NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION – MARCH 2018

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages, an Answer Sheet of 2 pages and a Data Sheet of 2 pages (i–ii). Please make sure that your question paper is complete.
2. Answer ALL the questions.
3. Read the questions carefully.
4. Use the data and formulae whenever necessary.
5. Start each question on a new page.
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 express answers to TWO decimal places.
9. It is in your own interest to write legibly and to present your work neatly.

QUESTION 1 MULTIPLE CHOICE

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.

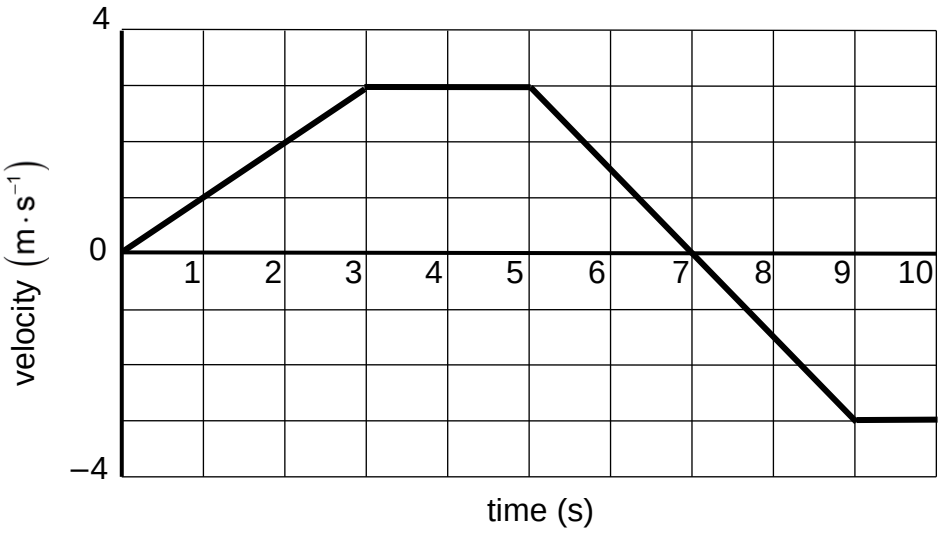
1.1 When a force *F* moves an object through a displacement s in the direction of the force, the work done by the force is given by the equation:

$$W = \mathrm{F} \cdot \mathrm{s}$$

How many vector and scalar quantities does this equation contain?

A One scalar quantity and two vector quantities.
B Two scalar quantities and one vector quantity.
C Three scalar quantities.
D Three vector quantities.

1.2 A bike starts at the origin and its velocity along a straight line is represented on the velocity vs time graph shown. During which intervals is the bike moving **towards** the origin?



A For times between 0 s and 3 s.
B For times between 0 s and 7 s.
C For times between 5 s and 7 s.
D For times greater than 7 s.

1.3 A model car completes one lap around a circular track of 400 m at an average speed of 5 $\mathrm{m \cdot s^{-1}}$ and then a second lap at an average speed *v*. The average speed for the completion of both laps was 8 $\mathrm{m \cdot s^{-1}}$. What was the average speed of the second lap?

A 11,0 $\mathrm{m \cdot s^{-1}}$
B 12,5 $\mathrm{m \cdot s^{-1}}$
C 15,0 $\mathrm{m \cdot s^{-1}}$
D 20,0 $\mathrm{m \cdot s^{-1}}$

1.4 A ball is thrown vertically upwards and returns to the thrower's hand. Ignore air resistance. Which one of the following best describes the direction of the ball's **acceleration** during its flight?

