NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2015

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages, a Data Sheet of 2 pages (i – ii) and an Answer Booklet of 3 pages (i – iii). Please make sure that your question paper is complete.

2. Answer ALL the questions.

3. Read the questions carefully.

4. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the Answer Sheet provided on the inside cover of your Answer Book. The letter that corresponds with your choice for the correct answer must be marked with a cross as shown in the example below:

   A **B** [✓ **C**] **D** Here the answer C has been marked as correct.

5. Use the data and formulae whenever necessary.

6. Start each question on a new page.

7. Show your working in all calculations.

8. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.

9. Where appropriate express answers to TWO decimal places.

10. It is in your own interest to write legibly and present your work neatly.

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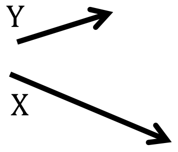
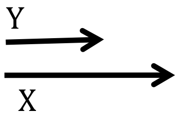
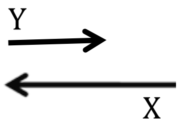
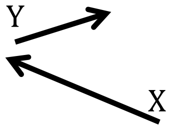
QUESTION 1 MULTIPLE CHOICE

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 which you consider to be correct.

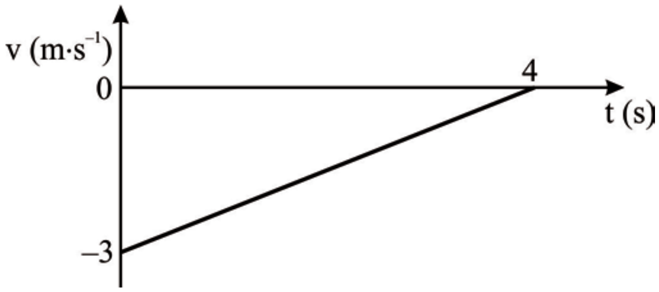
1.1 Two vectors X and Y are shown in the following diagrams.
For which diagram will the magnitude of the resultant of X + Y be a **minimum**?

			
A	B	C	D

1.2 You have two identical marbles. You drop the first marble and throw the second marble down from the same height. Air resistance is negligible. While the marbles are in the air, which statement is NOT correct?

A The second marble will spend less time in the air
B The first marble will have a smaller velocity when it reaches the ground
C The second marble will experience a larger force
D Both marbles will have the same acceleration

1.3 A sketch of the velocity-time graph for a moving object is shown below.



Which answer best describes the magnitude of the object's velocity and the sign of the acceleration?

	v (m·s^{-1})	a (m·s^{-2})
A	decreasing	+
B	decreasing	–
C	increasing	+
D	increasing	–

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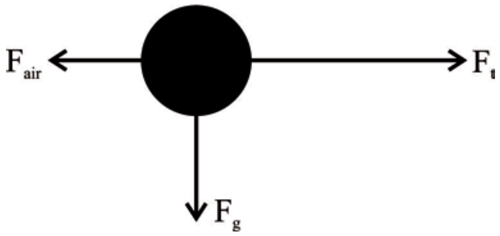
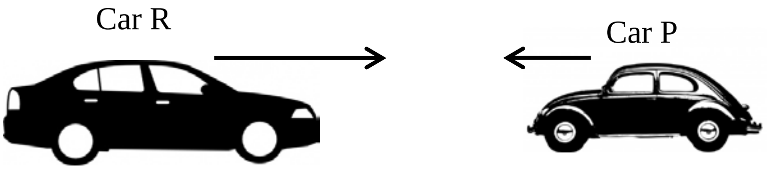
1.4 A student draws the force diagram below showing the forces acting on a ball **after** it has been thrown. The ball is in mid-flight and is travelling horizontally to the right.



Which force, if any, is incorrect?

A F_{air}, the force due to air resistance
B F_t, the force due to the throw
C F_g, the force due to gravity
D All of the forces are correct

1.5 Car R is travelling towards car P as shown in the diagram. Car R has a greater mass than car P and is moving faster. The two cars collide head on.



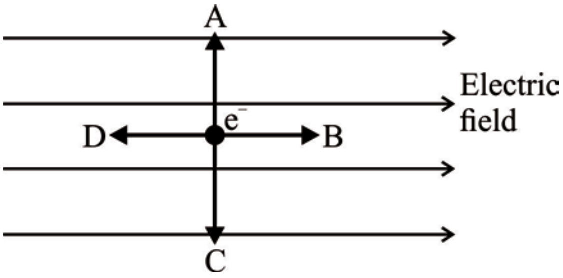
Which statement best describes the magnitudes of the forces experienced by the cars during the collision?

