NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION – MARCH 2019

PHYSICAL SCIENCES: PAPER I

Time: 3 hours | 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 16 pages, an Answer Sheet of 2 pages (i-ii) and a Data Sheet of 2 pages (i–ii). Please check 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. Answers must be expressed in decimal format, not left as proper fractions.
9. Where appropriate express answers to TWO decimal places.
10. It is in your own interest to write legibly and to present your work neatly.

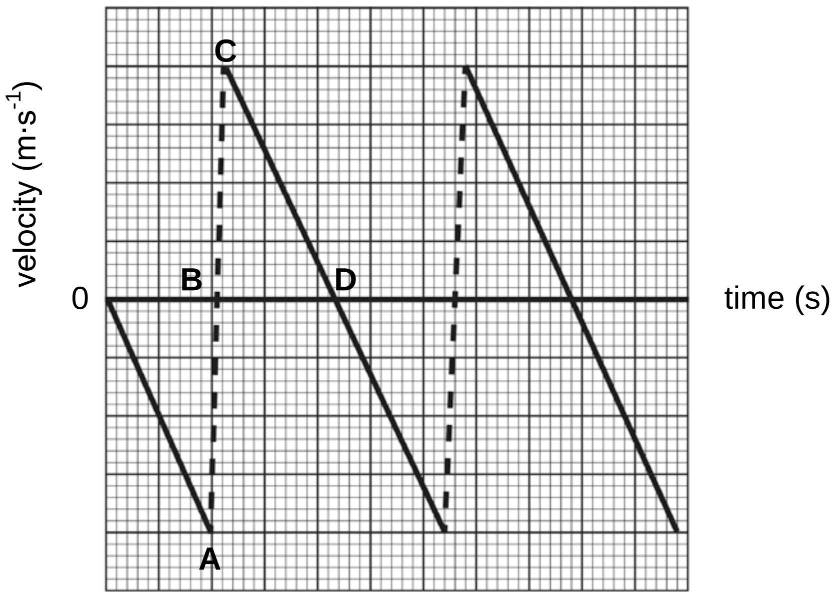
QUESTION 1 MULTIPLE CHOICE

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 Which of the following pairs of physical quantities contains ONLY scalar quantities?

A velocity, energy
B acceleration, distance
C work, speed
D displacement, velocity

1.2 A ball is dropped from a certain height above the ground and bounces a few times as it hits the ground. The velocity-time graph below describes the motion of the ball from the time it is dropped. Ignore the effects of air friction.



In relation to the velocity-time graph for the bouncing ball shown above, which statement below is correct?

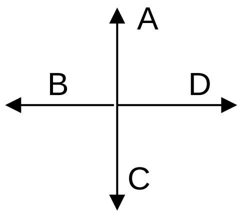
A Down is taken as the positive direction and the ball is at the highest position of its first bounce at C.
B Down is taken as the negative direction and the ball is at the highest position of its first bounce at D.
C Down is taken as the negative direction and the ball is at the highest position of its first bounce at C.
D Down is taken as the positive direction and the ball is at the highest position of its first bounce at D.

1.3 When two objects collide in an elastic collision,

A both momentum and kinetic energy are conserved.
B both impulse and momentum are conserved.
C only momentum is conserved.
D only kinetic energy is conserved.

1.4 In a certain electric field, the direction of the electric field is to the right as shown by the arrow below.

Which arrow below shows the direction in which an electron would move if placed in this field?



1.5 Electric charges with magnitudes q, 2q, 3q and 4q are placed in different electric fields. The force on each charge is measured and the results are recorded in the table shown below. Which charge experiences the greatest electric field strength?

	Magnitude of charge experiencing force	Force (N)
A	4q	55
B	3q	30
C	2q	25
D	q	20

1.6 A cricket ball of mass 160 g is travelling at 25 $m \cdot s^{-1}$ to the right. The ball is hit horizontally by the batsman and leaves the bat at 35 $m \cdot s^{-1}$ to the left.