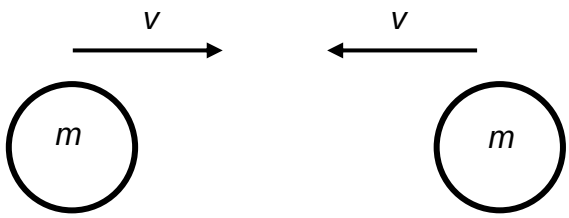
	Ball travelling upwards	**Ball at top of flight**	**Ball travelling downwards**
A	Downward	Downward	Downwards
B	Upward	Zero	Downwards
C	Downward	Zero	Downwards
D	Upward	Downward	Upwards

1.5 A 20,4 kg box remains at rest on a horizontal surface while the box is pushed horizontally with a force of 60 N. The coefficient of static friction between the box and the surface is 0,60.

What is the force of friction acting on the box during the push? (Rounded off to the closest whole number)

A 200 N
B 140 N
C 120 N
D 60 N

1.6 Two identical spheres, each with a mass m and travelling with a speed v, move towards each other in an isolated system.



The spheres have a head-on elastic collision.

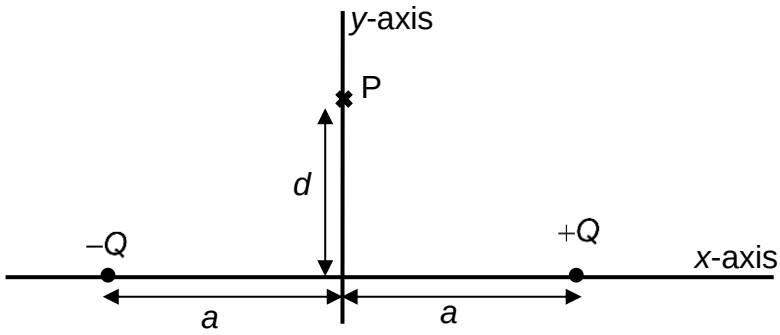
Which statement is correct for the collision described?

A The spheres stick together on impact.
B The total kinetic energy after impact is mv^2.
C The total kinetic energy before impact is zero.
D The total momentum before impact is $2mv$.

1.7 A particle with a mass m, and speed v is moving through a vacuum. The kinetic energy of the particle is increased by a factor of 4. What will be the new speed of the particle?

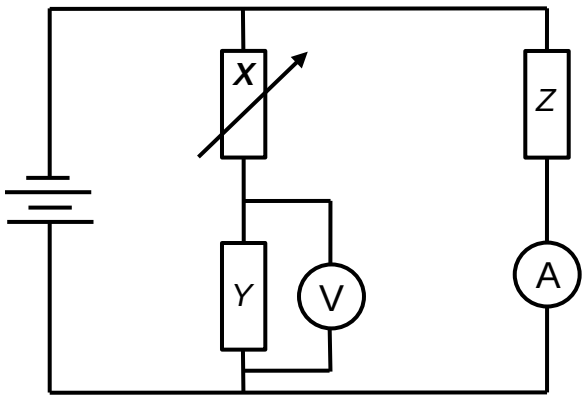
A $2v$
B $4v$
C $8v$
D $16v$

1.8 Two charges, $-Q$ and $+Q$ are fixed in place on the *x*-axis, each a distance *a* from the origin as shown in the diagram. What is the direction of the resultant electric field at the point labelled P, a distance *d* along the *y*-axis?



A Along the positive *y*-axis.
B Along the negative *y*-axis.
C Horizontally to the left in the diagram.
D Horizontally to the right in the diagram.

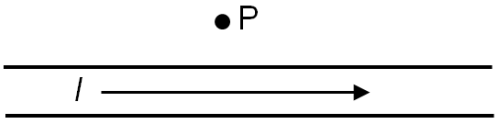
1.9 An electrical circuit with three different resistors is connected as shown across a battery of negligible internal resistance.



How do the readings on the ammeter and voltmeter change as the resistance of the variable resistor ***X*** is increased?