A Car R experiences the greater force
B Car P experiences the greater force
C The cars experience equal forces
D It depends on the ratio of the car's masses

1.6 Which quantities are conserved in the absence of external forces, in an inelastic collision?

	Kinetic energy	**Total energy**	**Linear momentum**
A	Conserved	Conserved	Not conserved
B	Conserved	Not conserved	Not conserved
C	Not conserved	Conserved	Conserved
D	Not conserved	Not conserved	Conserved

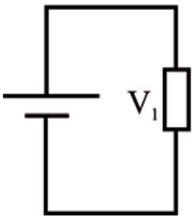
1.7 The diagram below shows an **electron** in an electric field. In which direction will the electron accelerate?

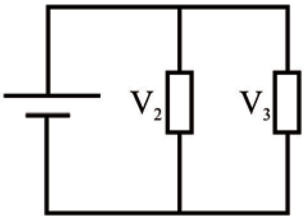


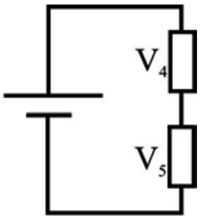
1.8 Power is a useful quantity to know in both electrical and mechanical systems. Which quantity is equivalent to 1 W?

A 1 J·s
B 1 V·A
C 1 J·m
D 1 V·C

1.9 Three circuits with identical resistors and cells are shown in the diagrams below. Arrange the potential differences, in order, across each of the five resistors in the three circuits. List the **largest potential difference first**. The cells have negligible internal resistance.







A $V_1 > V_2 = V_3 > V_4 = V_5$
B $V_2 > V_3 > V_1 > V_4 > V_5$
C $V_2 = V_3 > V_1 > V_4 = V_5$
D $V_1 = V_2 = V_3 > V_4 = V_5$

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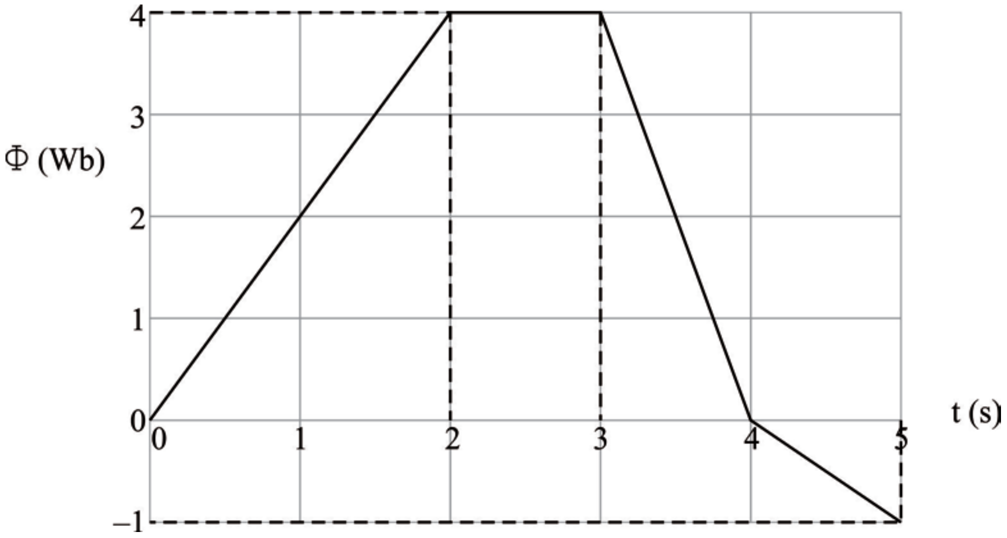
1.10 The magnetic flux passing through a coil of wire varies as shown in the graph of magnetic flux vs time. During which time interval will the emf induced in the coil be a maximum?