The change in momentum of the ball is

A 1,6 $kg \cdot m \cdot s^{-1}$ left
B 9,6 $kg \cdot m \cdot s^{-1}$ left
C 1600 $kg \cdot m \cdot s^{-1}$ right
D 1,6 $kg \cdot m \cdot s^{-1}$ right

1.7 The role of a step-up transformer in an electrical power station is to …

A reduce heat in the transmission lines by increasing the voltage.
B reduce heat in the transmission lines by increasing the current.
C increase heat in the transmission lines by increasing the voltage.
D increase heat in the transmission lines by increasing the current.

1.8 A kettle with a power of 2 000 W is used for a total of 20 minutes per day. Assuming that the cost of electricity is R1,80 per kWh, the cost in rands, per day, of using the kettle is best expressed as:

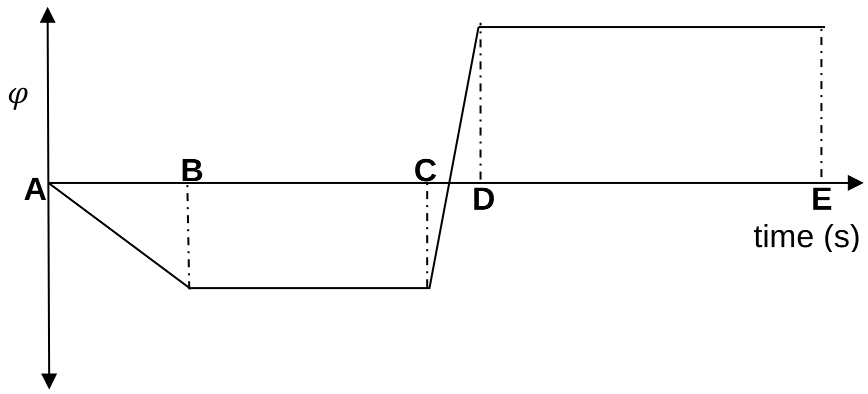
A $\frac{2 \times 20 \times 1{,}8}{1000}$

B $\frac{2 \times 20 \times 180}{1000}$

C $\frac{2000 \times 20 \times 1{,}8}{1000 \times 60}$

D $\frac{2000 \times 20 \times 1{,}8}{60}$

1.9 The magnetic flux (φ) through a loop of wire changes as shown in the sketch graph below. During which time interval will the induced emf be **positive and non-zero**?



A A–B
B B–C
C C–D
D D–E

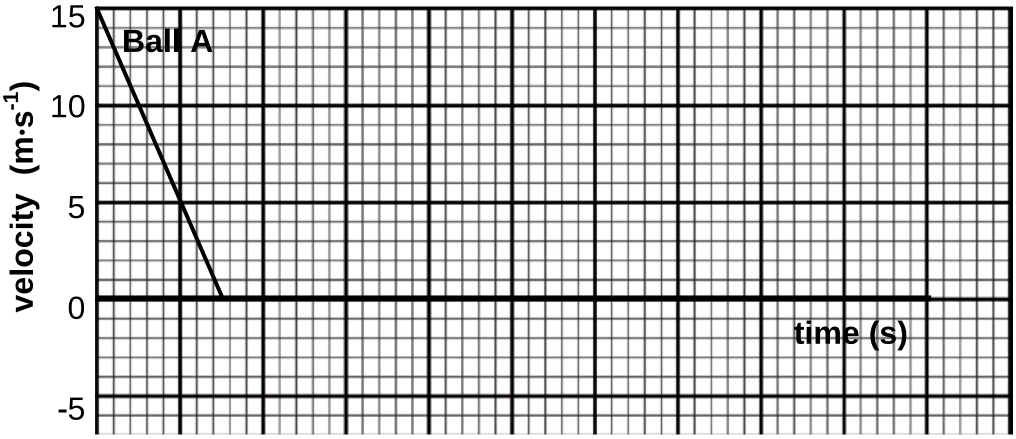
1.10 The name of the law used to determine the direction of the induced current in a conducting coil which experiences a changing magnetic flux is:

A Faraday's law
B Flemming's left hand motor rule
C Flemming's right hand dynamo rule
D Lenz's law

[20]

QUESTION 2 KINEMATICS

2.1 A boy standing on a very high bridge, projects **ball A** vertically upwards at a velocity of 15 m·s^{-1}. The velocity-time graph for the motion of **ball A** is shown below. (Ignore air resistance for **ball A**).



