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KEARSNEY COLLEGE TRIAL EXAMINATION

10 SEPTEMBER 2021

PHYSICAL SCIENCES: PAPER 1 (PHYSICS)



Time: 3 hours

200 marks

EXAMINATION NUMBER

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Examiner: Mrs Murray

Moderator: Mr Moerdyk

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

- This paper consists of:
 - a question paper of 12 pages and
 - a yellow Answer Booklet (pages 13 to 16); and
 - a Data and Formulae sheet of 2 sides.Please make sure that your question paper is complete.
- Write your examination number on the Answer Booklet.**
- Answer ALL the questions.
- Read the questions carefully.
- Use the data and formulae whenever necessary.
- START EACH QUESTION ON A NEW PAGE.**
- Show your working in all calculations.
- Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
- Answers must be expressed in decimal format, not left as proper fractions.
- Where appropriate express answers to TWO decimal places.
- It is in your own interest to write legibly and to present your work neatly.

QUESTION 1

Answer these questions on the multiple-choice answer sheet 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.

1.1 Which one of the following formulae contains ONLY SCALAR quantities?

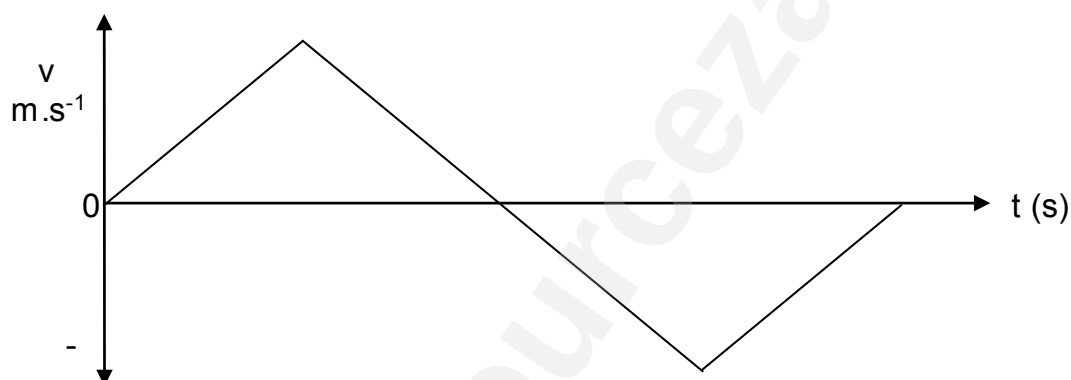
A $s = ut + \frac{1}{2}at^2$

B $F_{\text{net}} = ma$

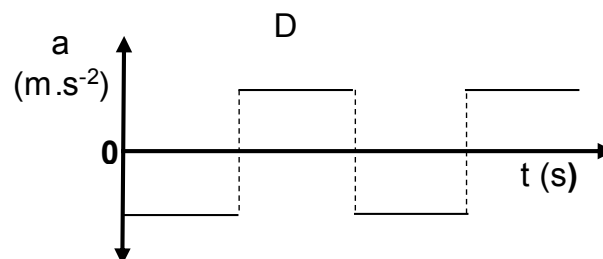
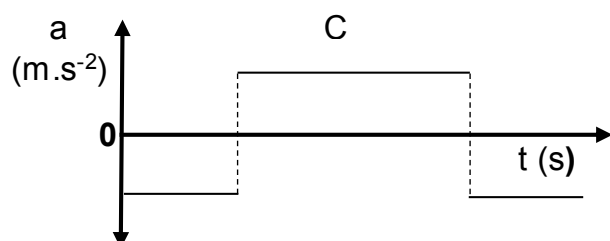
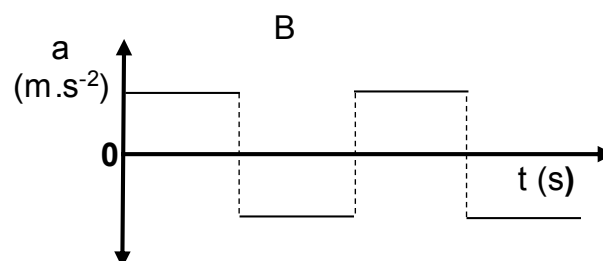
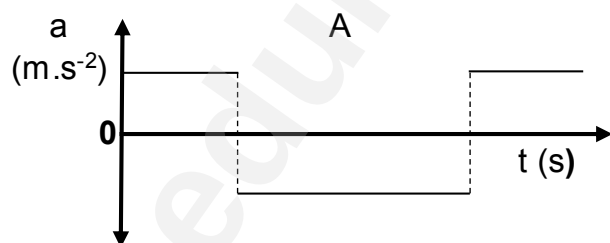
C $p = mv$

D $P = \frac{W}{t}$

1.2 The velocity-time graph below represents an object initially moving south.



Which one of the following acceleration-time graphs corresponds to the above v-t graph?

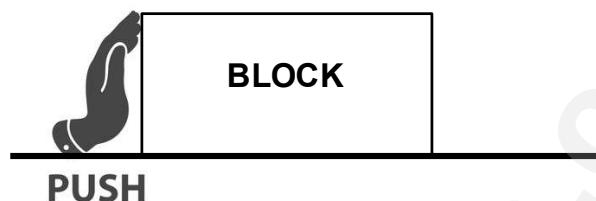


- 1.3 An object falls from rest through a certain distance in time t on Earth where the acceleration due to gravity is g .

What time will it take the same object to fall from rest through the SAME distance on a planet where the acceleration due to gravity is $4g$?

- A $\frac{t}{2}$ B $\frac{t}{4}$ C $2t$ D $4t$

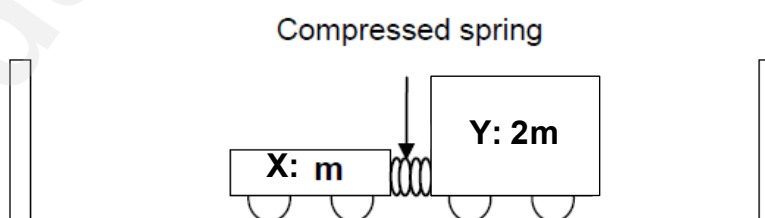
- 1.4 A block at rest on a rough horizontal surface is pushed by a hand.



Which option best explains why the block remains at rest and gives the law being applied?

