooth pulley and supports a $2,0 \text{ kg}$ mass at its other end.

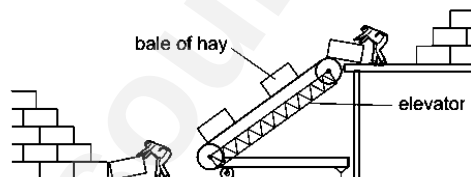


When the box is released, a frictional force of $6,0 \text{ N}$ acts on it. What is the magnitude of the acceleration of the box?

- A $1,4 \text{ m}\cdot\text{s}^{-2}$
- B $1,7 \text{ m}\cdot\text{s}^{-2}$
- C $2,0 \text{ m}\cdot\text{s}^{-2}$
- D $2,6 \text{ m}\cdot\text{s}^{-2}$

(2)

6. An electric motor runs a conveyor belt which lifts bales of hay as shown in the diagram below. All the bales of hay have the same mass.



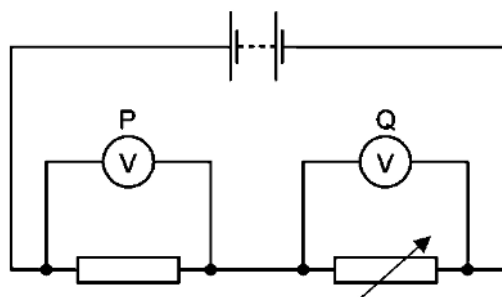
An hour before sunset, the speed of the motor is increased so that more bales are lifted per hour.

How does this affect the work done in lifting each bale, and the useful output power of the motor?

	Work done in lifting each bale	Useful power output of the motor
A	Remains the same	Increases
B	Increases	Increases
C	Decreases	Decreases
D	Remains the same	Decreases

(2)

7. A battery with negligible internal resistance is connected in series with a resistor and a rheostat as shown in the circuit diagram below.

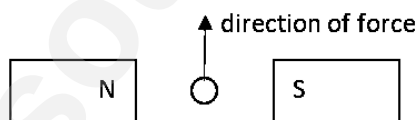


The resistance of the rheostat is increased.
How do the readings on the voltmeters change?

	Reading on voltmeter P	Reading on voltmeter Q
A	Decreases	Decreases
B	Decreases	Increases
C	Increases	Increases
D	Increases	Decreases

(2)

8. A wire is positioned horizontally between two identical bar magnets. When current is passed through it, the wire experiences a force in the direction shown in the diagram below.

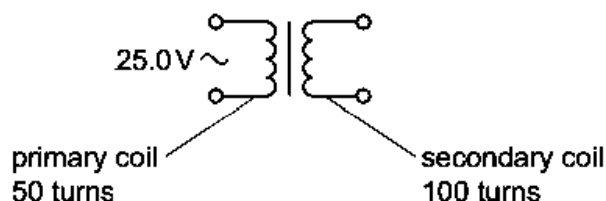


In which direction does the current pass through the wire, and which other arrangement of the bar magnets and current through the wire, will produce force to act in the same direction on the wire?

	Original direction of current	Other arrangement of magnets and current		
		Magnets		Current
A	Into the page	Left = N	Right = S	Out of the page
B	Into the page	Left = S	Right = N	Into of the page
C	Out of the page	Left = S	Right = N	Into the page
D	Out of the page	Left = S	Right = N	Out of the page

(2)

9. An ideal transformer has 50 turns on its primary coil and 100 turns on its secondary coil. An alternating voltage of 60 V is applied across the primary coil.

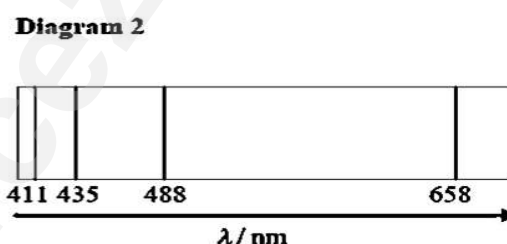
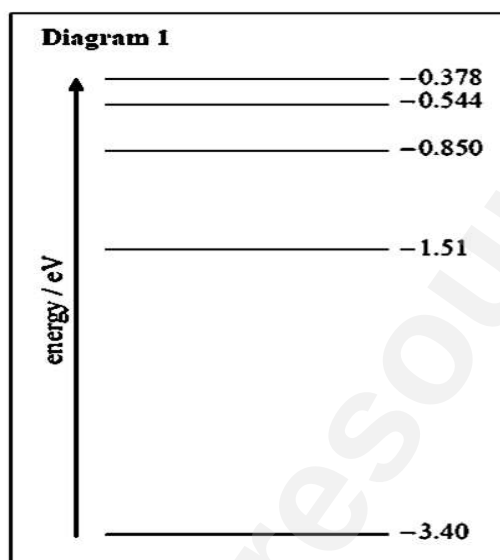


What is the voltage across the secondary coil?