2.1.1 Define *acceleration.* (2)

2.1.2 Determine the magnitude and direction of the acceleration of ball A. (2)

2.1.3 Show that the time taken for ball A to reach a maximum height above the bridge is 1,53s. (2)

2.1.4 Calculate the maximum height reached by the ball above the bridge. (3)

Ball A continues in its motion and hits the ground 5s **after it was originally projected**.

2.1.5 The speed of ball A when it hits the ground is 34 m·s^{-1}. Calculate the height of the bridge. (4)

2.1.6 Complete the velocity-time graph for ball A on your ANSWER SHEET, ensuring that you fill in the correct scale on the time axis. (3)

Ball B is dropped from the bridge at exactly the same time as **ball A** is projected upwards. **Ball B** is attached to a small parachute containing a measuring device which records the velocity of ball B every second. The results are recorded in the table below:

Time (s)	Magnitude of velocity of ball B ($m{\cdot}s^{-1}$)
0	0
1	3,1
2	5,9
3	9,2
4	11,9
5	15

2.1.7 On the same set of axes as the graph drawn in Question 2.1.6 on the ANSWER SHEET, draw the velocity-time graph for ball **B**. (3)

2.1.8 From the graph drawn in Question 2.1.7, determine the time at which the balls have the same velocity. (1)

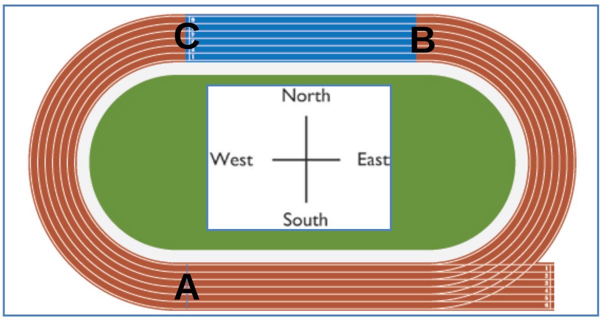
2.1.9 Comment on the relative positions of ball **A** and ball **B** at the time mentioned in Question 2.1.8 above. Just answer:
Ball A is above ball B
OR
Ball B is above ball A
OR
Ball A and ball B are at the same height above the ground. (1)

2.1.10 Justify your choice in Question 2.1.9, WITHOUT PERFORMING A CALCULATION. (2)

2.1.11 Calculate the time at which the balls have the same displacement above the ground. (5)

2.1.12 Draw position-time sketch graphs for the entire motion of balls A and B on the graph paper provided on the ANSWER SHEET.
No scale is required on the y-axis, but show the times on the x-axis. (5)

2.2 An athlete runs in an anticlockwise direction around an 800 m long track shown below. The athlete starts from point A, running east.



[Source: <https://cdn.tutsplus.com/vector>]

