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ST JOHN'S COLLEGE

UV Physical Sciences Paper 1: Physics

July 2018

Time: 3 hours

200 marks

Examiner: B Beukes

Moderator: N Stocks

Name: _____

Please circle your teacher's initials:

NS	JN	CH	GH	BB
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Instructions:

1. This paper contains 16 printed pages of questions. Check and make sure that you have all of the pages.
2. The answer sheet and graph paper are attached to the data sheet.
3. **Start each question on a new page.**
4. Where appropriate, round off your final answers to 2 decimal places.

ACKNOWLEDGMENTS :

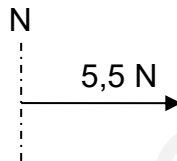
Various DBE, IGCSE, NSC and Cambridge A level papers, IEB and SQA examinations boards.

Question 1:**[2×10=20]**

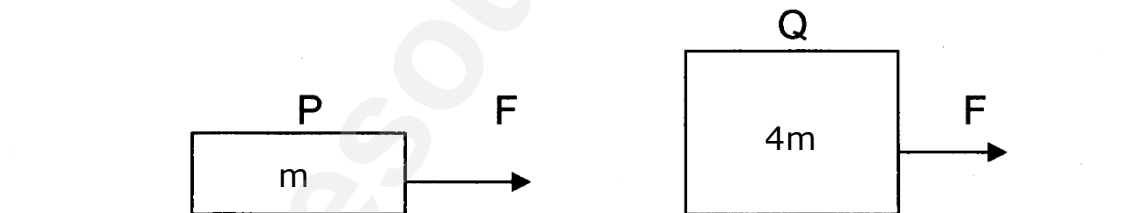
Answer on the answer sheet provided

- 1.1 Which of the following statements is TRUE of a body that accelerates uniformly?
- A. Its rate of change of position remains constant.
 - B. Its position changes by the same amount in equal time intervals.
 - C. Its velocity increases by the same amount in equal time intervals.
 - D. Its velocity increases by increasing amounts in equal time intervals.

- 1.2 Which one of the following vectors will balance the given vector?



- A. 5,5 N due east
 - B. 5,5 N on a bearing 270°
 - C. 5,5 N on a bearing 180°
 - D. 5,5 N on a bearing 90°
- 1.3 A net force F acts on each of two isolated objects, P and Q, as shown below. The mass of Q is four times that of P. (Ignore the effect of friction.)



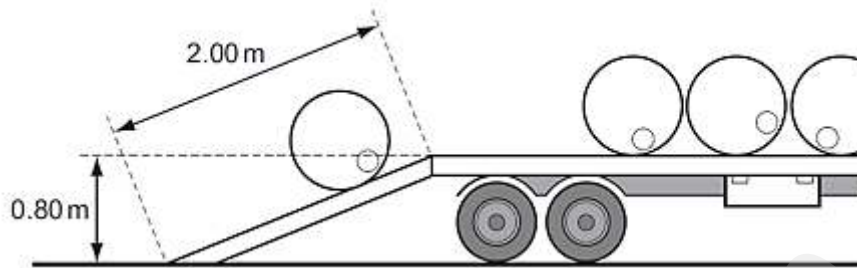
If the rate of change of velocity of object Q is x , then the rate of change of velocity of object P is as follows:

- A. $\frac{1}{16}x$
 - B. $\frac{1}{4}x$
 - C. x
 - D. $4x$
- 1.4 A half-brick is thrown vertically upwards and reaches a height h above the ground. A full brick is also thrown vertically upwards and reaches the same height h . Ignore all effects of friction.

Which of the following is TRUE concerning the bricks which were thrown?

- A. The half-brick will take a shorter time to reach the builder.
- B. Both bricks have the same kinetic energy when they are thrown.
- C. Both bricks have the same velocity when they are thrown.
- D. Both bricks have the same momentum when they are thrown.