- A 12,5 V
- B 50,0 V
- C 100 V
- D 200 V

(2)

10. Diagram 1 shows some of the energy levels of the hydrogen atom. Diagram 2 shows part of the line emission spectrum of atomic hydrogen.



Which energy transition between energy levels gives rise to a photon of wavelength 658 nm?

	From	To
A	-3,40 eV	-0,378 eV
B	-3,40 eV	-1,51 eV
C	-1,51 eV	-3,40 eV
D	-0,378 eV	-3,40 eV

(2)

10 × (2) = [20]

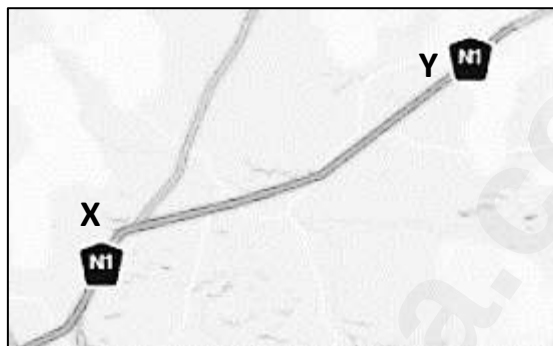
Answer these Questions in your Answer Book. Show all working in calculations.

START EACH QUESTION ON A NEW PAGE. Write on both sides of each page.

QUESTION 2. KINEMATICS

44 marks

- 2.1 A camera positioned on the N1 highway takes a photo of car **A** passing position **X**. A second camera takes a photo 8 minutes later at point **Y** which is 12 km further along the road.



- 2.1.1 Calculate the average speed of Car **A** in $\text{m}\cdot\text{s}^{-1}$. (4)
- 2.1.2 The camera positioned at point **X** takes a photo of Car **B**, which is stuck behind a delivery truck travelling at $30 \text{ km}\cdot\text{h}^{-1}$. The driver accelerates for 15 s to $32 \text{ m}\cdot\text{s}^{-1}$ and passes the truck. He continues driving at constant speed until he passes point **Y**.
- Determine the magnitude of Car **B**'s acceleration (in $\text{m}\cdot\text{s}^{-2}$). (4)
 - Determine the distance travelled by Car **B** during these 15 s. (3)
 - Calculate how long it takes car **B** to travel from point **X** to point **Y**. (4)
- 2.1.3 Explain why the average velocity of these cars cannot be determined using the data that is available. (3)

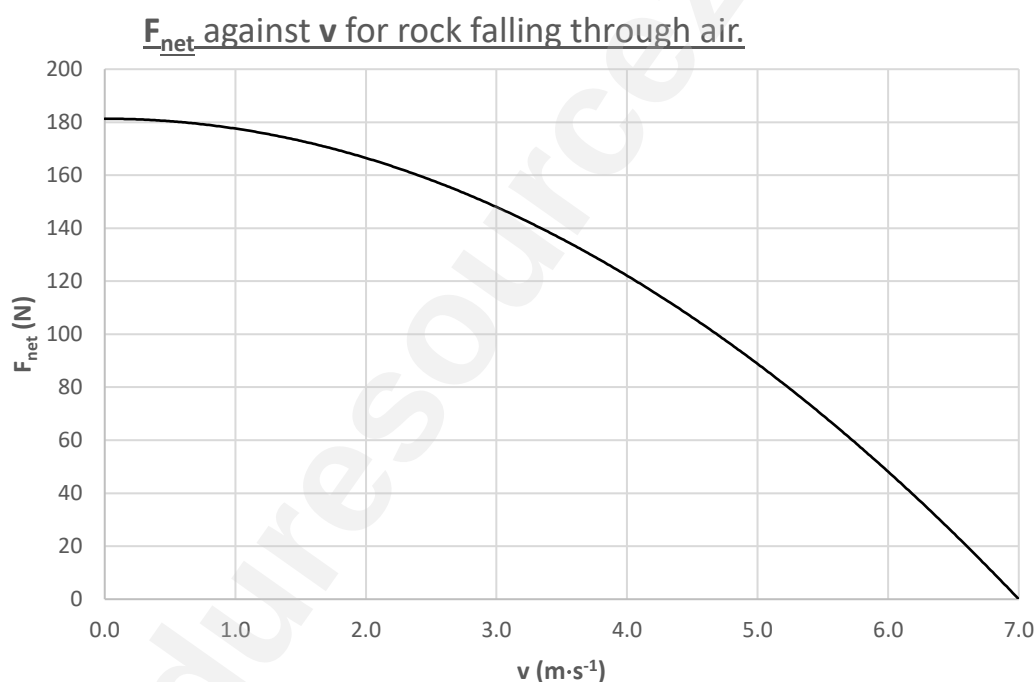
- 2.2 A rock drops vertically from a cliff to the valley below. Air resistance acts on it as the rock falls. The force of air resistance increases as the velocity of the rock increases until the air resistance equals the weight of the rock. Thereafter the rock falls at constant terminal velocity.