2.2.1 Define *speed*. (2)

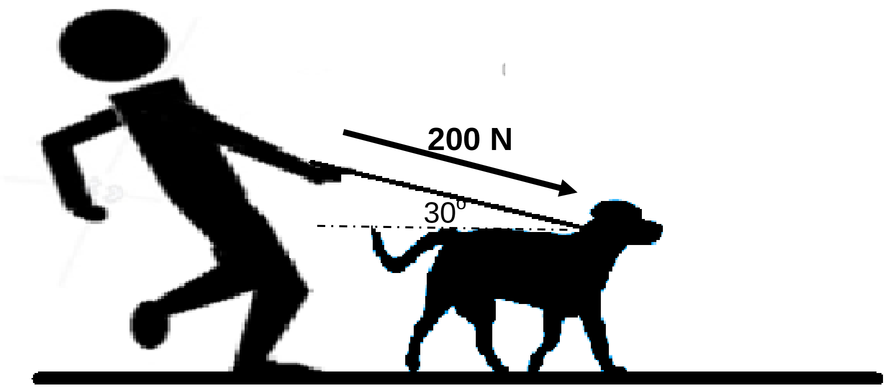
2.2.2 It takes the athlete 1 minute and 45 seconds to run half way around the track to point B. Calculate the average speed of the athlete. (3)

2.2.3 Suppose the athlete continues running at a constant speed, what is the athlete's **instantaneous velocity** at point C? (2)

[40]

QUESTION 3 NEWTON'S LAWS

3.1 A child of mass 40 kg is holding a dog stationary when the dog pulls forward on an inextensible leash. The dog exerts a force of 200 N, so that the leash makes an angle of 30° to the horizontal as shown below.



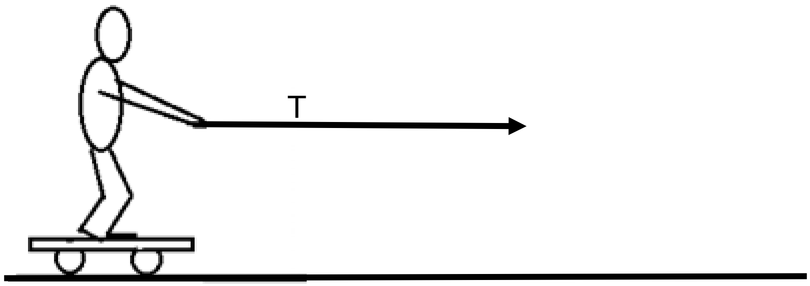
3.1.1 Calculate the horizontal and vertical components of the 200 N force applied by the dog. (4)

3.1.2 Calculate the magnitude of the normal force experienced by the child. (3)

3.1.3 Given that the coefficient of static friction between the child's foot and the ground is 0,4, calculate the maximum force of static friction experienced between the child's foot and the ground. (3)

3.1.4 Decide whether the child's foot will slip or not when the dog exerts the 200 N force at this angle and justify your answer. (2)

3.2 A child on a skateboard is pulled by a rope and experiences a horizontal force T to the right as shown in the sketch below. The mass of the child and the skateboard together is 55 kg. A total force of 80 N, due to friction, opposes the motion. The child and skateboard accelerate at 2 $m \cdot s^{-2}$ to the right.



3.2.1 Calculate the magnitude of the force T. (4)

3.2.2 The force T is increased and the acceleration is measured, for each value of T. All other forces remain constant. Draw a sketch graph for the system showing the relationship between acceleration and T. No values need to be given on the axes. (3)

3.2.3 Sometime later, the force T is removed and the child and skateboard continues to move to the right for a short distance. The skateboard then hits a stone in the path and stops. State and explain what happens to the child. (3)

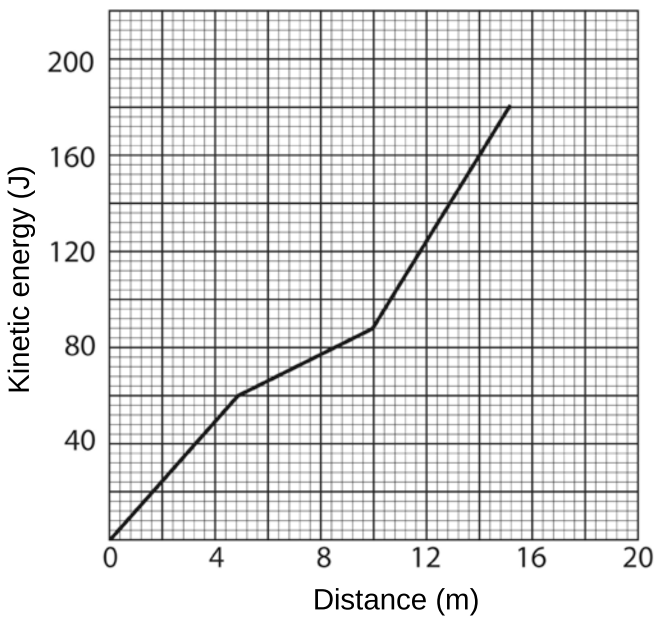
3.2.4 Name the Law of Physics which you applied in Question 3.2.3. (1)