- 1.5 A workman rolls a barrel of weight 2000 N up a plank of length 2 m and on to a lorry. The back of the lorry is 0,8 m above the horizontal surface of the road.



What work is done on the barrel against gravity?

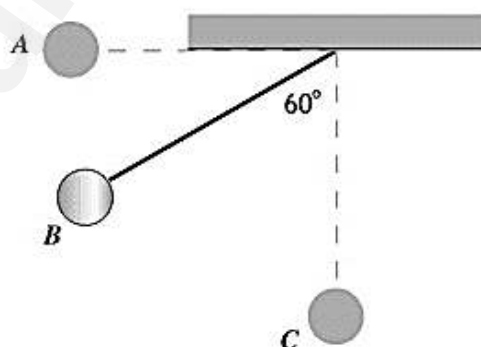
- A. 1000 J B. 1600 J C. 2500 J D. 4000 J
- 1.6 Two identical bullets, X and Y, with identical velocities strike a steel block and wooden block respectively.

Bullet X bounces 180° back from the steel block. Bullet Y penetrates and becomes embedded inside the wooden block.

Which one of the following statements about the impulse of the bullets is correct?

Impulse of bullet X...

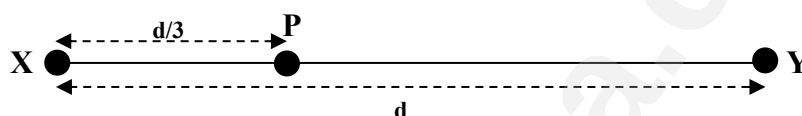
- A. is smaller than the impulse of bullet Y.
 B. is greater than the impulse of bullet Y.
 C. is equal to the impulse of bullet Y.
 D. and bullet Y are zero.
- 1.7 A frictionless pendulum is raised to position A and then released. What is the relationship between the speed of the bob at positions B and C?



- A. $V_B = 2V_C$ B. $V_B = 0,5V_C$
 C. $V_B = V_C$ D. $V_B = \frac{V_C}{\sqrt{2}}$

- 1.8 An astronaut on a strange planet finds that acceleration due to gravity is twice that on the surface of Earth. Which of the following could explain this?
- Both the mass and radius of the planet are twice as that of Earth.
 - Mass of the planet is half as that of Earth, but radius is same as that of Earth.
 - Both the mass and radius of the planet are half as that of Earth.
 - Radius of the planet is half as that of Earth, but the mass is the same as that of Earth.

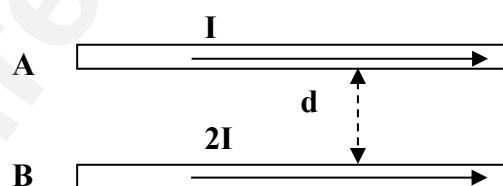
- 1.9 Two point charges (X and Y) are placed a distance d apart from each other. The net/resultant electric field intensity (strength) at point P is zero.



Which of the following statements concerning X and Y is correct?

	Charge on X	Charge on Y	
A	Positive	Positive	Charge on Y > charge on X
B	Positive	Negative	Charge on Y > charge on X
C	Positive	Positive	Charge on X > charge on Y
D	Positive	Negative	Charge on X > charge on Y

- 1.10 Two parallel current-carrying conductors are placed a distance d apart from each other. Conductor A carries a current of I and conductor B carries a current of $2I$. Conductor B is in the magnetic field due to conductor A.