	Ammeter	**Voltmeter**
A	Decreases	Increases
B	Increases	Decreases
C	No change	Decreases
D	No change	Increases

1.10 A wire has a conventional current *I* directed to the right as shown in the diagram.



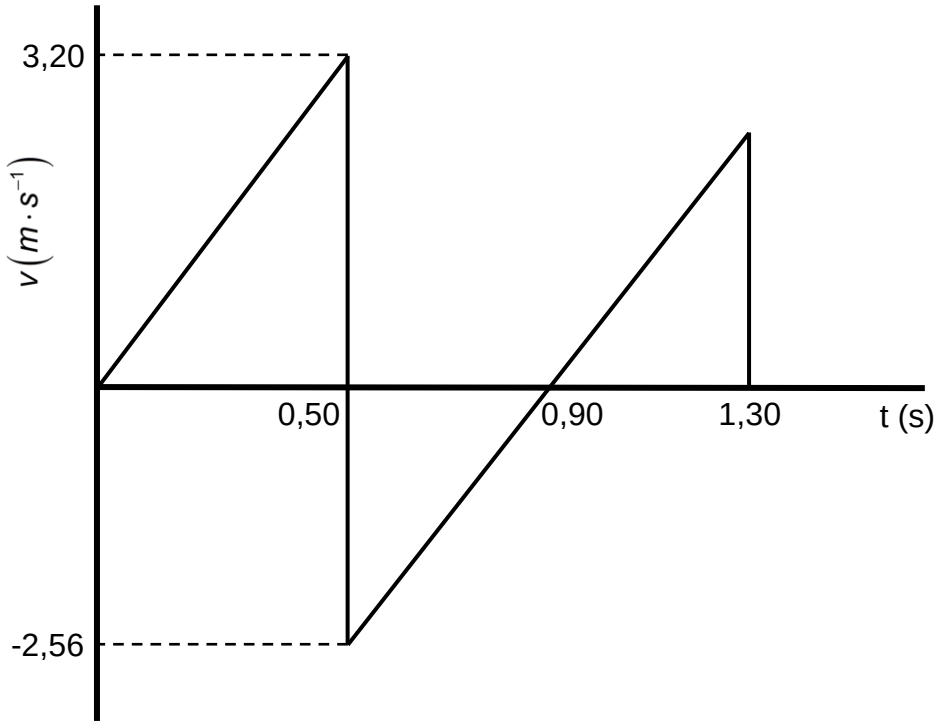
At point P, what is the direction of the associated magnetic field?

A Into the plane of the paper.
B Out of the plane of the paper.
C Towards the top of the page.
D Towards the bottom of the page.

[20]

QUESTION 2 KINEMATICS AND GRAVITATIONAL FIELDS

A ball on a distant planet is dropped from a certain height. The velocity-time graph represents the motion of the ball as it bounces vertically on a solid floor. The time of the bounce is negligible. The planet has no atmosphere so there is zero air resistance.



2.1 Define *acceleration*. (2)

2.2 Calculate the magnitude of the acceleration of the ball on this planet. (3)

2.3 Calculate the height from which the ball was dropped. (3)

2.4 Draw a labelled free-body diagram showing the forces acting on the ball at 0,7 s. Ignore air resistance. (2)

2.5 Is the collision with the floor elastic or inelastic? Briefly explain your answer. (2)

2.6 State the magnitude of the velocity with which the ball hits the ground at 1,30 s. (2)

2.7 On the set of axes **on the answer sheet**, sketch the corresponding position-time graph for the motion of the ball from 0 s to 1,3 s. Use the ground as position zero. (3)

The Earth has a mass *M* and a radius *R*. The distant planet has the same mass as Earth, but has a different radius.