[23]

QUESTION 4 MOMENTUM, WORK, ENERGY AND POWER

4.1 A box of mass **m** is pushed, from rest, with a constant applied force of 20 N over a horizontal surface which has three different regions, A, B and C. Each region is 5 m long and exerts a different frictional force on the box as it moves through. The regions are A, B and C as illustrated in the diagram below.

The graph below shows the kinetic energy of the object as a function of the distance from the starting position as the object experiences the constant applied force of 20 N.



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

4.1.2 Use the work-energy theorem to show that the gradient (slope) of the graph represents the net force experienced by the object. (3)

4.1.3 Calculate the net force experienced by the object in region C. (4)

4.1.4 Hence determine the magnitude of the friction force experienced by the block as it moves over region C. (3)

4.1.5 Which region, A, B or C offers the largest friction force? (1)

4.1.6 Justify your answer in Question 4.1.5. (2)

4.1.7 Assuming that the box starts from rest, and accelerates at 1 $m \cdot s^{-2}$ while moving over region A, calculate the mass of the box. (4)

4.2 A car engine dissipates a power of 60 000 W while the car is travelling at a constant velocity of 60 $km \cdot h^{-1}$.

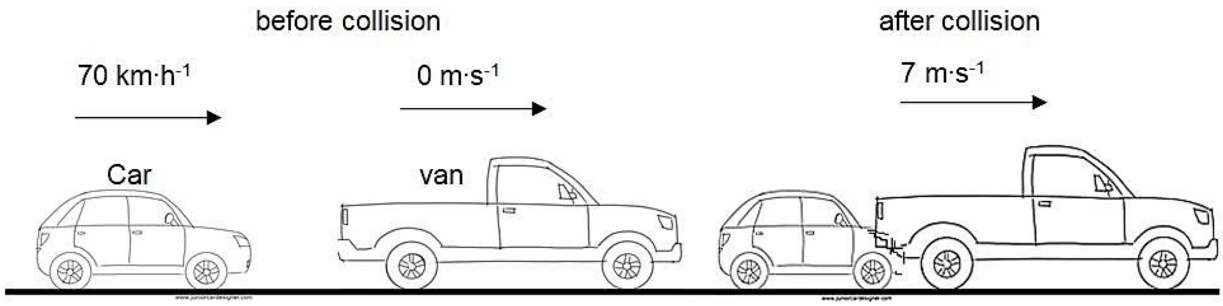
4.2.1 Define *power.* (2)

4.2.2 Convert 60 $km \cdot h^{-1}$ to $m \cdot s^{-1}$. (2)

4.2.3 Explain what it means for the car to dissipate power at 60 000 W. (2)

4.2.4 Calculate the force applied by the engine under these conditions. (3)

4.3 The car of mass 1 500 kg travelling to the right at 70 $km \cdot h^{-1}$ runs into the back of a stationary van of unknown mass. The two vehicles lock together and move to the right at 7 $m \cdot s^{-1}$.