	Explanation	Law
A	The force of the hand on the block is equal in magnitude to the force of the block on the hand.	Newton's 3 rd law
B	The force of the hand on the block is equal in magnitude to the force of the block on the hand.	Newton's 1 st law
C	The force of the hand on the block is equal in magnitude to the force of static friction on the block.	Newton's 3 rd law
D	The force of the hand on the block is equal in magnitude to the force of static friction on the block.	Newton's 1 st law

- 1.5 Trolleys, **X** and **Y**, of mass m and $2m$, respectively are connected with a compressed, massless spring as shown in the diagram below. They are initially at rest on a frictionless surface.



When the spring is released trolley **X** moves with speed v to the left.

The speed of trolley **Y** moving to the right will be:

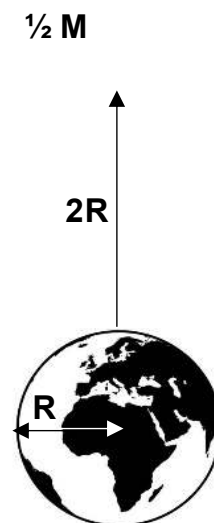
- A $\frac{2v}{3}$ B $\frac{v}{2}$ C v D $2v$

- 1.6 A rocket of total mass M (including fuel) takes off from Earth, which has a radius R . When the rocket is at a height of $2R$ above the Earth's surface its mass has decreased to $\frac{1}{2}M$ since it has burnt fuel.

The gravitational force of the Earth on the rocket when on the surface of the Earth is F .

What is the gravitational force of the Earth on the rocket when at a height of $2R$?

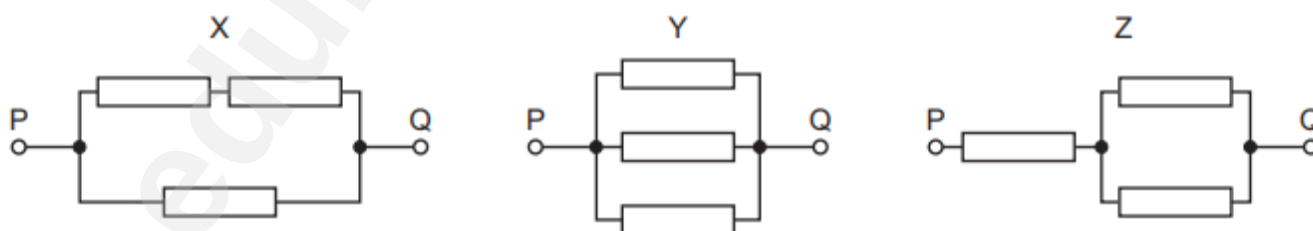
- A $\frac{F}{4}$
B $\frac{F}{6}$
C $\frac{F}{8}$
D $\frac{F}{18}$



- 1.7 What name is given to that property of a body which causes it to resist a change in its state of rest or uniform motion?

- A Impulse
B Acceleration
C Inertia
D Mass

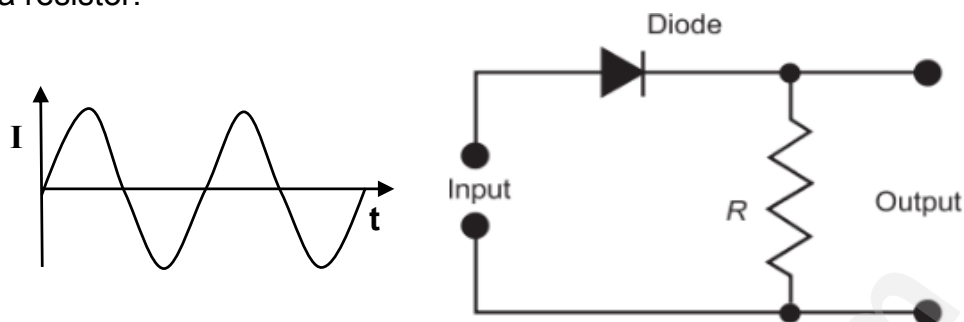
- 1.8 Three identical resistors are connected between terminals P and Q in different networks X, Y and Z as shown.



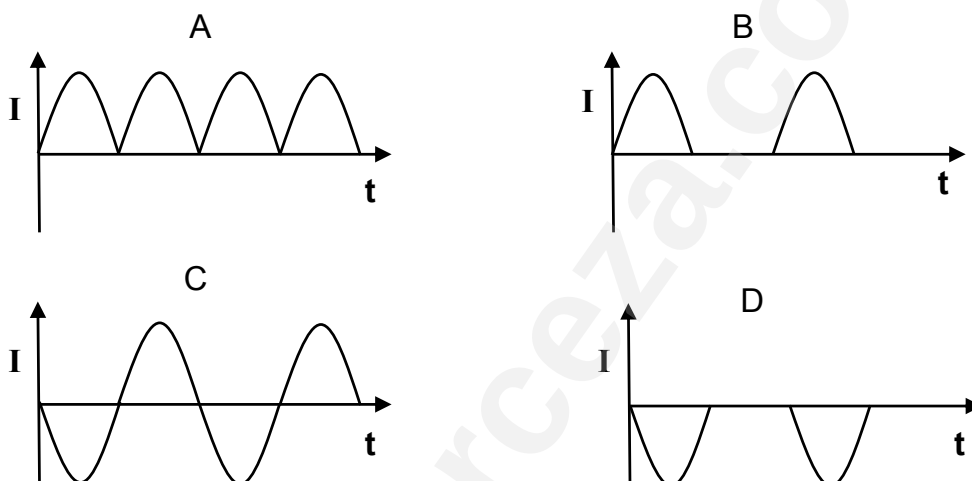
What is the order of **increasing** combined resistance between P and Q (lowest first)?

- A $X < Y < Z$
B $X < Z < Y$
C $Y < X < Z$
D $Y < Z < X$

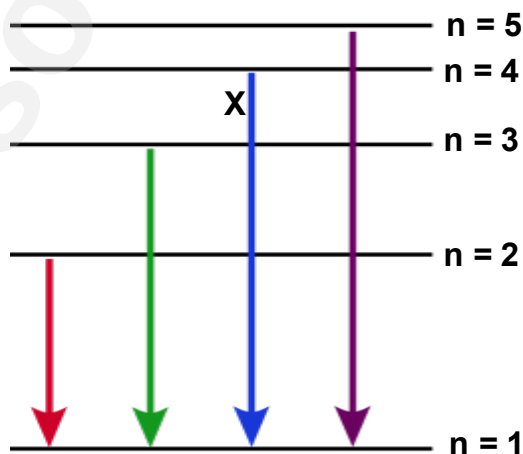
- 1.9 The diagram shows an alternating current input connected in a circuit with a single diode and a resistor.