The table below shows the velocity of the rock, and the net force acting on it.

Table of velocity of the rock and net force acting on it as it falls.

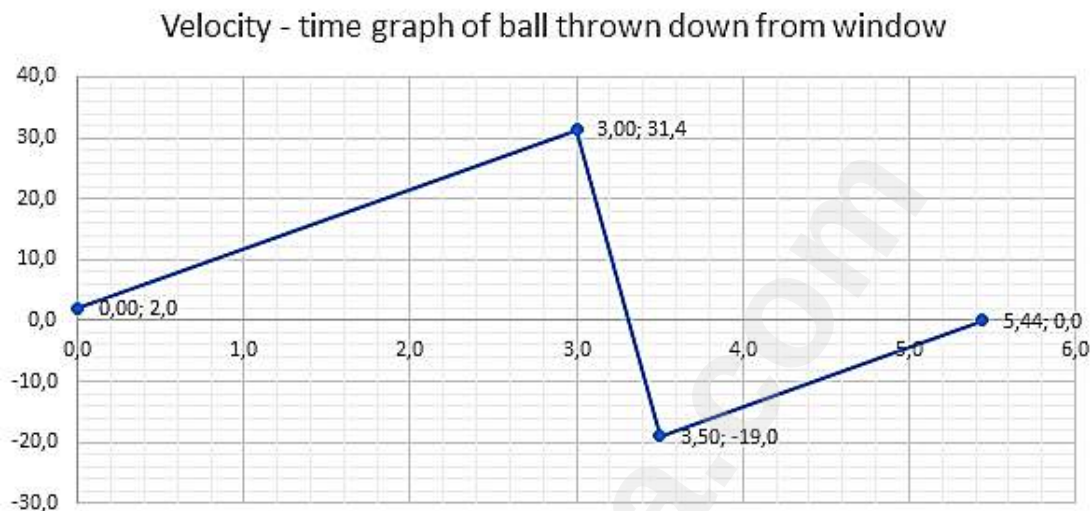
$v_f \text{ (m}\cdot\text{s}^{-1}\text{)}$	$F_{\text{net}}\text{(N)}$
1	177,6
2	166,5
3	148
5	88,8
6	48,1

The graph of the net force acting on the rock against its velocity is shown below.



- 2.2.1 Use this graph to calculate the mass of the rock. (3)
- 2.2.2 Write the answers to this question on the Answer Sheet provided.
- Use the extra column in the Table of Results to calculate v^2 . (1)
 - Draw the graph of F_{net} against v^2 on the graph paper provided. (6)
 - Describe the relationship between the net force on the rock and its velocity. (2)

- 2.3 A ball is thrown down at a speed of $2,0 \text{ m}\cdot\text{s}^{-1}$ from a high window onto a concrete floor. The velocity – time graph for the first part of its motion is shown below.



- 2.3.1 Describe the motion of the ball for the first 5,44 s. (3)
- 2.3.2 Calculate the gradient of the graph for the ball's motion during the first 3 s. (3)
- 2.3.3 Calculate the height above the ground from which the ball was dropped. (4)
- 2.3.4 On the graph paper provided in the **Answer** Booklet, sketch a position – time graph of the ball's motion **for the first 5,44 s**. Take the position at which the ball was released as the reference point. (4)

QUESTION 3. NEWTON'S LAWS AND APPLICATIONS.

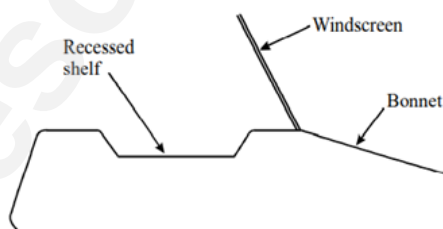
24 marks

- 3.1 A child sits on a sled on a hill. The hill makes an angle of 20° with the horizontal. The child and sled have a combined mass of 45 kg. The coefficients of maximum static friction and kinetic friction are 0,3 and 0,2 respectively.