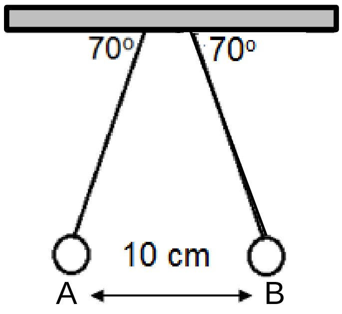
[Source: <www.juniorcardesigner.com>]

Calculate the mass of the van. (4)

[32]

QUESTION 5 FIELDS

5.1 Two small identical polystyrene balls, A and B, each of mass 2 g are hung by insulating threads from a support. Each ball is given an identical negative charge. The balls repel each other so that they reach equilibrium 10 cm apart with the threads at angles of 70° to the horizontal as shown in the diagram below.



5.1.1 Draw the electric field pattern around the two negative charges. (2)

5.1.2 Define *weight.* (2)

5.1.3 Calculate the weight of one of the polystyrene balls. (2)

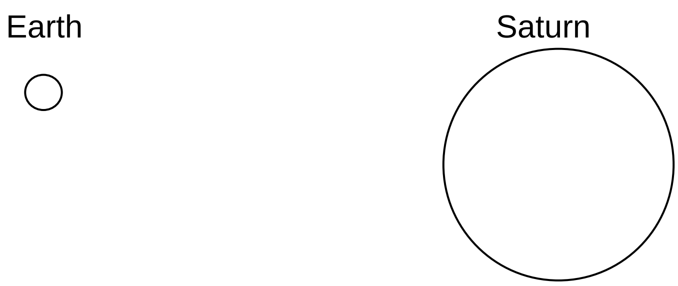
5.1.4 Define a *vector quantity*. (2)

5.1.5 Draw a labelled free body diagram for polystyrene ball A. (3)

5.1.6 State *Coulomb's law*. (2)

5.1.7 Calculate the magnitude of the negative charge on each polystyrene ball. (6)

5.2 Saturn is a massive planet with a radius 9 times larger than that of the earth and a mass 94 times larger than that of the earth.

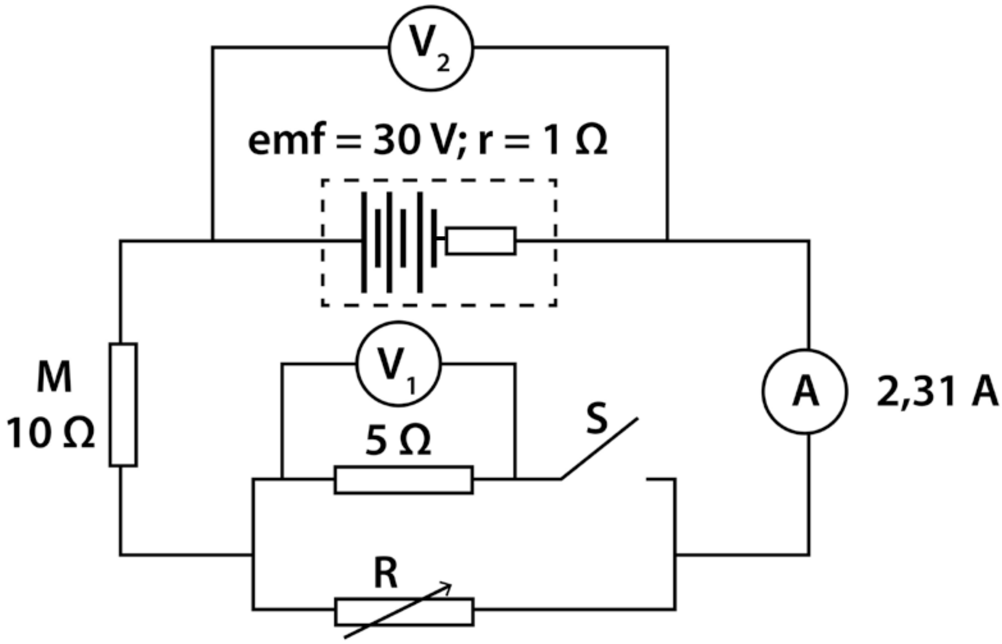


The acceleration due to gravity, g, on Earth has a value of 9,8 $m \cdot s^{-2}$. Calculate the value of g on Saturn. (4)

[23]

QUESTION 6 ELECTRIC CIRCUITS

A circuit consists of a battery with an emf of 30 V and an internal resistance of 1 Ω. A motor M, a variable resistor (rheostat) which can be set at different values R, a 5 Ω resistor and a switch S are connected as shown in the diagram below.