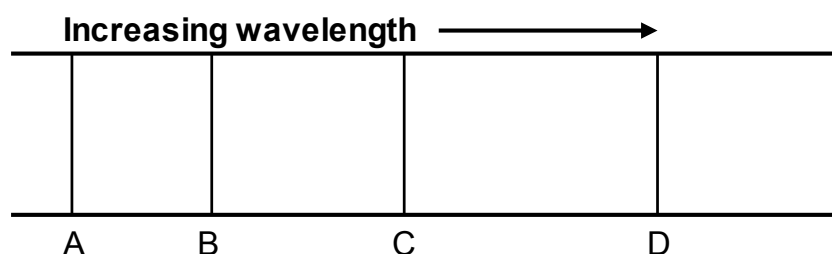
Which one of the following graphs shows the output current through the resistor?



- 1.10 The diagram below shows 4 possible transitions of an excited electron as it falls between energy levels of an atom.



The diagram below shows the line emission spectrum produced as a result of the above transitions. Which spectral line corresponds to emission X, from energy level $n = 4$ to $n = 1$?



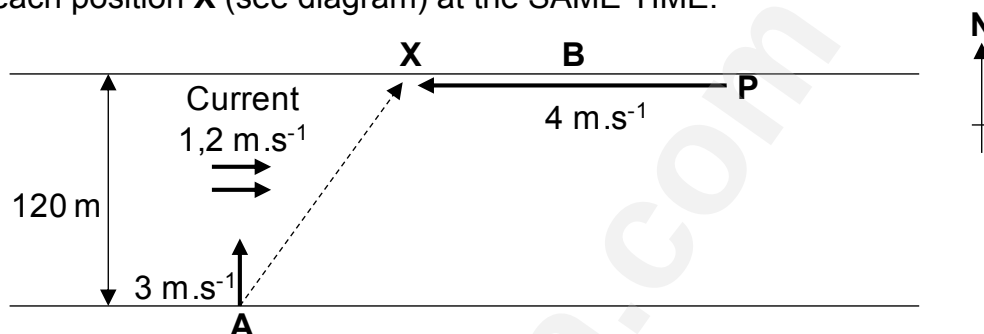
[20]

QUESTION 2

- 2.1 Boat **A** sets off directly across a river at a constant speed of 3 m.s^{-1} . The river is 120 m wide. There is a current flowing at $1,2 \text{ m.s}^{-1}$ east, because of which boat **A** arrives at position **X** on the opposite bank.

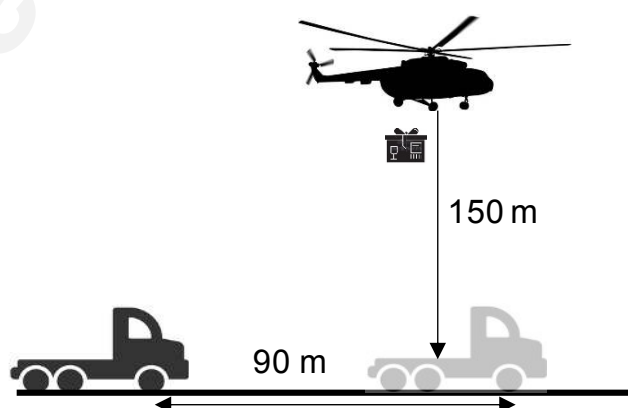
At the instant boat **A** sets off across the river, boat **B** leaves position **P** and travels at a constant speed of 4 m.s^{-1} west parallel to the banks of the river.

Both boats reach position **X** (see diagram) at the SAME TIME.



- 2.1.1 Define *resultant vector*. (2)
- 2.1.2 Consider the velocity of the current and hence, determine the resultant velocity of boat **B**. (2)
- 2.1.3 Calculate the time taken for boat **A** to cross the river. (3)
- 2.1.4 Define *displacement*. (2)
- 2.1.5 Calculate the displacement of **X** from **P**. (3)
- 2.2 A helicopter drops a fragile parcel from a height of 150 m. At the instant the parcel is released a flatbed truck sets off from rest towards the landing site of the parcel. The initial distance between the truck and the landing site is 90 m. Ignore air resistance.

Not to scale

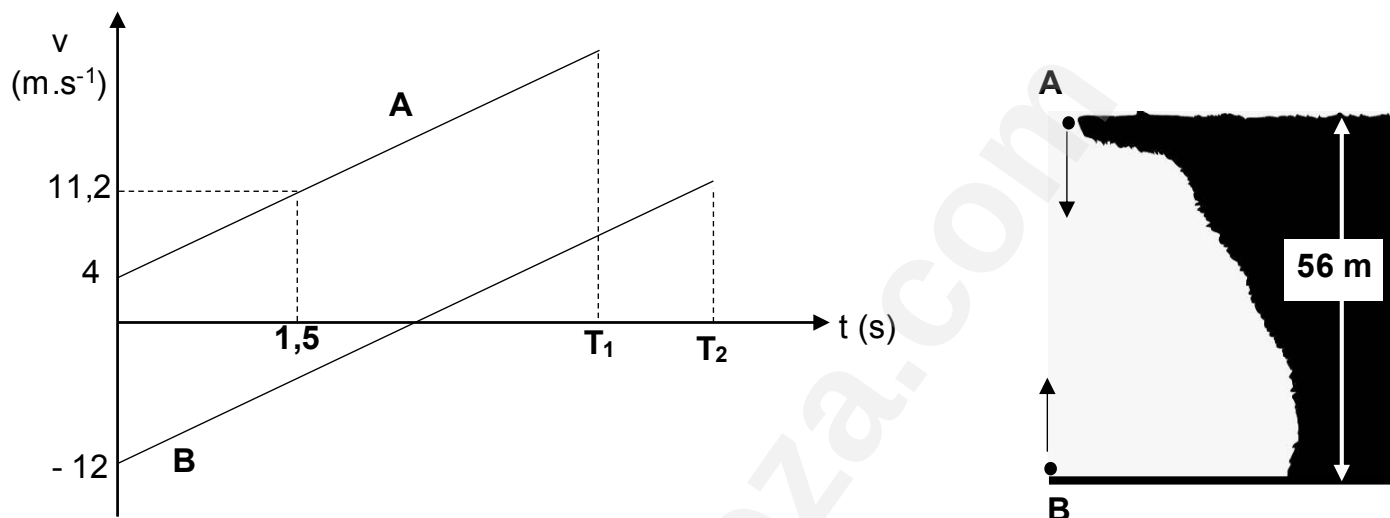


- 2.2.1 Calculate the magnitude of the minimum acceleration of the truck if it is to reach the landing site in time to catch the parcel on the soft mattress in its truck bed. (Ignore the height of the truck bed above the ground). (5)
- 2.2.2 Define *impulse*. (2)
- 2.2.3 Explain, referring to a suitable formula, why the fragile parcel is less likely to break if it lands on a soft mattress rather than on the hard ground. (4)