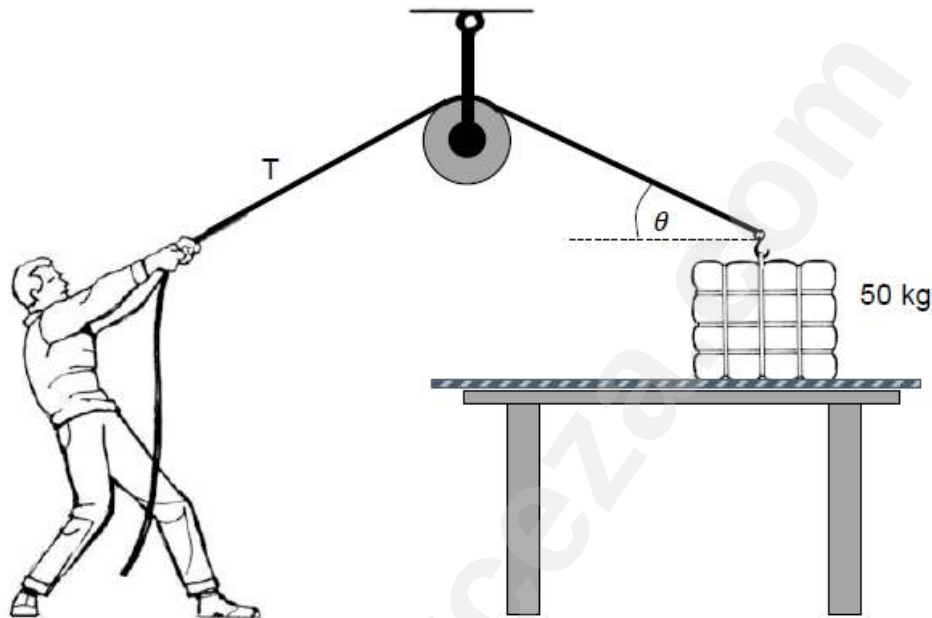


Which of the following statements about the force that current-carrying conductor A exerts on current-carrying conductor B is correct?

	Magnitude of force of A on B	Direction of force on B
A	Less than force that B exerts on A	Downwards
B	Less than force that B exerts on A	Upwards
C	Equal to the force that B exerts on A	Downwards
D	Equal to the force that B exerts on A	Upwards

Question 2:

A man applies a constant pulling force on a heavy parcel of mass 50 kg using a light inextensible rope which passes over a light frictionless pulley as shown in the diagram below. The coefficient of static friction between the parcel and the rough table is 0,34. The magnitude of the maximum static frictional force is 120 N. Ignore the mass of the rope. The man is unable to lift the parcel off the table.

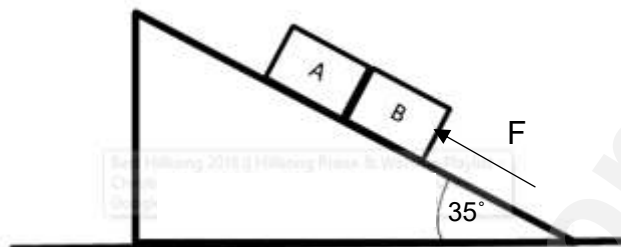


- 2.1 Draw a free-body diagram showing all the forces exerted on the parcel. (4)
- 2.2 Define *frictional force*. (2)
- 2.3 Calculate the magnitude of the perpendicular force that the table exerts on the parcel when the static friction is at a maximum. (3)
- 2.4 When the static friction is at a maximum, show that the magnitude of the vertical component of the tension force in the rope is 137,06 N. (3)
- 2.5 Hence, calculate the angle (θ) that the rope forms with the horizontal. (3)
- 2.6 Calculate the magnitude of the tension in the rope (T). (2)

[17]

Question 3:

A copper block A and a steel block B, each of mass 0,4 kg are only just held at rest by a force F acting up the slope as shown in the sketch below. The coefficient of static friction between block A on the slope is 0,52.



3.1 Define a *resultant vector*. (2)

3.2 Draw a labelled free body diagram showing all the forces acting **on block A** while at rest. (4)

3.3 Calculate the maximum frictional force acting on block A. (5)

The maximum frictional force on block B is 1,3 times the frictional force on block A.

3.4 Explain how block B can have a larger maximum frictional force than block A. (2)

The force F is removed and the blocks accelerate down the slope. Block A experiences a frictional force of 0,9 N and block B experiences a frictional force of 1,17 N.