A 0 – 2 s
B 2 s – 3 s
C 3 s – 4 s
D 4 s – 5 s

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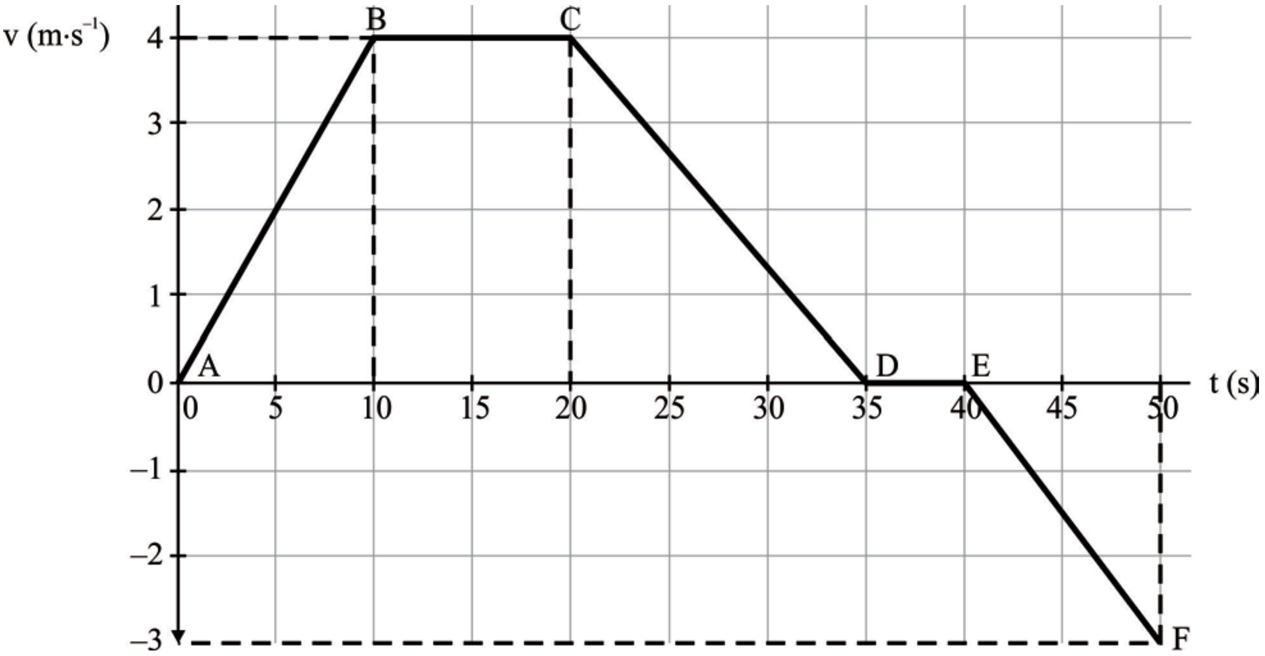
QUESTION 2 TRAVELLING CARS

2.1 A model car starts from rest and initially travels **east**. A velocity vs time graph of the motion is shown below.



2.1.1 Use the graph of motion to determine the acceleration of the car between 20 s and 35 s of the motion. (4)

2.1.2 During which time interval/s is the speed of the car increasing? (2)

2.1.3 Define *displacement*. (2)

2.1.4 Use the graph of motion to determine the displacement of the car after 50 s. (4)

2.1.5 Calculating the distance travelled by this car from the graph would give you a value greater than the calculated displacement. Is the distance travelled for any object always greater than its displacement? Explain your answer. (2)

2.1.6 Sketch a position vs time graph for the car from 0 s to 50 s on the axes provided **in the Answer Booklet**. Values are not required but you must use the labels A – F. (5)

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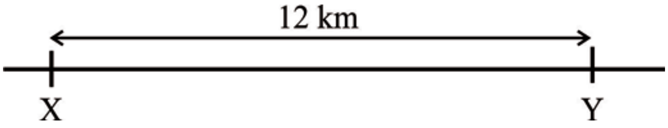
2.2 Motorists on the N3 highway in KwaZulu-Natal are often fined because their average speed exceeds the speed limit.

A camera at position X takes a photo of a Toyota and records the time. At position Y, a distance of 12 km further along the road, a second camera takes a photo and again records the time.



2.2.1 The Toyota takes 7,6 minutes to travel the 12 km between X and Y. Calculate the average speed of the car in $m \cdot s^{-1}$. (4)

The speed limit in the area is 100 km/h.

2.2.2 Convert 100 km/h to $m \cdot s^{-1}$. (2)

2.2.3 Should the driver of the Toyota car be fined for exceeding the speed limit? (1)

A BMW car travelling on the same road is stuck behind a slow truck for 6 km and only manages a speed of 60 km/h. The driver passes the truck and knowing that the average speed is 100 km/h, he travels at 140 km/h for the next 6 km.