2.8 Use the answer from Question 2.2 to calculate the radius of the planet in terms of *R*. (4)

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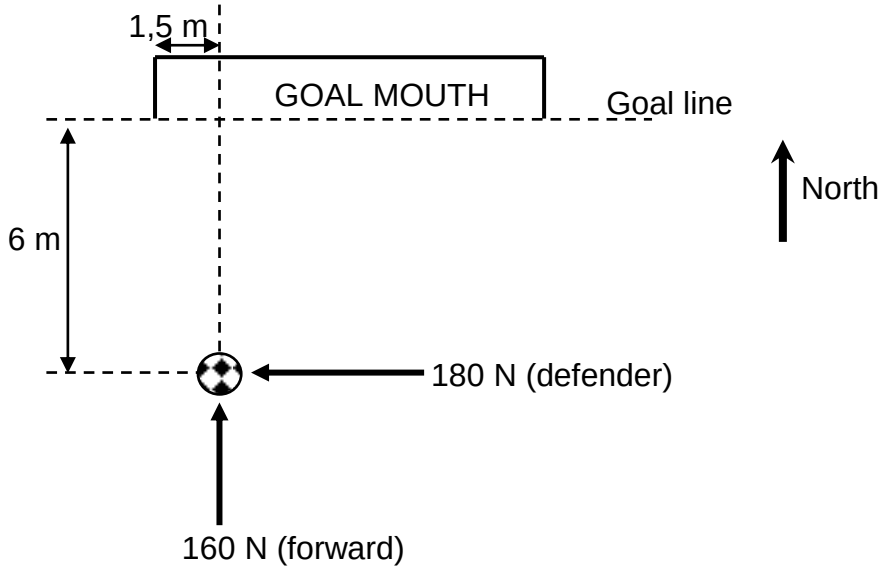
QUESTION 3 KINEMATICS

3.1 Two players kick a stationary soccer ball at the same time. The defender kicks with a force of 180 N due West while a forward kicks the ball with a force of 160 N due North as shown in the diagram. Assume that the time of contact between the ball and the players are the same.



3.1.1 Calculate the resultant force acting on the soccer ball while being kicked. (Ignore the weight of the ball.) (4)

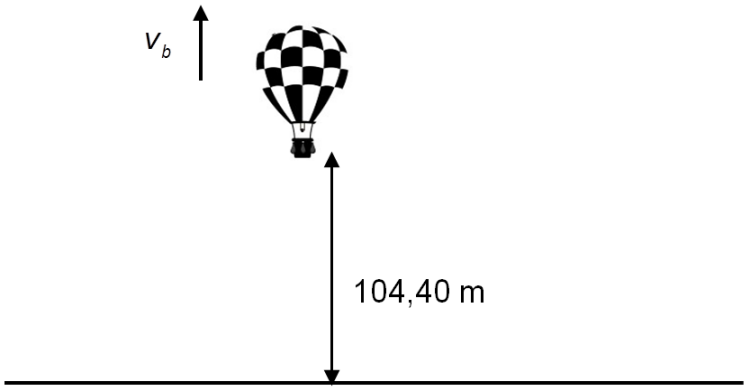
The ball is at the position shown in the diagram. The ball leaves the players at a speed of $18\ m \cdot s^{-1}$. The ball experiences frictional forces from the grass and the air and accelerates at $2{,}5\ m \cdot s^{-2}$.

3.1.2 Calculate the distance travelled by the ball before it stops. (3)

In order to score a goal, the ball must go into the goal mouth and cross the goal line.

3.1.3 Will a goal be scored? Use a calculation to motivate your answer. (5)

3.2 A hot air balloon is rising vertically upwards at a constant velocity. A cellphone is accidentally dropped from the balloon when the balloon is at a height of 104,40 m as shown in the diagram. The cellphone strikes the ground 6 s after it is dropped. Ignore air resistance.