3.5 Why is the frictional force on block A now less than that calculated in question 3.3? (2)

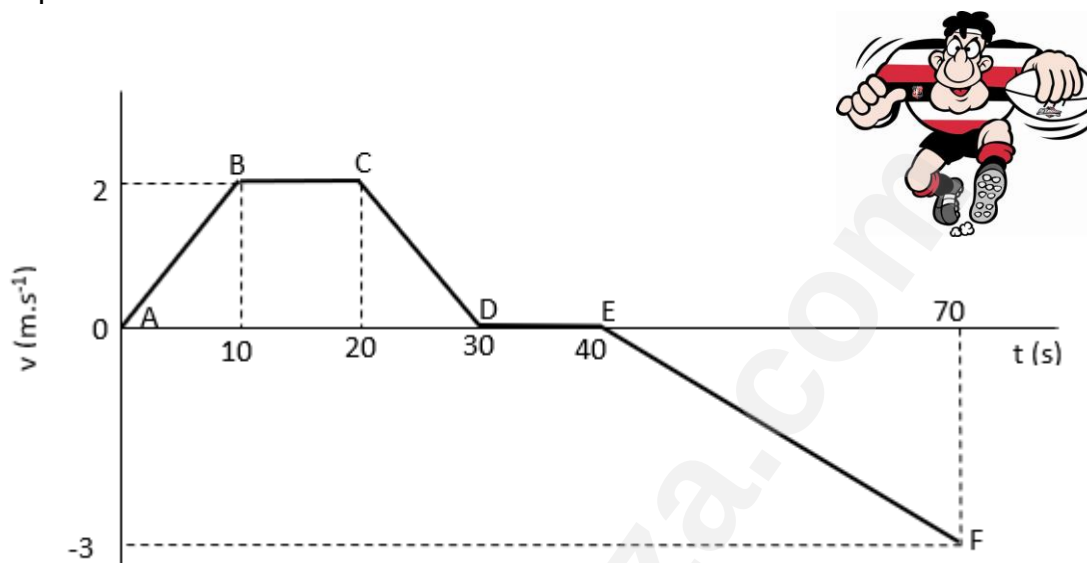
The acceleration of the blocks is measured to be $3,03 \text{ m.s}^{-2}$ down the slope.

3.6 Calculate the force exerted by block B **on block A**. (6)

[21]

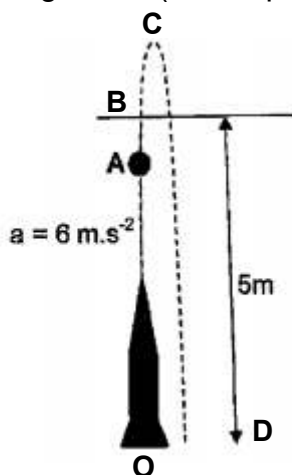
Question 4:

- 4.1 A camera mounted on a straight horizontal rail moves initially **east** along the side of a rugby field. The following velocity-time graph shows its motion over a period of 70 seconds.



- 4.1.1 Calculate the acceleration of the camera between 40 and 70 seconds. (4)
- 4.1.2 Calculate the **total distance** covered by the camera during the 70 seconds. (4)
- 4.1.3 Complete the following statement for the camera's journey.
Rewrite the sentence and insert only 'east' or 'west' to make the statement true.
- At 70 seconds the camera's new position is _____ of its starting position whilst it is moving _____.
- 4.1.4 Define *displacement*. (2)
- 4.1.5 Draw a labelled sketch graph of the **displacement-time** for the complete journey for the camera. Label points A-F. Numerical values not required. (5)

- 4.2 A model rocket is shot vertically upwards off the ground (position O). The rocket accelerates at 6 m.s^{-2} upwards from rest. The fuel completely burns out at a height 5 m above the ground. (Take up as positive)



- 4.2.1 Define *acceleration*. (2)
- 4.2.2 Calculate the magnitude of the velocity of the rocket at 5 m above the ground. (3)
- 4.2.3 Calculate the time taken for the fuel to burn out. (3)
- 4.2.4 Calculate the maximum height from the ground that the rocket reaches. (5)