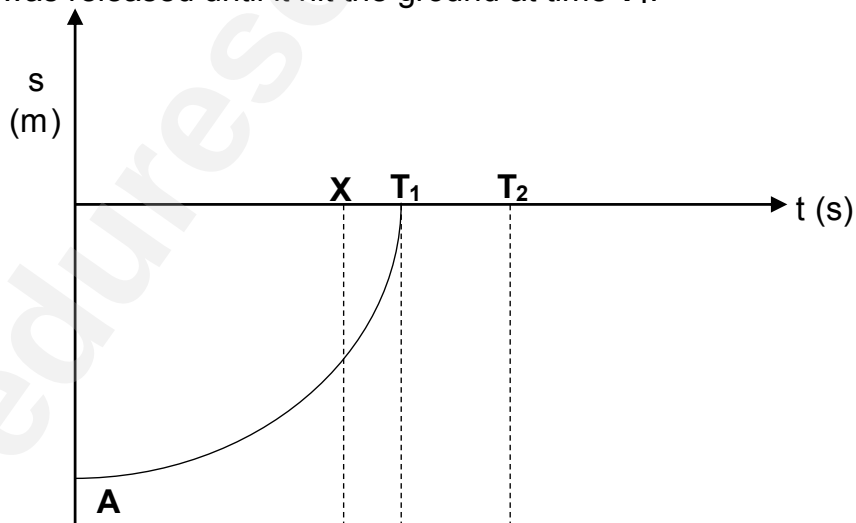
QUESTION 3

Stone **A** is thrown vertically down from the top of a 56 m high cliff on an **unknown planet**. At the instant stone **A** is thrown down, stone **B** is projected vertically upwards from the base of the cliff. Stone **A** hits the ground at time T_1 . Stone **B** hits the ground at time T_2 .

The velocity-time graph below represents the motion of stones **A** and **B**. Ignore air resistance.



- 3.1 Calculate the magnitude of the acceleration due to gravity on this planet. (3)
- 3.2 This planet has a radius of $1,6 \times 10^4$ m. Calculate the mass of the planet. (3)
- 3.3 Calculate the time taken for stone **B** to reach its highest point. (3)
- 3.4 Calculate the time (**X**) at which the stones pass one another. (5)
- 3.5 The graph below represents the position of stone **A** with respect to time from the moment it was released until it hit the ground at time T_1 .



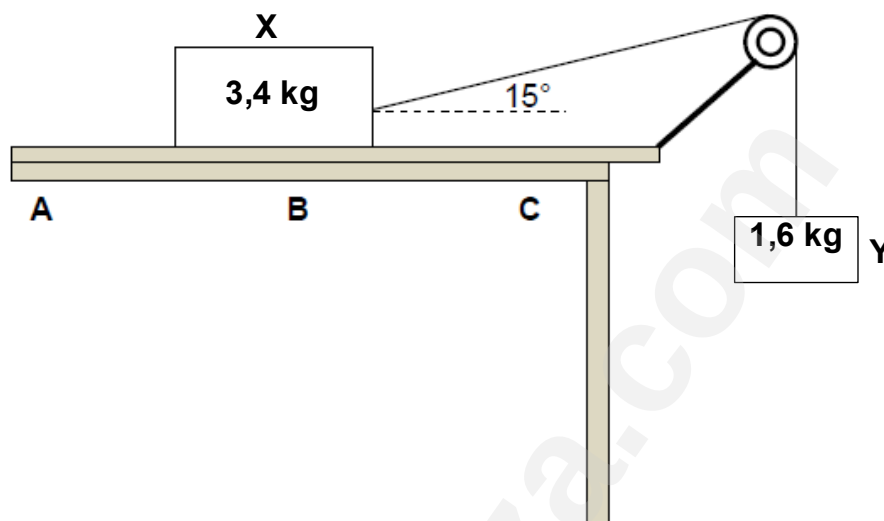
- 3.5.1 What has been taken as the frame of reference in this graph?
Answer only: BOTTOM OF CLIFF or TOP OF CLIFF. (1)
- 3.5.2 This graph has been reproduced in your ANSWER BOOKLET. On the same set of axes draw the position-time graph for stone **B** from the instant it was projected up until it hit the ground. No values need to be shown. (3)

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QUESTION 4

(Adapted from NSC Nov 2018 and St Andrews trials 2019)

Block **X**, of mass 3,4 kg, is placed on a rough horizontal surface. Block **X** is connected to block **Y**, of mass 1,6 kg, by means of a light inextensible string passing over a light frictionless pulley. Block **X** starts sliding from point **A**, as shown below.