2.2.4 Calculate the average speed of the BMW. For this question use km, hours and km/h. (5)

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QUESTION 3 WORLD RECORD STUNT

Dar Robinson, a stuntman, set a world record for a free-fall from a stationary helicopter without the use of a parachute. The 80 kg man fell a distance of 95 m before coming into contact with a large airbag. Ignore air resistance.

3.1 Define *velocity*. (2)

3.2 Calculate the magnitude of Robinson's velocity the moment he came into contact with the airbag. (3)

Robinson sank 5,8 m into the air cushion before coming to rest.

3.3 Define *acceleration*. (2)

3.4 Calculate Robinson's acceleration while coming to rest in the airbag. (4)

3.5 Draw a labelled free-body diagram of the forces acting on Robinson while slowing down while in contact with the airbag. The forces must be drawn to indicate their relative sizes. (3)

3.6 Calculate the magnitude of the average force that the airbag exerted on Robinson while bringing him to rest. (5)

3.7 Explain how using the airbag saved Robinson's life. Make use of a suitable equation in your explanation. (3)

[22]

QUESTION 4 ROCKET IN SPACE

A rocket of **total mass** (m) is in deep space travelling at a speed of 1 000 $m \cdot s^{-1}$.

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

The rocket fires its engine. The burnt fuel has an exhaust speed of 500 $m \cdot s^{-1}$ in the opposite direction to the rocket.

4.2 Explain why firing the engine changes the speed of the rocket. Use one of Newton's laws to help you in your explanation. (3)

4.3 State the law of conservation of linear momentum. (2)

4.4 Calculate the rocket's final speed if one third of its mass is lost due to the burnt fuel being ejected in a single short burn. (5)

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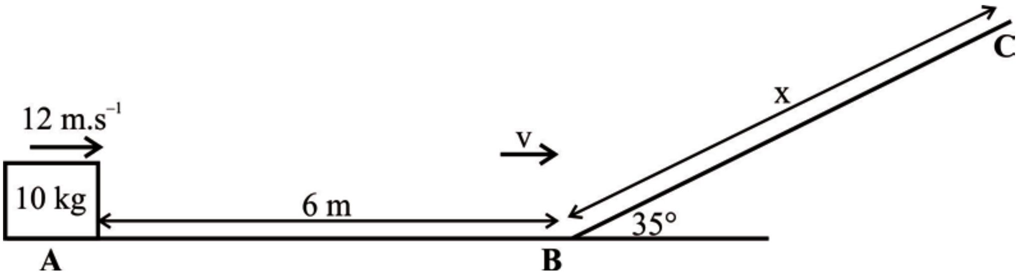
QUESTION 5 SLIDING BLOCK

A block of mass 10 kg is sliding along a uniform rough surface. The surface is horizontal from A to B and inclined at 35° to the horizontal from B to C.



The block is travelling at a speed of 12 $m \cdot s^{-1}$ as it passes A.

5.1 Define the term *kinetic energy*. (2)

5.2 Calculate the kinetic energy of the block as it passes A. (3)

The frictional force acting on the block as it slides from A to B is **54,9 N**.

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

5.4 Calculate the speed of the block (v) as it reaches B. (4)

The block slides up the incline from B and comes to rest at C. The frictional force acting on the block as it slides from B to C is **45,0 N**.

5.5 Write an expression for the potential energy of the block at C in terms of x (the distance along the slope from B to C). (2)

5.6 Calculate the distance, x, that the block slides up the slope before coming to rest at C. (5)

5.7 The frictional force experienced by the block on the inclined plane is less than the frictional force experienced on the horizontal surface even though the surfaces are made of the same material. Explain by making use of a relevant equation. (3)

At point C, the object **only just** manages to remain at rest.

5.8 Draw a labelled free-body diagram of the block at rest at C. (3)

5.9 Calculate the frictional force acting on the block at C. (3)

5.10 Hence calculate the coefficient of friction. (3)

5.11 Explain why the frictional force calculated in Question 5.9 is greater than the frictional force of 45,0 N acting while the block was sliding. (2)

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QUESTION 6 FIELDS

6.1 On 12 November 2014, NASA landed a spacecraft named Philae on the surface of a comet named 67P. The mass of the comet was 1×10^{13} kg and the comet had a radius of 4 km. The mass of Philae is 96 kg.