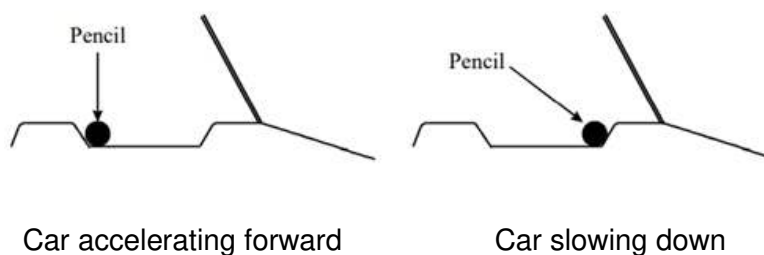


- 3.1.1 Distinguish between *mass* and *weight*. (2)
- 3.1.2 Draw a labelled free-body diagram of all the forces acting on the child/sled combination. Show appropriate angles in the diagram. (4)
- 3.1.3 Determine the perpendicular component of weight of the child/sled combination. (3)
- 3.1.4 Determine the magnitude of maximum static friction that can act on this sled. (3)
- 3.1.5 **Show** by calculation, that the sled slides down the hill. (3)
- 3.1.6 Determine the magnitude of the sled's acceleration down the hill. (5)

- 3.2 Behind the windscreen of a luxury car there is a shelf which is horizontal but recessed to stop items from falling off. Refer to the diagram below.



A pencil is placed in the middle of the recessed part of the shelf. Whenever the car accelerates forward, the pencil is at the back edge, and it is at the front edge when the car is slowing down.

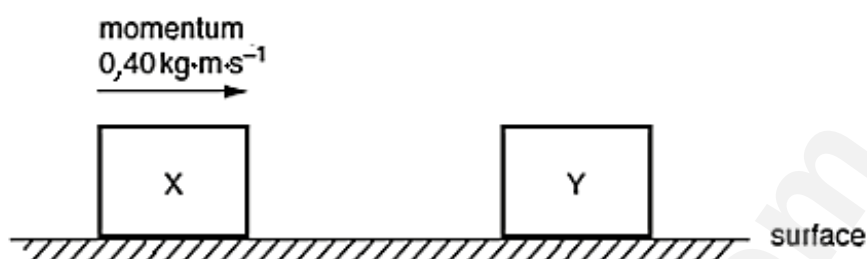


Explain the observations of the pencil's position when the car accelerates forwards from rest, as detailed above, with reference to one of Newton's laws of motion. (4)

QUESTION 4. MOMENTUM, IMPULSE, WORK, ENERGY AND POWER

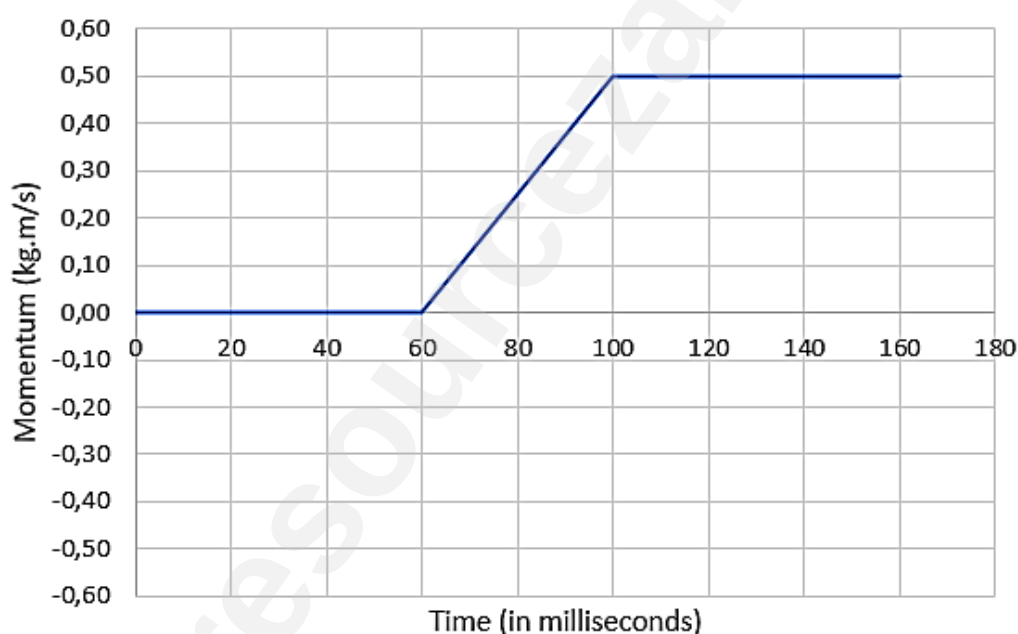
29 marks

- 4.1 Block **X** moves at constant speed along a frictionless horizontal surface towards stationary block **Y** as shown in the diagram below. No resistive forces act on block **X**.