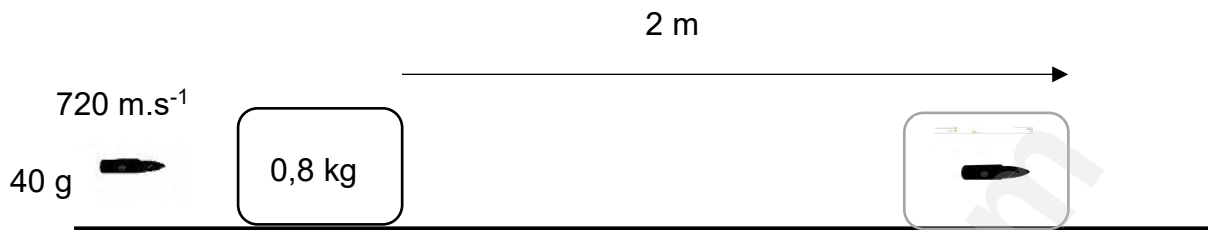
The rocket falls back to the ground at position D.

- 4.2.5 Calculate the **total** time taken for the rocket to fall back down to the ground from its **launch position**. (3)
- 4.2.6 Sketch the **velocity versus time graph** of the rocket's entire flight. Use the labels O, A, B, C and D from the diagram to show the corresponding points on your graph. (No numerical values are required). (4)

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Question 5:

A bullet with a mass of 40 g is shot horizontally at 720 m.s^{-1} into a stationary wooden block with a mass of 0,8 kg. The bullet becomes embedded in the block sliding it 0,2 m along a rough horizontal surface before coming to rest.

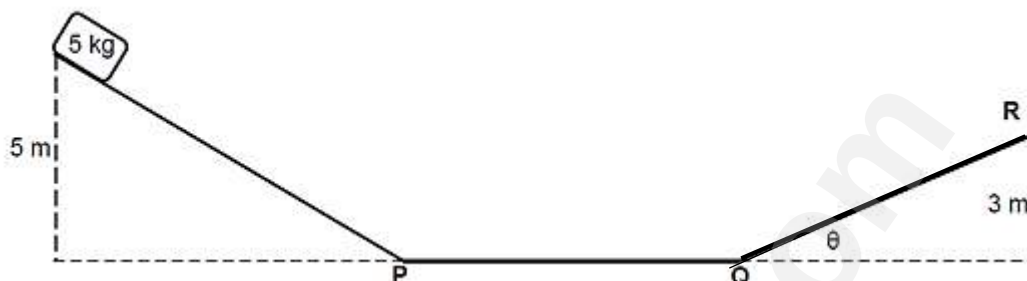


- 5.1 State the Law of *conservation of linear momentum*. (2)
- 5.2 Calculate the speed of the bullet and block after the collision. Ignore the friction between the block and surface during the period of the collision. (4)
- 5.3 Show by calculation that the collision was inelastic. (4)
- 5.4 State the *work energy theorem*. (2)
- 5.5 Use the work-energy theorem to calculate the frictional force which brings the bullet and block to rest. (5)

[17]

Question 6:

A 5 kg block is released from rest from a height of 5 m and slides down a **frictionless** incline to point P as shown in the diagram below. It then moves along a **frictionless** horizontal path PQ and finally moves up a second **rough** inclined plane. It comes to rest at point R which is 3 m above the horizontal.



6.1 Using ENERGY PRINCIPLES ONLY, calculate the speed of the block at point P. (3)

6.2 Explain by identifying the relevant law of physics, why the kinetic energy at point Q is the same as that at point P. (3)

The frictional force between the surface and the block from Q to R is 18 N.