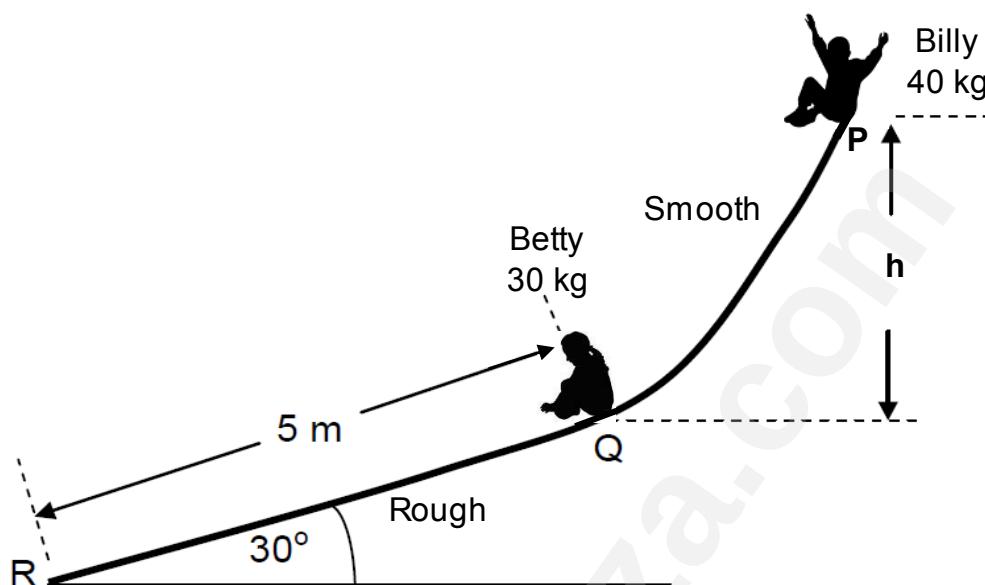


- 4.1 When block **X** reaches point **B**, the angle between the string and the horizontal is 15° and the acceleration of the system is $1,2 \text{ m}\cdot\text{s}^{-2}$.
- 4.1.1 Consider the forces acting on block **Y**, and hence, determine the magnitude of the tension in the string. (4)
- 4.1.2 Draw a labelled free body diagram for block **X** at point **B**. (4)
- 4.1.3 Calculate the magnitude of the force of kinetic friction between block **X** and the horizontal surface. (4)
- 4.1.4 Calculate the magnitude of the normal force which the surface exerts on block **X**. (3)
- 4.2 Consider the force of kinetic friction between block **X** and the horizontal surface.
- 4.2.1 Define *frictional force due to a surface*. (2)
- 4.2.2 How does the force of kinetic friction between block **X** and the horizontal surface change as block **X** moves from **B** to **C**.
Answer only: INCREASES, DECREASES or NO CHANGE. (1)
- 4.2.3 Explain your answer to Question 4.2.2 with reference to a suitable formula. (3)
- 4.3 A small 40 W motor is used to raise a different block, **Z**, to the table at a **constant speed** of $0,5 \text{ m}\cdot\text{s}^{-1}$.
- 4.3.1 Calculate the mass of block **Z**. (4)
- 4.3.2 The motor cable snaps when block **Z** is 2 m above the ground.
- (a) Calculate the speed of block **Z** as it hit the ground. (4)
- (b) Calculate the time from the instant the cable snapped until block **Z** hit the ground. (4)

[33]

QUESTION 5

A slide, **PQR**, at an amusement park consists of a curved **frictionless** section, **PQ**, and a section, **QR**, which is rough, straight and inclined at 30° to the horizontal. **QR** is 5 m long.



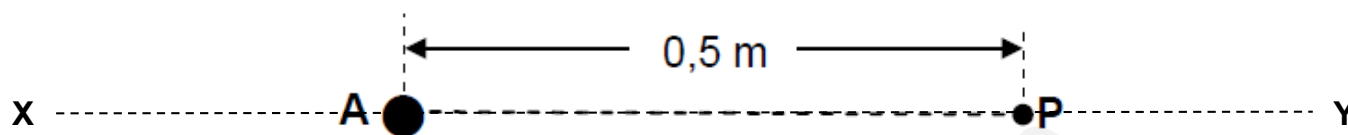
Billy (mass 40 kg) starting from rest at **P**, slides down section **PQ**. His speed when he reaches **Q** is 7 m.s^{-1} . Betty (mass 30 kg) is sitting stationary at **Q**. Billy collides with, and holds onto, Betty at **Q**. Billy and Betty slide together down the rough straight section, **QR**.

- 5.1 State the principle of conservation of mechanical energy. (2)
- 5.2 Hence, calculate the vertical height (**h**) of **P** above **Q**. (4)
- 5.3 State the principle of conservation of linear momentum. (2)
- 5.4 Calculate the speed of Billy and Betty immediately after the collision. Consider the collision to be linear. (4)
- 5.5 The total kinetic frictional force acting on Billy and Betty together, as they slide down section **QR** is 59,4 N. Consider Billy and Betty together as ONE body.
- 5.5.1 Calculate the co-efficient of kinetic friction between Billy and Betty and the surface **QR**. (4)
- 5.5.2 Calculate the speed of Billy and Betty as they reach **R**. (6)

[22]

QUESTION 6

P is a point 0,5 m from charged sphere **A**. The electric field at **P** is $3,6 \times 10^4 \text{ N}\cdot\text{C}^{-1}$ directed towards **A**. Refer to the diagram below.



- 6.1 Describe *an electric field*. (2)
- 6.2 State whether the sign of the charge on sphere **A** is POSITIVE or NEGATIVE. (1)
- 6.3 Draw the electric field pattern due to charged sphere **A**. (2)
- 6.4 Calculate the magnitude of the charge on sphere **A**. (3)
- 6.5 Another charged sphere, **B**, having LOST 5×10^{13} electrons, is now placed at point **P**.
- 6.5.1 State whether the sign of the charge on sphere **B** is POSITIVE or NEGATIVE. (1)
- 6.5.2 Calculate the magnitude of the charge on sphere **B**. (2)
- 6.6 Calculate the electrostatic force experienced by sphere **B**. (4)
- 6.7 A POSITIVELY charged sphere, **C**, is placed somewhere on the line **XY** in the field set up by charged spheres **A** and **B**. The NET ELECTROSTATIC FORCE experienced by charged sphere **C** is ZERO.

What is the position of charged sphere **C**? Choose from:

- TO THE LEFT OF SPHERE **A**; or
- BETWEEN SPHERES **A** and **B**; or
- TO THE RIGHT OF SPHERE **B**. (2)

[17]

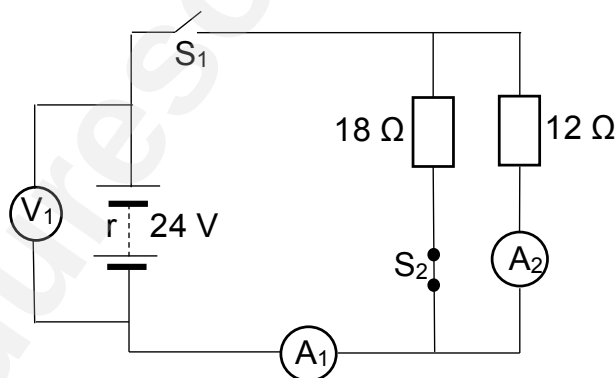
QUESTION 7

- 7.1 An experiment is conducted to determine how the current (I) through a resistor affects the energy (W) transferred in the resistor PER MINUTE. The current (I) is varied, and the energy (W) is measured using a data sensor.