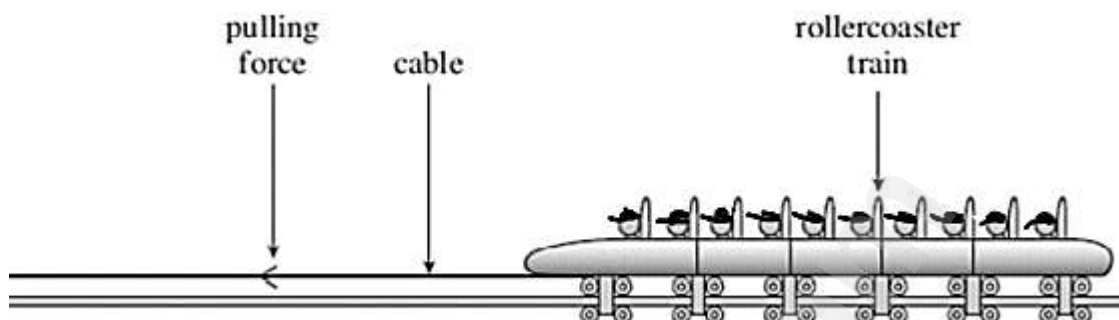
Initially block **X** has momentum of $0,4 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$ to the right. The two blocks collide and then separate.

Graph of the variation of the Momentum of block **Y** against Time (ms (milliseconds))



- 4.1.1 Define (*linear*) momentum. (2)
- 4.1.2 Describe the motion of Block **Y** from 60 ms to 100 ms. (1)
- 4.1.3 Describe the motion of Block **Y** from 100 ms to 160 ms. (1)
- 4.1.4 State Newton's second law. (2)
- 4.1.5 Calculate the magnitude of the force of Block **X** on Block **Y** when they are in contact with one another. (4)
- 4.1.6 On a copy of the graph of Momentum against time in your Answer Booklet, draw the graph of the momentum of Block **X** against time for 160 ms. (4)

- 4.2 A rollercoaster train is accelerated by being pulled horizontally by a cable, as shown in the diagram below. A frictional force of 10 000 N acts on the rollercoaster train.



The train accelerates from rest to a speed of $50 \text{ m}\cdot\text{s}^{-1}$ in 4,0 s.

The mass of the fully loaded train is 6 000 kg.

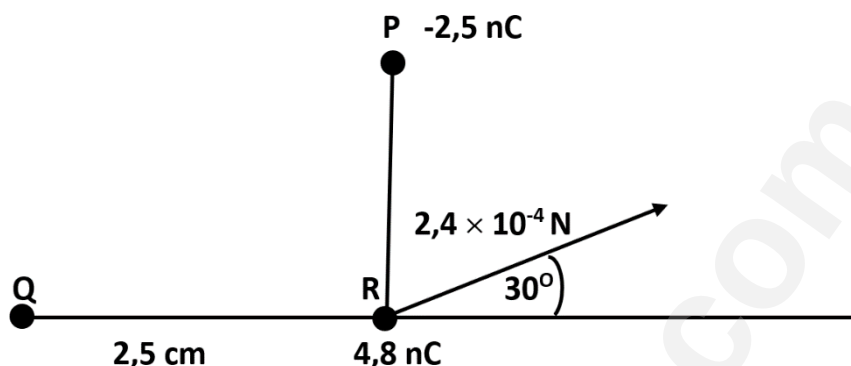
- 4.2.1 State the work-energy theorem. (2)
- 4.2.2 Calculate the net work done on the rollercoaster train. (3)
- 4.2.3 Calculate the distance travelled by the train in 4,0 s. (3)
- 4.2.4 Calculate the magnitude of the pulling force. (4)
- 4.2.5 The efficiency of the pulling system is only 20%. Calculate the average power input to accelerate the rollercoaster at this rate for 4,0 s. (3)

QUESTION 5. FIELDS

19 marks

5.1 State Coulomb's law. (2)

5.2 Point charges, **P**, **Q**, and **R**, are positioned as shown in the diagram below.



The resultant force on **R** is $2,4 \times 10^{-5} \text{ N}$ at an angle of 30° to the horizontal line running through **Q** and **R**.

R carries a charge of $+4,8 \text{ nC}$; and **P** carries a charge of $-2,5 \text{ nC}$.

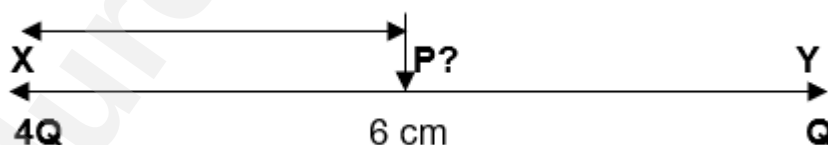
5.2.1 Draw a free-body diagram of the electrical forces acting on charge **R**. (2)

5.2.2 Determine the charge on **Q**. (4)

5.2.3 Determine the distance between **R** and **P**. (4)

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

5.4 Two positive point charges **X** and **Y** are placed 6 cm apart from one another as shown in the diagram below. The charge on **X** is four times that on **Y**.