6.1.1 State Newton's Law of Universal Gravitation. (2)

6.1.2 Calculate the magnitude of the gravitational force that the comet exerts on Philae. (4)

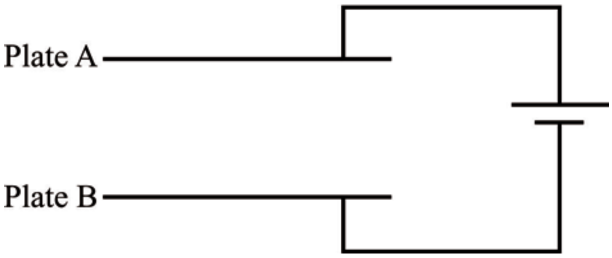
6.1.3 Hence, determine the acceleration due to gravity (a_{67P}) that Philae experienced as it was about to land. (3)

6.1.4 If Philae had landed on a comet of twice the radius and five times the mass of 67P, determine the **ratio** of the acceleration on the new comet (a_{new}) and the acceleration on 67P (a_{67P}). (4)

6.2 A charged particle of charge 25 nC is placed in an electric field of strength $4{,}8 \times 10^5$ N·C^{-1}.

6.2.1 Calculate the magnitude of the force experienced by the charge while in the electric field. (3)

6.2.2 A uniform electric field could be established by a parallel plate system connected to a source of potential difference as shown.



On the diagram **in your Answer Booklet** sketch the electric field pattern between the parallel plates. You must also label the positive and negative plates. (3)

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QUESTION 7 ELECTRIC CIRCUITS

Lauren's dad complains when she does not turn off the lights when she is not in the room. He says it is a waste of power and money.

7.1 Electricity costs R1,40 per kWh. Calculate the cost of having a 100 W light bulb on for six hours. (3)

7.2 The light bulb is labelled '240 V, 100 W'. Calculate the resistance of the light bulb. (3)

Lauren decides to carry out an experiment to determine how the number of identical bulbs in use affects the power consumed. She connects two bulbs in parallel to a power supply, determines the effective resistance (R) of the bulbs in parallel and measures the power consumption (P). She repeats the experiment adding another identical bulb in parallel each time and obtains the following results:

No of bulbs	**R (Ω)**	**P (W)**	Error! Bookmark not defined. $\mathbf{\frac{1}{R}\left(\times 10^{-3}\,\Omega^{-1}\right)}$
2	288	168	3,47
3	192	252	**(7.5.1)**
4	144	336	6,94
5	115	420	8,70
6	96	504	**(7.5.2)**
7	82	588	12,2

7.3 Name the independent variable. (2)

7.4 Explain why the effective resistance of the parallel circuit decreases as more bulbs are added. (2)

Lauren decides it would be useful to calculate $\frac{1}{\mathrm{R}}$.

7.5 All but two values of $\frac{1}{\mathrm{R}}$ have been calculated in the last column. Calculate the values shown as **(7.5.1)** and **(7.5.2)** in the table. (2)

7.6 Plot a graph of P on the y-axis vs. $\frac{1}{\mathrm{R}}$ on the x-axis on the graph paper provided **in the Answer Booklet**. (6)

7.7 Use your graph to state the relationship between Power and Resistance. What **two** features of the graph led you to your conclusion? (3)

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

7.9 Use your answer from Question 7.8 to determine the potential difference of the power supply that the bulbs are actually connected to. You are reminded that $P = V^2 \cdot \frac{1}{R}$ and that the equation $y = mx + c$ describes a straight line. (3)

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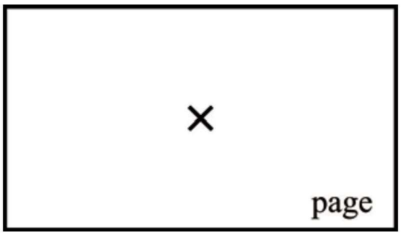
QUESTION 8 ELECTRODYNAMICS

8.1 A long, straight conductor has a current directed into the page as shown.



8.1.1 On the diagram **in the Answer Booklet**, sketch the magnetic field that is produced around the current carrying conductor. You must draw at least three magnetic field lines. (2)