[Image of hot air balloon from: <http://images.clipartpanda.com/vintage-hot-air-balloon-drawing-11785812-hot-air-balloon-in-black-and-white-colour.jpg>]

3.2.1 Calculate the speed v_b with which the balloon is rising when the cellphone is dropped. (4)

3.2.2 State the velocity of the cellphone at the instant it is dropped. (2)

3.2.3 Calculate the maximum height that the cellphone reaches above the ground. (5)

3.2.4 Calculate the height of the balloon when the cellphone strikes the ground. (4)

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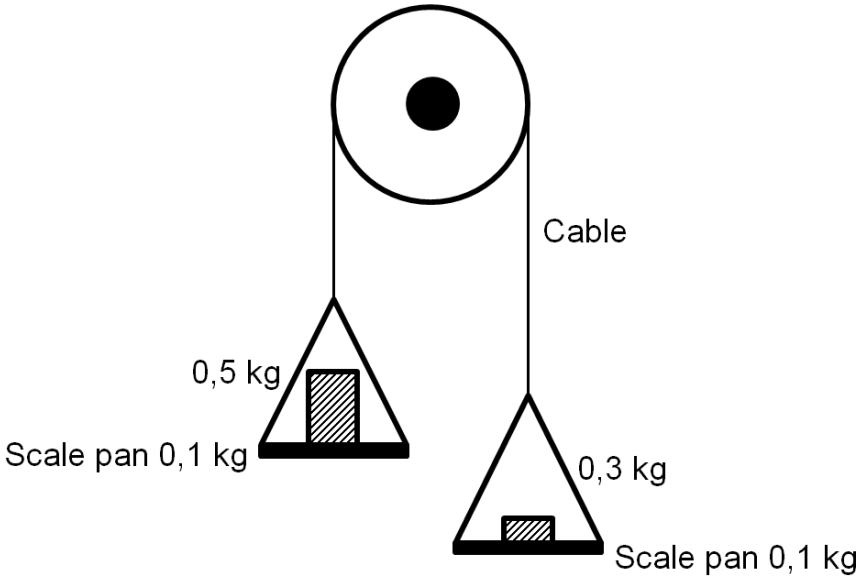
QUESTION 4 NEWTON'S LAWS

Two scale pans each of mass 0,1 kg are attached to a light inextensible cable which passes over a smooth pulley. A mass of 0,5 kg is placed on one pan and a mass of 0,3 kg is placed on the other pan as shown in the diagram. The system is released from rest.



4.1 State *Newton's second law of motion*. (2)

4.2 Consider each side separately and use Newton's second law to write an equation for each side. (3)

4.3 Hence, calculate the magnitude of the acceleration of the system and the magnitude of the tension in the cable. (2)

4.4 Draw a free-body diagram for the 0,5 kg mass piece while the system is accelerating. The relative sizes of the forces must be clear. (3)

4.5 Calculate the force that the scale pan exerts on the 0,5 kg mass. (3)

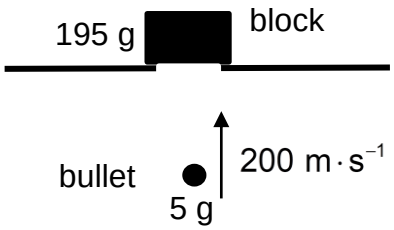
4.6 State *Newton's third law of motion*. (2)

4.7 Describe the force that is the Newton third law pair to the force that the scale pan exerts on the 0,5 kg mass. (2)

[17]

QUESTION 5 MOMENTUM, WORK, ENERGY AND POWER

5.1 A lead bullet of mass 5 g is shot vertically upwards into a wooden block of mass 195 g which is at rest over a hole in a table. Ignore air resistance.



The bullet hits the block with a velocity of 200 $m \cdot s^{-1}$. The bullet embeds itself in the block.

5.1.1 State *the law of conservation of momentum*. (2)

5.1.2 Calculate the speed of the block and bullet immediately after the bullet has embedded in the block. (4)

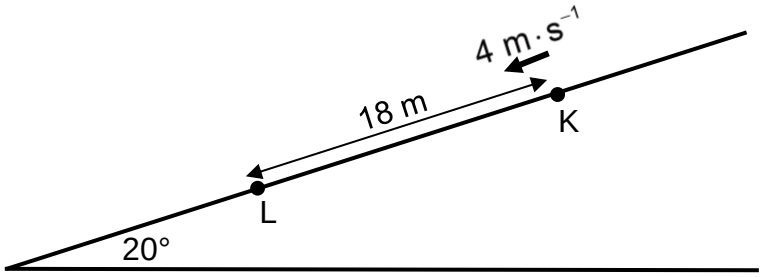
5.1.3 Calculate how high the block will rise above the block's original position. (4)

5.2 A crate of mass 70 kg slides down a rough incline which is at an angle of 20° to the horizontal. The crate experiences a constant frictional force of 190 N.