5.4.1 Draw a diagram of the electric field lines around charge **X**. (2)

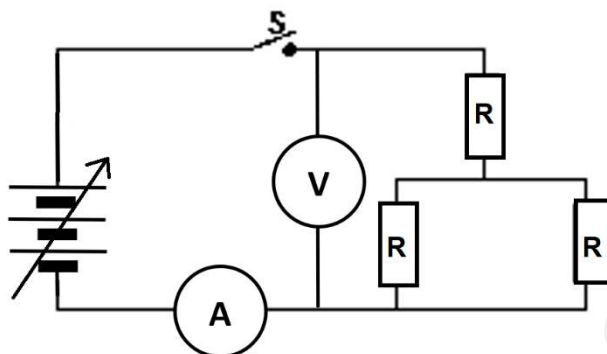
5.4.2 Describe how the electric field pattern around charge **Y** will differ from that around charge **X**. (2)

5.4.3 Compare the distance away from **X** (**XP**) at which the resultant electric field is zero, with the distance away from **Y** (**PY**). (1)

QUESTION 6. ELECTRIC CIRCUITS

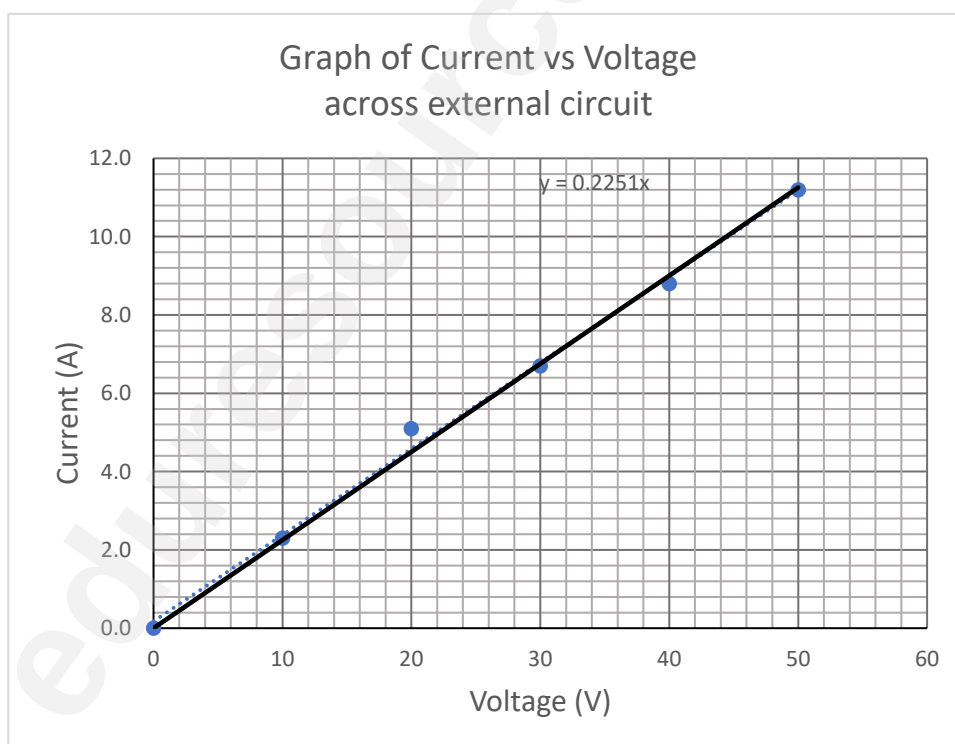
28 marks

6.1 Study the circuit diagram shown below. The three resistors in the circuit are identical.



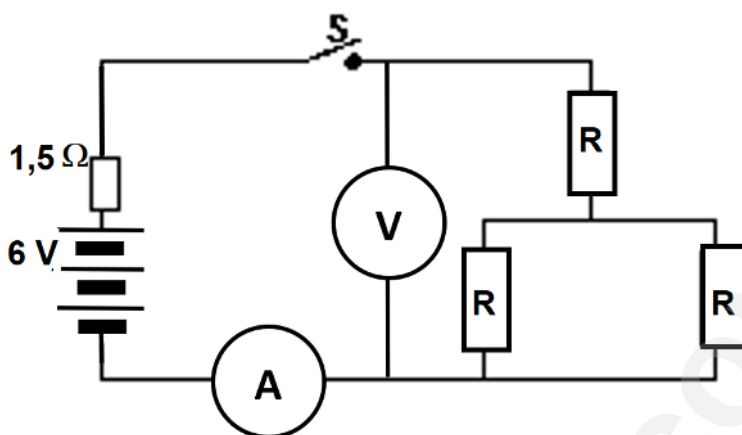
The ammeter, connecting wires and battery have negligible resistance.