8.1.2 The long, straight conductor is now placed between the poles of permanent magnets, as shown.

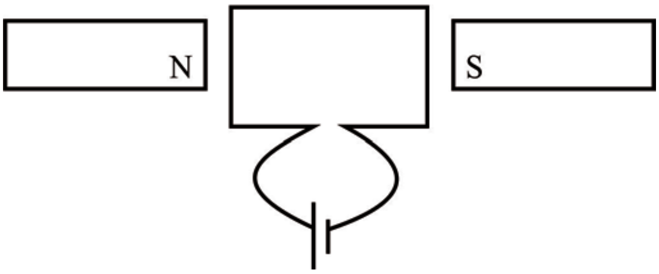
On the diagram **in the Answer Booklet** indicate:

- the magnetic field due to the permanent magnets. You must draw at least two field lines between the magnets.
- the direction of the force experienced by the conductor. Label this force, F. (4)

8.1.3 Briefly explain the origin of the force experienced by the conductor. (2)

8.1.4 How would you position the long straight conductor in a magnetic field so that it does not experience a force? (2)

8.2 An electric motor is constructed as part of an experiment by some students. A diagram of their motor with the coil in the horizontal position is shown.



8.2.1 State the energy conversion that occurs while a motor operates. (2)

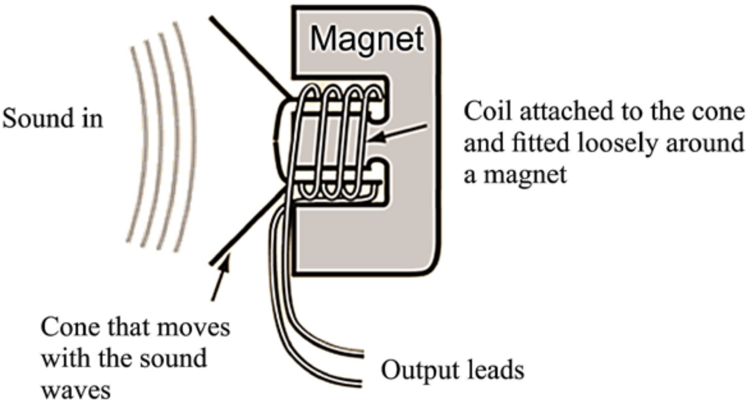
The motor initially rotates from the horizontal position shown until the coil is just past the vertical. At this position, the coil starts rotating in the opposite direction.

8.2.2 What device have the students forgotten to include in their motor? (2)

8.2.3 Explain the purpose of the forgotten device. (2)

8.3 A microphone is often used when addressing large audiences.

A simple microphone generates electricity from sound waves. The figure below shows the structure of a microphone.



[Source: <http://hyperphysics.phy-astr.gsu.edu>]

The magnet is fixed to the case inside the microphone. There is a coil that is attached to the cone. The sound waves move the cone backwards and forwards. The leads from the coil are connected to a recording device or an amplifier.

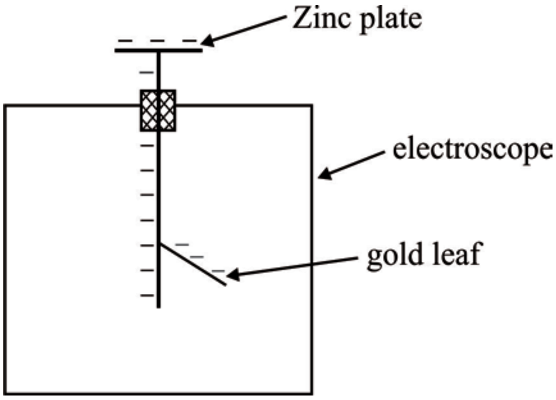
8.3.1 State Faraday's law of electromagnetic induction. (2)

8.3.2 Use the diagram above to help you explain how the microphone converts sound to voltage. Use bullet points in your explanation. (4)

[22]

QUESTION 9 PHOTONS AND ELECTRONS

9.1 An electroscope with a negatively charged zinc plate is shown below. The gold leaf is deflected due to like charges repelling each other.



When visible light is shone on the plate, nothing is observed. When ultraviolet light is shone on the negatively charged electroscope, the gold leaf collapses.

9.1.1 Name the phenomenon described. (2)

9.1.2 Explain why visible light has no effect while the ultra-violet light collapses the gold leaf. (3)

9.2 The work-function of caesium is $3,36 \times 10^{-19}$ J.

9.2.1 Define *work-function*. (2)

9.2.2 Calculate the lowest frequency photon that can eject an electron from caesium. (3)

9.2.3 Calculate the maximum kinetic energy of an electron ejected from caesium by a photon of wavelength 400 nm. (4)

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Total: 200 marks

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