The table below shows values for current squared and the corresponding energy values.

$I^2 \text{ (A}^2\text{)}$	$W \text{ (J)}$
0,01	10
0,04	40
0,09	75
0,16	150
0,25	225

- 7.1.1 Identify the dependent variable in this investigation. (1)
- 7.1.2 On the graph paper provided in your ANSWER BOOKLET plot a graph of W vs I^2 . (6)
- 7.1.3 Calculate the gradient of your graph. Show the values you used on your graph and include the appropriate unit in your answer. (5)
- 7.1.4 Hence, use an energy formula and your gradient calculated in Question 7.1.3 to calculate the resistance of the resistor used in the investigation. (4)
- 7.2 In the circuit below, the battery has an emf of 24 V and an unknown internal resistance. The resistances of the switch, ammeters and connecting wires are negligible. The voltmeter has very high resistance.



When **both** switches are **closed** A_1 reads 3 A.

- 7.2.1 Define *emf*. (2)
- 7.2.2 Calculate the internal resistance of the battery. (4)
- 7.2.3 Calculate the reading on A_2 when both switches are closed. (3)
- 7.2.4 S_2 is now opened, while S_1 remains closed.
- (a) How is the reading on V_1 affected?
Answer only: INCREASES, DECREASES or REMAINS CONSTANT. (1)
- (b) Explain your answer to Question 7.2.4 (a). (3)

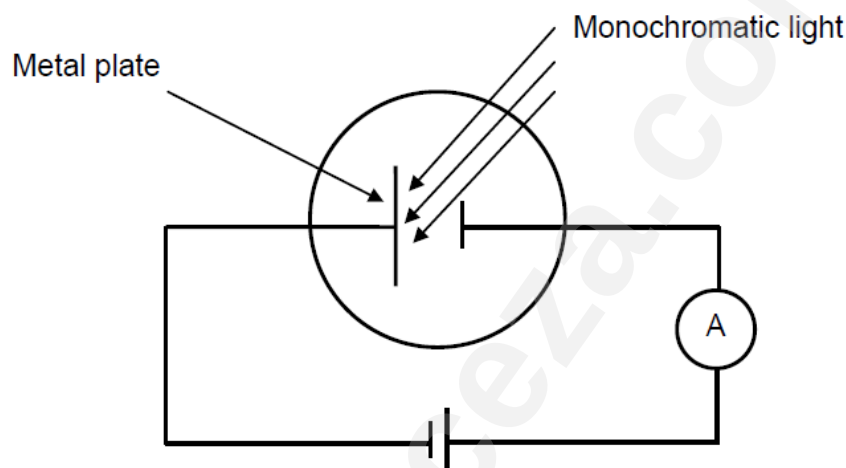
[29]

QUESTION 8

ANSWER QUESTION 8 IN YOUR ANSWER BOOKLET**[23]**

QUESTION 9

- 9.1 In the diagram below, monochromatic light is incident on the metal plate of a photocell.
A sensitive ammeter shows a reading.



- 9.1.1 Define *threshold frequency*. (2)
- 9.1.2 How does the frequency of the incident light compare to the threshold frequency required for the metal plate?
Choose from GREATER THAN or LESS THAN. (1)
- 9.1.3 Give a reason for your answer to Question 9.1.2. (2)
- 9.2 Ultraviolet radiation of wavelength 280 nm is incident on the surface of sodium metal. The work function for sodium is $3,78 \times 10^{-19} \text{ J}$.
- 9.2.1 Calculate the energy of a photon of UV radiation. (4)
- 9.2.2 Calculate the maximum speed of an electron emitted from the metal surface. (5)

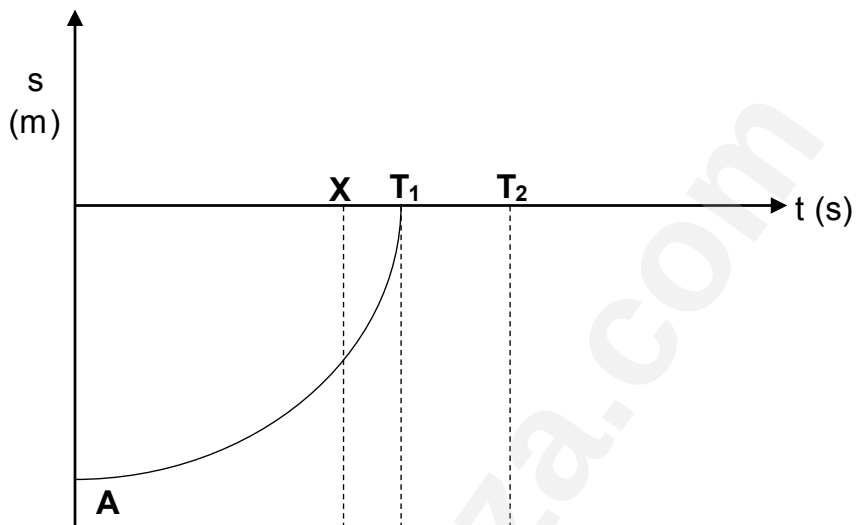
[14]**Total: 200 marks**

ANSWER BOOKLET

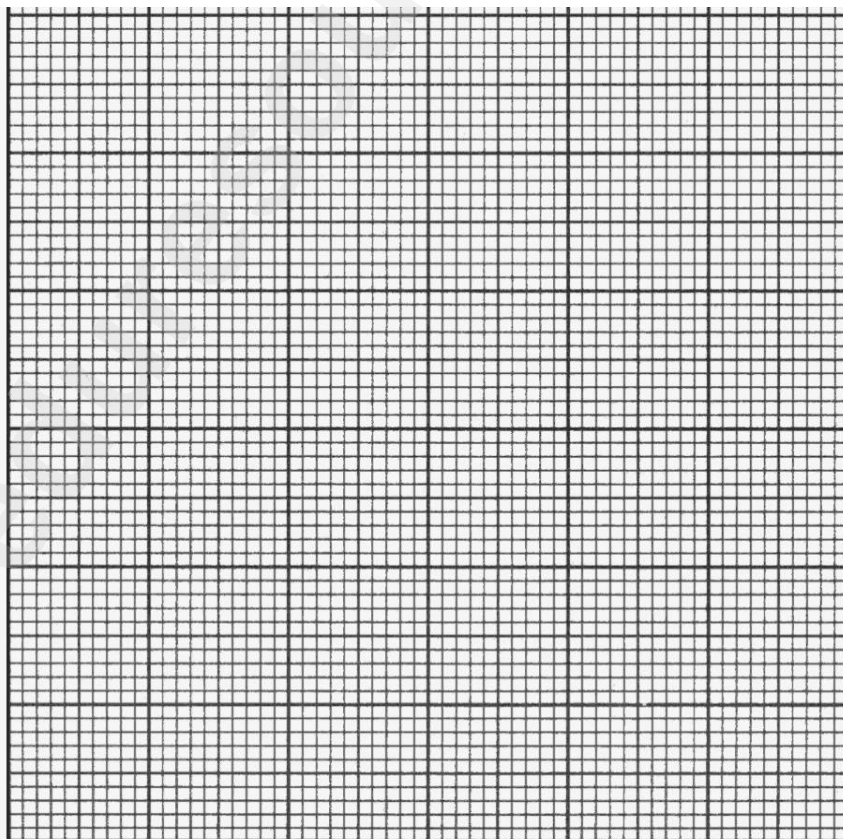
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QUESTION 3.5.2