6.3 Which force acting on the block from Q to R does no work on the block? (2)

6.4 Calculate the work done against friction from Q to R. (4)

6.5 Hence, calculate the angle (θ) to the horizontal of the slope QR. (5)
[17]

Question 7:

7.1 Two space capsules, of **equal mass**, are in outer space 30 m apart. The gravitational force between them is 2×10^{-7} N.

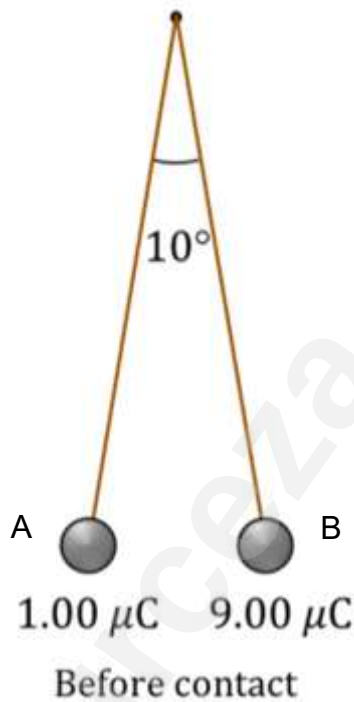
Calculate the mass of each capsule. (4)

7.2 The Earth has a mass of 6×10^{24} kg and a radius of $6,4 \times 10^6$ m. The International Space Station is at a height of 380 km above the Earth's surface.

Calculate the magnitude of the acceleration due to the Earth's gravity on the space station. (4)
[8]

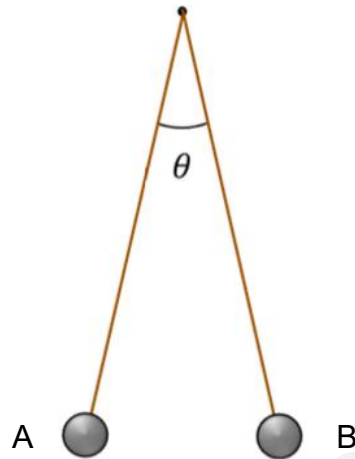
Question 8:

Two positively charged metal spheres each with a mass of 4 g are suspended from the same point by light, inextensible strings of equal length, making an angle of 10° with each other as shown in the diagram below.



- 8.1 Sketch the combined field pattern between charges A and B. (4)
- 8.2 State *Coulomb's Law*. (2)
- 8.3 Draw a labelled free body diagram of the forces acting on sphere B. (3)
- 8.4 Calculate the magnitude of the electrostatic force of repulsion between charge A and B. (4)
- 8.5 Hence, calculate the distance between the two charges. (4)

The spheres are now **brought into contact** with each other and allowed to separate, making a new angle θ between them as shown in the diagram below:



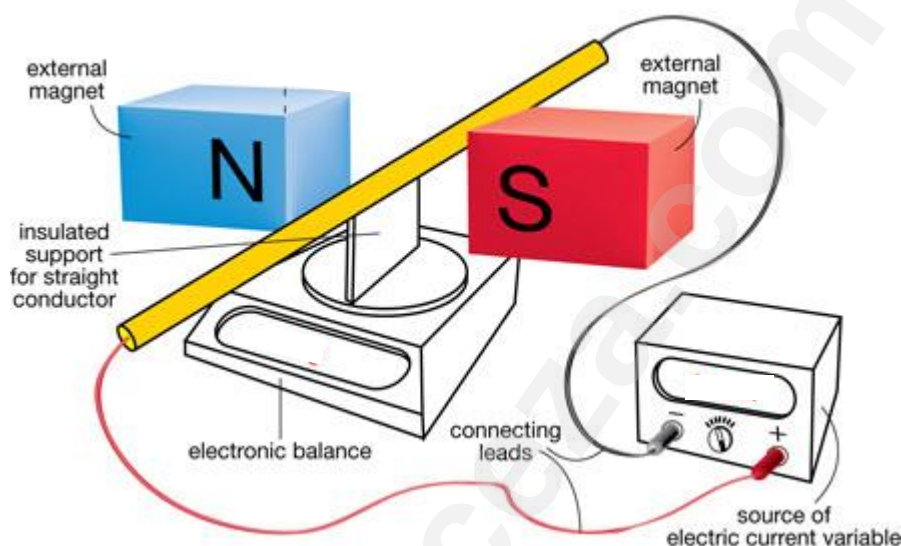
After contact

- 8.6 Calculate the new charge on each sphere. (2)
- 8.7 Determine the number of electrons moved and determine if they moved from A to B or B to A. (3)