The reading on the ammeter is 2,31 A with the **switch open**:

6.1 Define *current.* (2)

6.2 Calculate the power dissipated in the motor M. (3)

6.3 Calculate the resistance at which the rheostat is set, R. (4)

6.4 What is the reading on the voltmeter V_1? (1)

6.5 What is the reading on the voltmeter V_2? (2)

6.6 Define *resistance*. (2)

6.7 Suppose the rheostat is now adjusted so that it has a higher resistance.

6.7.1 Will the power dissipated in the motor increase, decrease or remain the same? (1)

6.7.2 Justify your answer in Question 6.7.1 making reference to two relevant formulae. (3)

6.8 The rheostat is adjusted so that its resistance is 10 Ω **and the switch is now closed**.

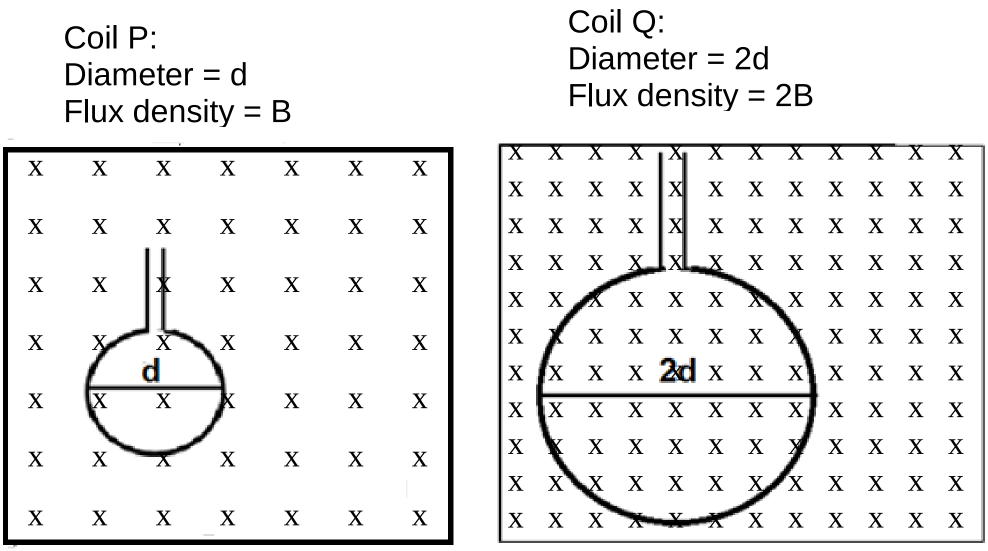
6.8.1 Calculate the reading on the ammeter. (5)

6.8.2 Calculate the reading on the voltmeter V_1. (3)

[26]

QUESTION 7 ELECTRODYNAMICS

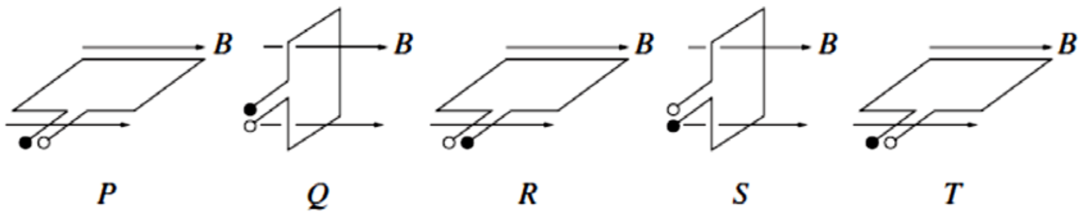
7.1 Two coils P and Q have diameters d and 2d respectively. The magnetic field in the region of P has magnitude of 1 unit and in the region of Q the magnetic field has a magnitude of 2 units. Both magnetic fields are directed into the page.