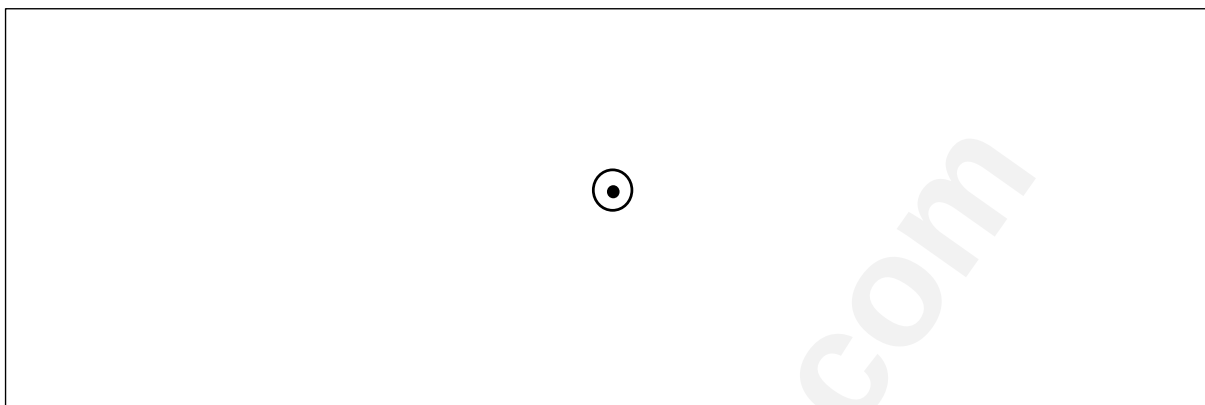


QUESTION 7.1.2

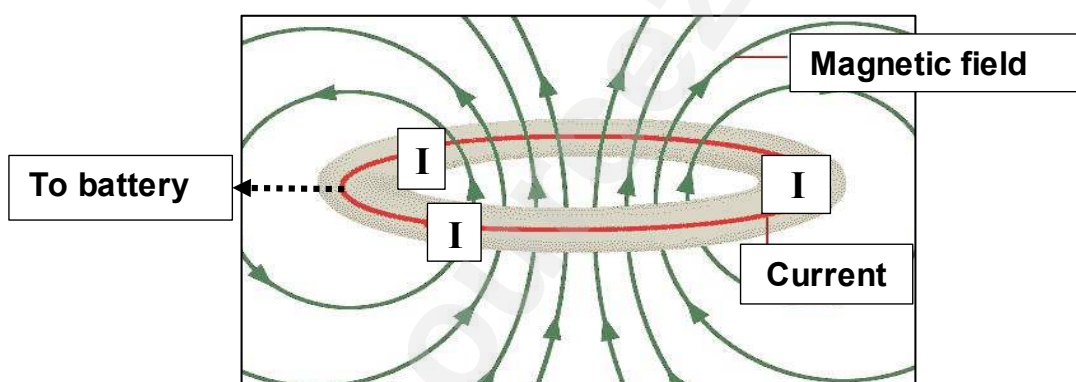


QUESTION 8

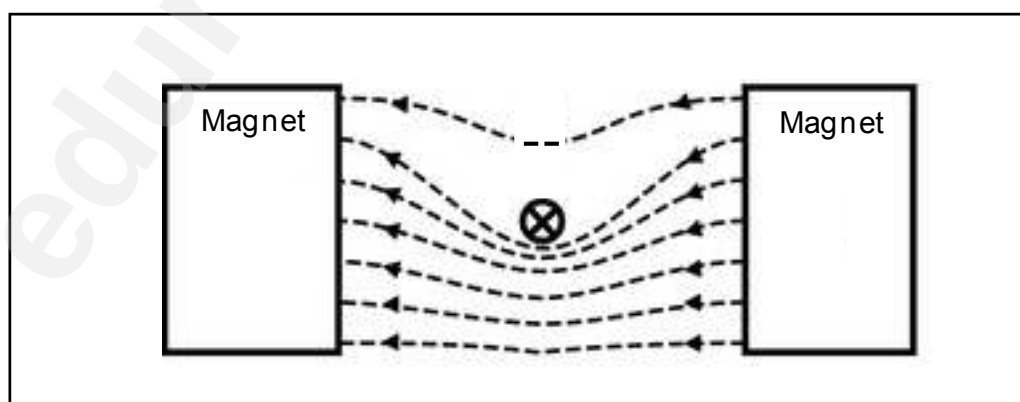
- 8.1.1 Draw 3 lines to represent the magnetic field around a straight conductor carrying current perpendicularly OUT of the plane of the paper. Indicate the direction of the magnetic field with arrows. (3)



- 8.1.2 The diagram shows the magnetic field set up by a single current carrying loop of wire. Use an ARROW to show the direction of the conventional current (I) in the loop. (2)