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Question 9:

Two large magnets produce a uniform magnetic field of flux density B between them. A stiff wire is placed on top of a sturdy block of wood and this is placed on top of a mass balance and the wire is situated between the poles of the magnets, as shown in the diagram below.



The wire is horizontal and normal to the magnetic field. A direct current is passed through the wire in the direction shown by the power pack. The reading on the mass balance **increases**.

A student decided to investigate experimentally the relationship between the increase in mass Δm and the magnitude of the current I flowing in the wire.

The following data was collected:

$I \text{ (A)}$	$\Delta m \text{ (g)}$
0,5	0,46
1,0	0,86
1,5	1,32
2,0	1,74
2,5	2,23
3,0	2,61

- 9.1 State the independent variable in this experiment. (2)
- 9.2 On **the answer sheet**, use the graph paper provided to plot a graph of increase in mass (y axis) versus current (x axis) (7)
- 9.3 Calculate the gradient of the graph. Include the units of the gradient. (5)

The relationship between the increase in the mass and the current is represented by the equation:

$$\Delta m = \frac{\ell B}{g} I$$

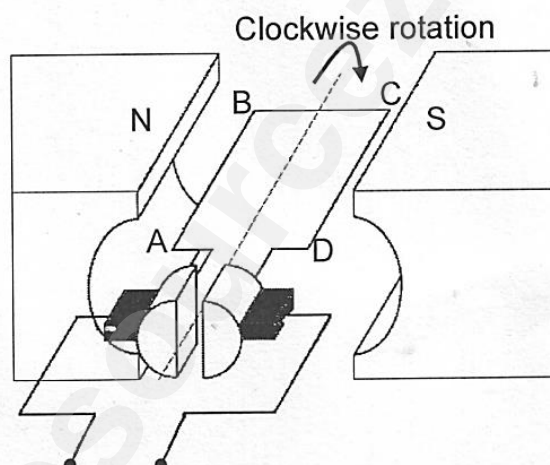
Where ℓ is the **length of wire** between the poles of the magnet and is measured to be **4,4 cm**. The other symbols have their usual meanings.

- 9.4 Use the gradient you calculated in question 9.3 and the manipulated equation above, to determine the magnetic field strength of the magnet.

(4)
[18]

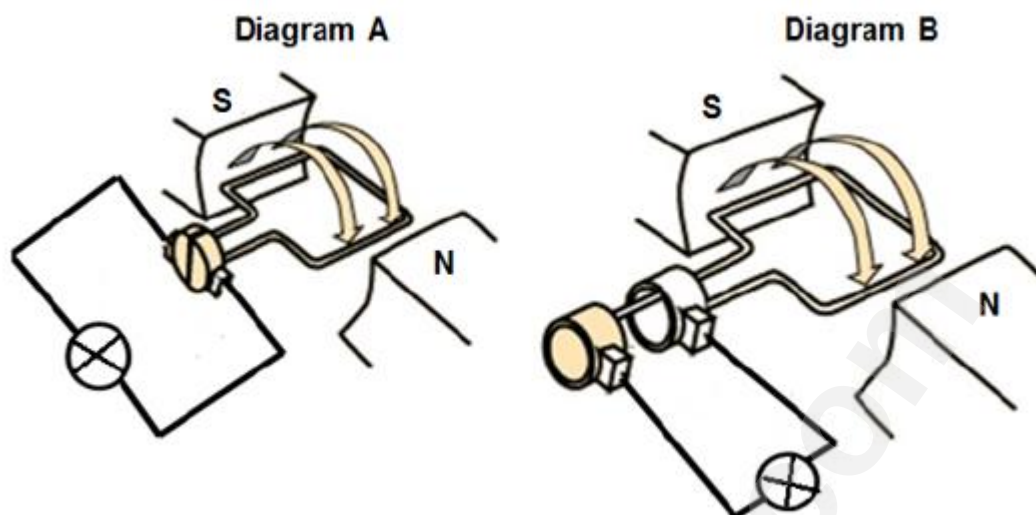
Question 10:

- 10.1 The diagram below illustrates an electric motor.

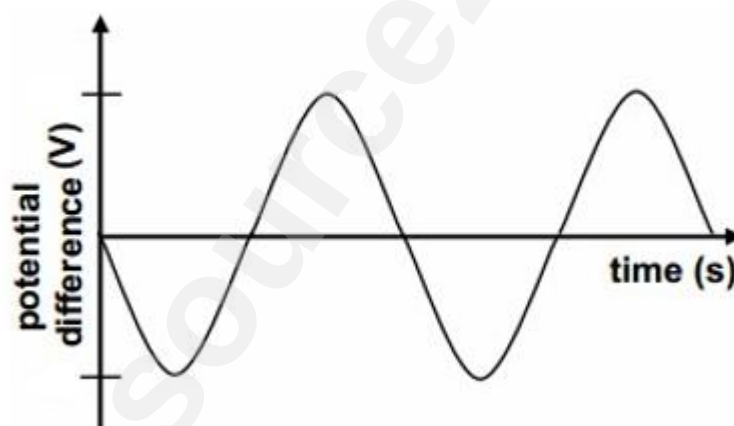


- 10.1.1 Describe two ways in which the rate of rotation of the coil could be increased. (2)
- 10.1.2 If the coil turns in a clockwise direction, in what direction is the current in the section AB of the coil flowing in the diagram above? Write down from **A to B** or **B to A** only. (2)

10.2 The following diagrams show two types of generators:



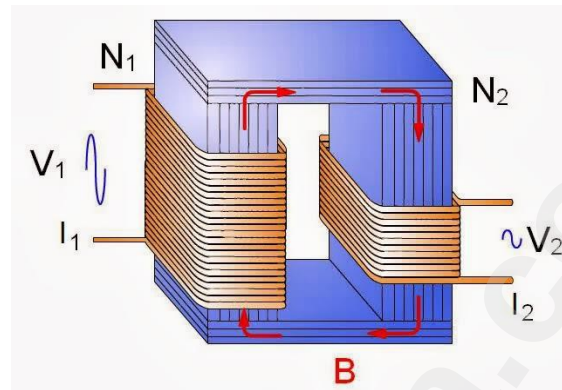
- 10.2.1 Identify the diagram above which illustrates the generator that produced the potential difference as shown in the sketch below. (1)



- 10.2.2 State *Faraday's Law*. (2)
- 10.2.3 On the copy of this graph on **your answer sheet**, indicate 2 points where the magnetic flux would be zero and label these points X and Y. (2)
- 10.2.4 On the same axes as Q 10.2.3 on **your answer sheet**, add a graph to show how this graph would change when the frequency of the generator is **halved**. Complete one revolution and label this pattern Z. (2)

- 10.2.5 Use a relevant equation to explain why it is an economic advantage to transmit electrical energy through the national grid at high voltage and low current. (2)

- 10.3 A transformer has 200 coils on the primary coil and 50 coils on the secondary coil



- 10.3.1 Define *magnetic flux linkage*. (2)

- 10.3.2 Is this a step up or a stepdown transformer? Use the equation for Faraday's law to justify how you arrived at your answer. (3)

An AC generator supplies a peak voltage of 220 V to the transformer.

- 10.3.3 Explain why the input supply needs to be an AC source. (2)

- 10.3.4 Calculate the voltage V_2 . (3)
[23]