5.2.1 Draw a labelled free-body diagram of all the forces acting on the crate. (3)

5.2.2 Which force in your free-body diagram does no work on the crate? (2)

The crate passes point K on the incline at a speed of 4 $m \cdot s^{-1}$ before passing point L 18 m lower down the incline.



5.2.3 Calculate the kinetic energy of the crate as it passes point K. (3)

5.2.4 Calculate the magnitude of the resultant force acting on the crate between point K and point L. (3)

5.2.5 State *the work-energy theorem*. (2)

5.2.6 Use the work-energy theorem to calculate the speed of the crate as it passes point L. (5)

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QUESTION 6 FIELDS

Two identical isolated metal spheres, R and T, carry charges of + 6 nC and + 10 nC as shown in the diagram.

6.1 Sketch the electric field lines around the two charged spheres. (3)

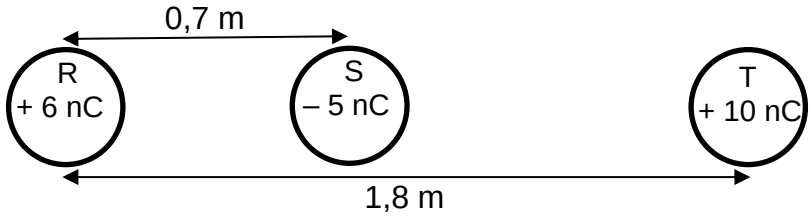
The two spheres are brought together and allowed to touch each other. The spheres are then separated to a distance of 1,8 m apart.

6.2 Calculate the new charge on each sphere. (2)

6.3 Calculate the number of electrons transferred while the spheres were touching. (2)

6.4 Did the electrons move from sphere R to T or from sphere T to R while the spheres were touching? (2)

A third sphere S with a charge of – 5 nC is placed between the original spheres R and T at a distance of 0,7 m from sphere R.



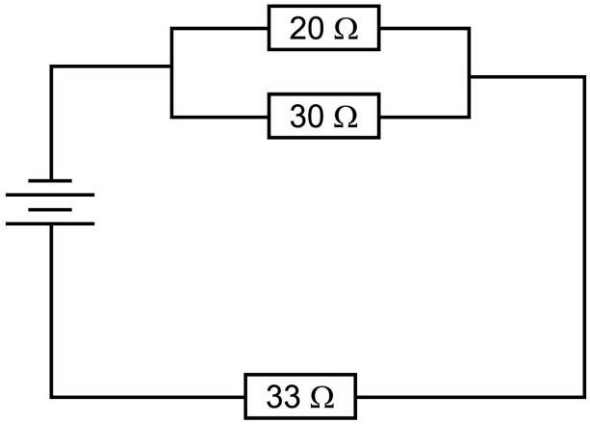
6.5 State *Coulomb's Law*. (2)

6.6 Calculate the magnitude of the net force acting on sphere S due to spheres R and T. (6)

[17]

QUESTION 7 ELECTRIC CIRCUITS

7.1 A battery with an **emf of 28 V** and an **internal resistance of 7 Ω** is connected in a circuit as shown.



7.1.1 Define *emf*. (2)

7.1.2 Calculate the total resistance of the external circuit. (5)

7.1.3 Calculate the total current drawn from the battery. (3)

7.1.4 Determine the potential difference across the terminals of the battery. (3)

7.1.5 On the circuit diagram **on the answer sheet**, draw a voltmeter symbol and an ammeter symbol that would enable the potential difference across the 20 Ω and the current through the 20 Ω to be measured. (4)

7.2 Students realise that the potential difference across the terminals of a battery and the current drawn from the battery change as the resistance in a circuit changes.