- 6.1.1 State *Ohm's law*. (2)
- 6.1.2 A variable DC voltage supply is connected across the combination of three resistors. As the voltage is varied, readings of voltage and current are recorded. The graph of current against voltage for this combination of resistors is shown below.



- a) Does the combination of resistors behave as an *ohmic conductor*? Explain briefly. (3)
- b) Use the graph to determine the effective resistance of the resistors. (3)

6.1.3. A 6 V battery with internal resistance of $1,5\ \Omega$ is connected across the circuit.



- a) Determine the resistance **R** of each of these resistors. (4)
- b) Determine the reading on the ammeter when switch **S** is closed. (3)

6.2 Two resistors of $2,0\ \Omega$ and $3,0\ \Omega$ are connected to a battery which has significant internal resistance.

When the two resistors are connected in series, the current is $0,97\ \text{A}$.

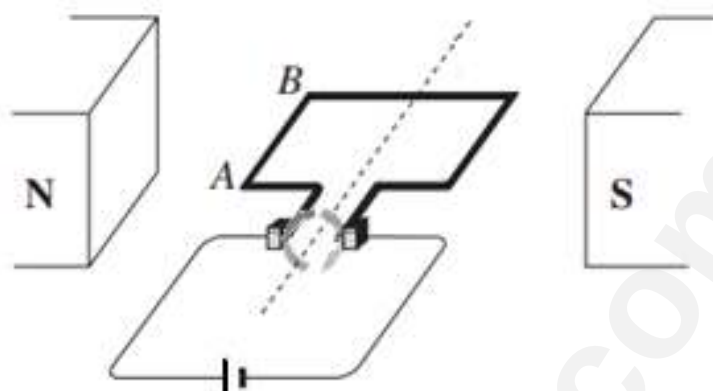
When the two resistors are connected in parallel, the current is $2,5\ \text{A}$.

- 6.2.1 Define the *emf of a battery*. (2)
- 6.2.2 Determine the emf and the internal resistance of the battery. (7)
- 6.2.3 Determine the power dissipated in the $2,0\ \Omega$ resistor when it is connected in parallel. (4)

QUESTION 7. ELECTRODYNAMICS

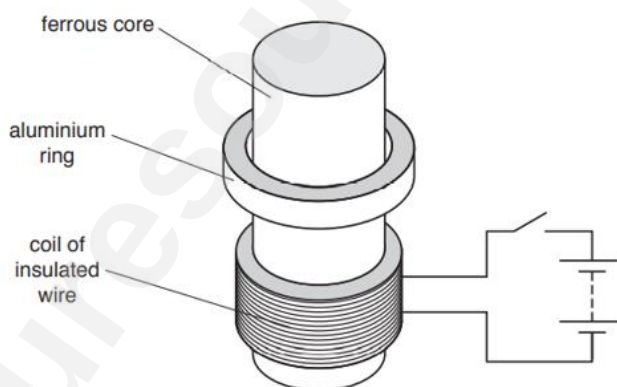
22 marks

7.1 The diagram shows a DC motor with a constant current passing through the coil.



- 7.1.1 Explain why the coil of the motor rotates when current passes through it. (2)
- 7.1.2 In which direction does the coil of this DC motor rotate? Answer CLOCKWISE or ANTI-CLOCKWISE. (1)
- 7.1.3 Suggest two different ways to increase the speed of rotation of the coil. (2)

7.2 A coil of insulated copper wire is wound on to a ferrous (iron) core and connected to a battery and a switch. Refer to the diagram below.



An aluminium ring is placed on the core. The ring can move freely up and down along the length of the core.

The switch is initially open.

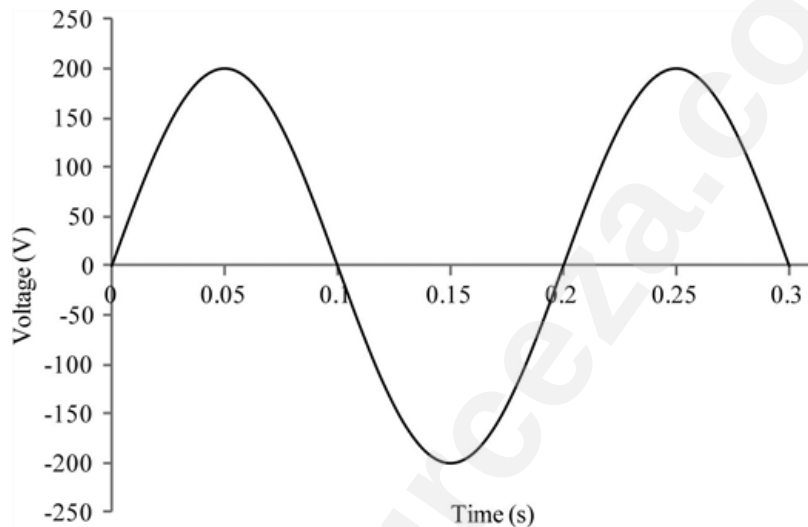
- 7.2.1 State Lenz's law. (2)
- 7.2.2 Use principles of Physics to explain why the aluminium ring jumps upwards when the switch is closed. (4)
- 7.2.3 If the polarity of the battery is reversed, will the ring still jump upwards? Explain briefly. (4)