7.1.1 Define *magnetic flux linkage* φ. (2)

7.1.2 Express the ratio $\frac{\varphi_P}{\varphi_Q}$ as a decimal. Show your working. (4)

7.2 The coil of an AC generator rotates at a constant rate in a magnetic field as shown below.

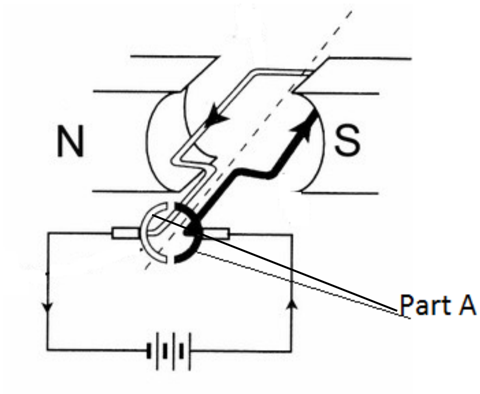


[Adapted from Physics HSC exam 2002]

7.2.1 Explain briefly why an emf is induced in the coil. (2)

7.2.2 Draw a sketch graph showing emf against position for the coil, marking P, Q, R, S and T on the x-axis. (3)

7.3 The sketch below shows a simple dc motor.



7.3.1 Describe the energy conversion that takes place in the dc motor. (2)

7.3.2 Name the law used to predict the direction of rotation of the coil. (1)

7.3.3 Predict whether the coil will rotate clockwise or anti-clockwise. (2)

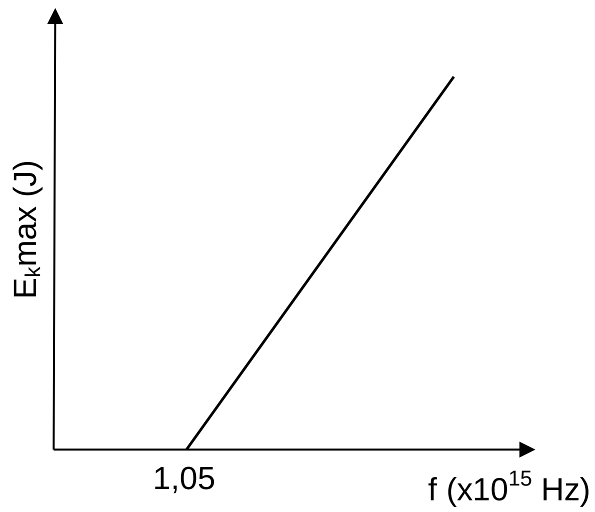
7.3.4 Name and state the function of part A, and describe briefly how it achieves this function. (4)

[20]

QUESTION 8 PHOTONS AND ELECTRONS

A Physics student measures the maximum kinetic energy of photoelectrons emitted from the surface of metal X, using different frequencies of the incident radiation. The student uses his data to plot the graph shown below.

Graph showing the relationship between the maximum kinetic energy of photoelectrons and the frequency of incident radiation for metal X.



The following table shows the work function of a variety of metals:

Metal	Work Function (J)
Sodium	$3,82 \times 10^{-19}$
Zinc	$6,97 \times 10^{-19}$
Copper	$7,52 \times 10^{-19}$
Platinum	$1,02 \times 10^{-18}$
Calcium	$4,78 \times 10^{-19}$

8.1 Define *work function*. (2)

8.2 State the independent variable in this experiment. (2)

8.3 Show that the gradient of the graph has units N·m·s. (2)

8.4 Use information from the graph and the table above to determine the identity of metal X. (4)

8.5 The wavelength of blue light is given as 475 nm. When this blue light is shone onto a certain metal surface, the maximum velocity of emitted electrons is $2,77 \times 10^5$ m·s^{-1}. Determine which metal from the table above is being used. (6)

[16]

Total: 200 marks