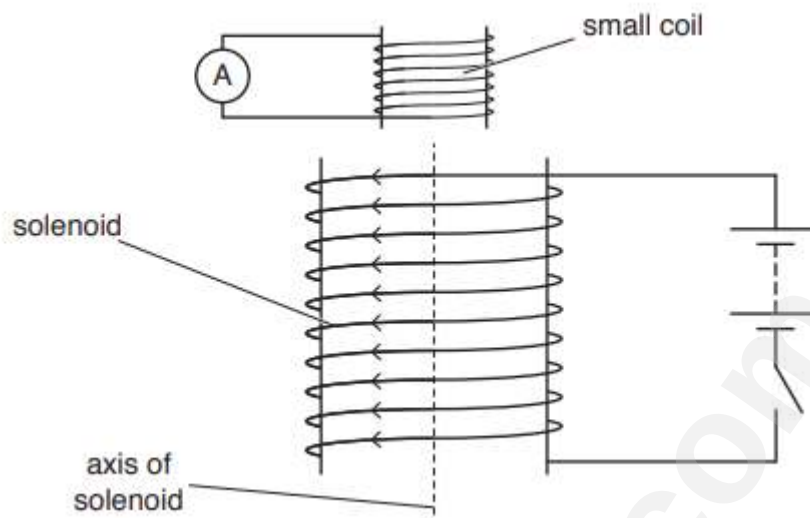


- 8.1.3 The diagram shows the combined magnetic field of a conductor carrying current perpendicularly INTO the plane of the paper and the permanent magnetic field of a pair of bar magnets



- Label the north pole (**N**) of the magnets. (1)
- Draw an arrow to show the direction of the force acting on the conductor. (1)
- State 2 methods of INCREASING the size of the force on the conductor. (2)

8.2 A solenoid is connected in series with a battery and a switch, as shown below.



A small coil, connected to a sensitive ammeter, is situated near one end of the solenoid. As the current in the solenoid is switched on, the ammeter needle flicks to indicate a current and then immediately returns to the zero position.

8.2.1 **On the diagram** label the north pole (**N**) of the magnetic field of the SOLENOID. (1)

8.2.2 **On the diagram**, draw an arrow on the axis of the solenoid to show the DIRECTION of the magnetic field INSIDE the solenoid. (1)

As the current in the solenoid is switched on, there is a current induced in the small coil.

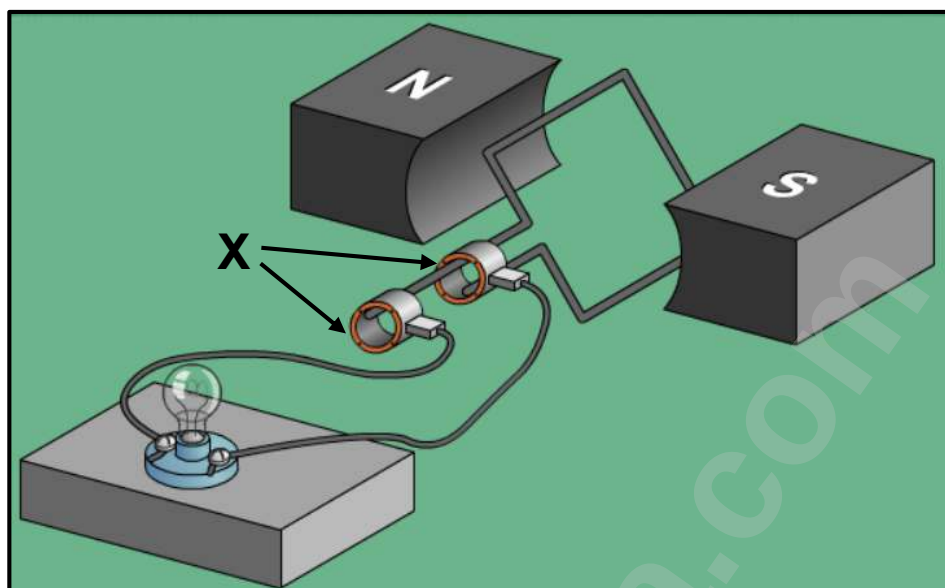
8.2.3 State *Lenz's law*. (2)

8.2.4 Use Lenz's law to determine the direction of the induced current in the SMALL COIL. Mark this direction **on the diagram** with an arrow on one of the windings of the SMALL COIL. (2)

8.2.5 Explain why a current is initially induced in the small coil. (2)

8.2.6 Explain why the current in the small coil immediately drops to zero after the initial induction. (2)

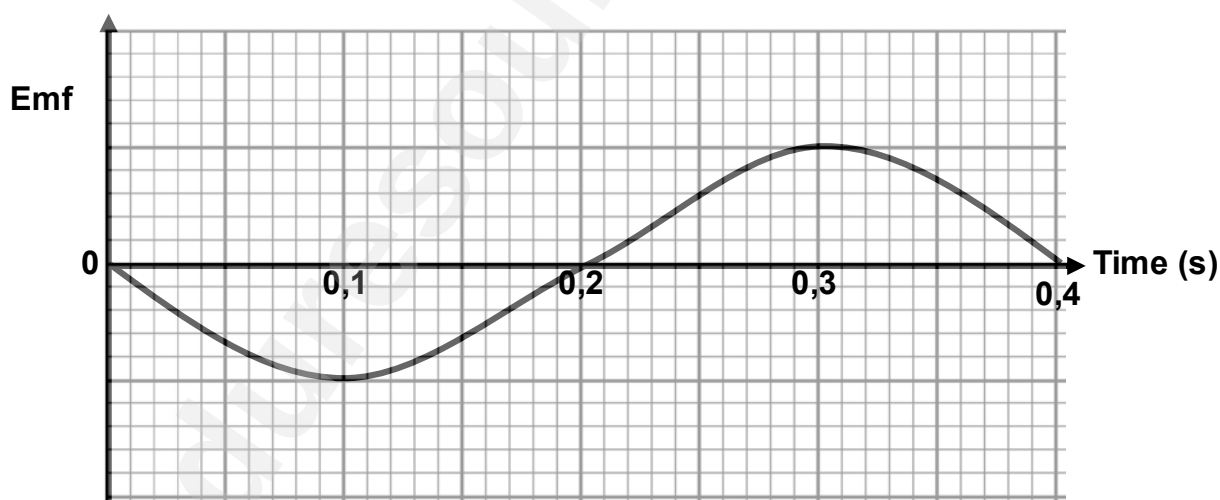
8.3 A simple AC generator is shown in the diagram below.



8.3.1 Name the components labelled **X** in the above diagram.

(1)

The emf-time graph for one complete revolution of the generator coil is shown below.



8.3.2 In what position is the coil at time $t = 0,1$ s? Answer only VERTICAL or HORIZONTAL. (1)

8.3.3 On the above axes draw a graph to represent the change in emf with time when the same generator coil is rotated at TWICE THE FREQUENCY in the OPPOSITE DIRECTION. (3)

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