The students decided to experiment and changed the external resistance of a circuit and recorded the following set of data.

Current (A)	Terminal potential difference (V)
0,15	11,75
0,35	11,10
0,55	10,52
0,75	10,23
0,95	9,64
1,15	9,15

7.2.1 Define *potential difference*. (2)

7.2.2 Plot a graph of the terminal potential difference (on the *y*-axis) vs current (on the *x*-axis) on the graph paper provided **on the answer sheet**. (6)

7.2.3 Calculate the gradient of the graph. Indicate the values you used for this calculation on your graph. (4)

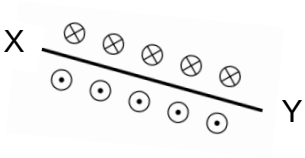
7.2.4 Use your answer for Question 7.2.3 to determine the internal resistance of the battery. (2)

7.2.5 What quantity does the *y*-intercept represent? (2)

[33]

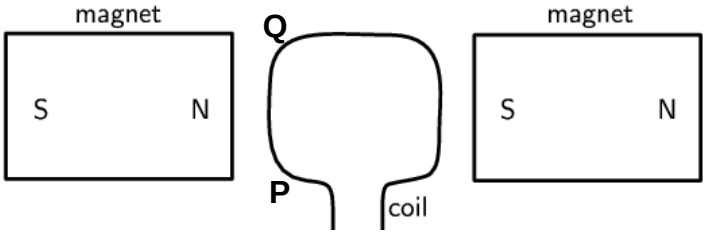
QUESTION 8 ELECTRODYNAMICS

8.1 The magnetic field lines created by a current in a conductor are shown in the diagram.



Is the conventional current direction from X to Y or Y to X? (2)

The coil and magnets illustrated in the diagram below could be part of a motor or a generator.



[Image from: <https://www.everythingmaths.co.za/science/grade-12/11-electrodynamics/11-electrodynamics-02.cnxmlplus>]

8.2 Compare the motor and generator in terms of energy conversion. (2)

8.3 Consider the coil in the above diagram to be part of a motor. The current direction is from **P** to **Q** in the coil.

8.3.1 In which direction would side PQ experience a force? (2)

8.3.2 How would you change two factors in order to increase the magnitude of the force exerted on side PQ? (2)

8.3.3 A current carrying conductor placed in a magnetic field will not always experience a force. Describe a situation in which a current carrying conductor in a magnetic field will not experience a force. (2)

8.4 Consider the coil to be part of a generator.

8.4.1 Define *magnetic flux linkage*. (2)

8.4.2 Use Faraday's Law to explain why a current is induced in the coil as it rotated in the magnetic field. (4)

8.4.3 State *Lenz's Law*. (2)

8.4.4 As side PQ is rotated out of the page, will the current be induced from **P** to **Q** or from **Q** to **P**? (2)

[20]

QUESTION 9 PHOTONS & ELECTRONS

9.1 Ultraviolet light of frequency $9{,}1\times10^{14}$ Hz is shone onto a metal surface. The work function of the metal is $3{,}5\times10^{-19}$ J. Electrons are ejected from the metal.

9.1.1 Calculate the energy of a photon of ultraviolet light. (3)

9.1.2 Define *work function*. (2)

9.1.3 Calculate the maximum velocity of the ejected electrons. (4)

9.2 Light of wavelength 524 nm is emitted from a certain element when an electron transition occurs between the fifth and second energy level.

9.2.1 Describe a photon. (2)

9.2.2 Calculate the energy of the photon of light that is emitted. (3)

The second energy level has an energy of $-2{,}81$ eV.

9.2.3 Calculate the energy of an electron in the fifth orbital. (3)

[17]

Total: 200 marks