7.3 An ideal transformer has 12 000 turns in the secondary. An AC voltage as shown in the graph below, is generated in the secondary coil, and an AC voltage of 5 V is applied to the primary coil. The current in the primary is 16 A.

7.3.1 Calculate the number of turns in the primary coil. (2)

7.3.2 Calculate the current in the secondary coil. (3)

7.3.3 A graph of voltage against time for the secondary coil is shown below.

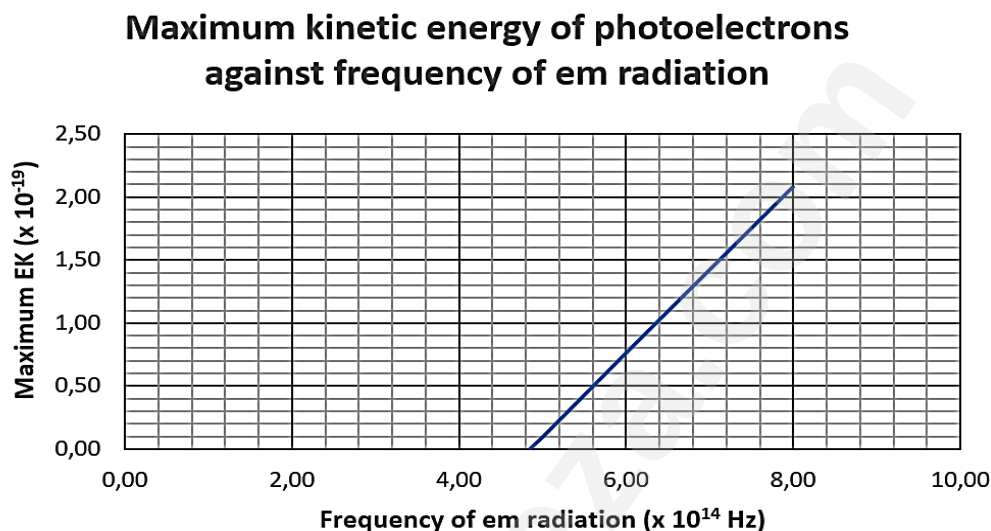


On the copy of this graph in the **Answer Sheet**, draw the **graph of magnetic flux through the iron core against time**. (2)

QUESTION 8. PHOTONS AND ELECTRONS

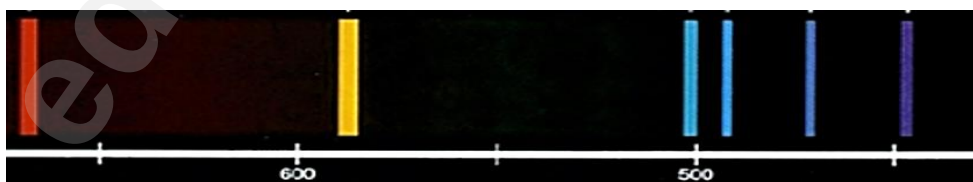
14 marks

- 8.1 The graph shows how the maximum kinetic energy ($E_{K \max}$) of electrons emitted from the surface of metal **A** varies with the frequency (f) of the incident electromagnetic radiation.



The threshold frequency of the metal is $4,85 \times 10^{14}$ Hz.

- 8.1.1 Define the *threshold frequency of a metal*. (2)
- 8.1.2 Calculate the work function of metal **A**. (2)
- 8.1.3 Metal **B** has half the work function of metal **A**.
- What is the threshold frequency of metal **B**? (1)
 - On a copy of this graph in your **Answer Sheet**, draw the graph of the maximum kinetic energy of photoelectrons against frequency for metal **B**. (2)
- 8.2 Each element emits its own unique line emission spectrum when high voltage is applied across a low-pressure vapour of its atoms enclosed in a glass tube. The spectrum is analysed using a spectrometer to disperse the colours and produce a line spectrum e.g., of hydrogen, as shown in the diagram below.



- 8.2.1 Calculate the energy of a photon of blue light with a wavelength of 492,1 nm. (3)
- 8.2.2 What causes a line spectrum to be emitted? (2)
- 8.2.3 Explain why each element emits a UNIQUE line emission spectrum. (2)

TOTAL: 200