NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2014

PHYSICAL SCIENCES: PAPER I

Time: 3 hours | 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - a question paper of 16 pages;
   - a yellow Answer Booklet of 4 pages (i – iv); and
   - a green Data and Formulae Sheet of 2 pages (i – ii).

   Please make sure that your question paper is complete.

2. Remove the Data Sheet and Answer Booklet from the middle of this question paper. **Write your examination number on the yellow Answer Booklet.**

3. Read the questions carefully.

4. Use the data and formulae whenever necessary.

5. 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 inside the front cover of your Answer Book. The letter that corresponds with your choice of 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.

6. Start each question on a new page.

7. It is in your own interest to write legibly and to set your work out neatly.

8. Show your working in all calculations.

9. Where appropriate take your answers to 2 decimal places.

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

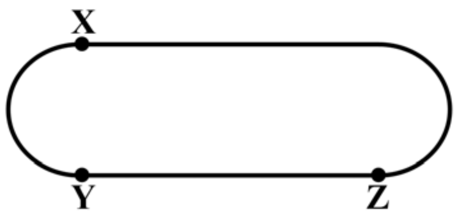
QUESTION 1 MULTIPLE CHOICE

Answer these questions on the Multiple Choice Answer Sheet in your Answer Book. Make a cross (X) on the letter of the response which you consider to be the most correct.

1.1 Which one of the following pairs consists of one vector quantity and one scalar quantity?

A acceleration and velocity
B power and time
C momentum and work
D velocity and impulse

1.2 An athlete runs around the athletics track at a constant speed in an anticlockwise direction. The athletics track is shown in the diagram below.



Which one of the following statements is true as the athlete runs past point X to Z via Y? The instantaneous velocity of the athlete is …

A constant between X and Y only.
B constant between Y and Z only.
C constant at all points between X and Z.
D never constant anywhere between X and Z.

1.3 A net force pushes an object horizontally in a straight line from rest. The distance moved by the object in time 't' is 'x' metres. What distance will the same object move from rest under the action of the same net force in time '$2t$'?

A $2x$
B $4x$
C x^2
D $\frac{1}{2}x^2$

1.4 The property of a body that causes it to resist a change in its state of rest or uniform motion is defined as …

A impulse.
B acceleration.
C resistance.
D inertia.

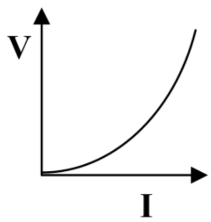
1.5 Which one of the following is NOT a unit of power?

A W
B $J.s^{-1}$
C $N.m.s^{-1}$
D $kg.m.s^{-1}$

1.6 The acceleration due to gravity on the Earth is g. What is the acceleration due to gravity on a planet which has double the mass of the Earth and half the radius of the Earth?

A 8 g
B 4 g
C 2 g
D ½ g

1.7 Which one of the following graphs best represents the relationship between the potential difference (V) across an ohmic conductor and the current (I) in the conductor at constant temperature?

A


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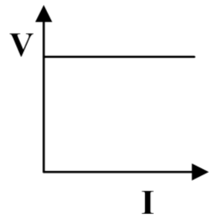
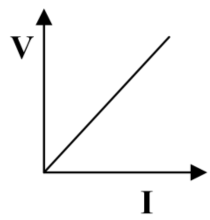


C


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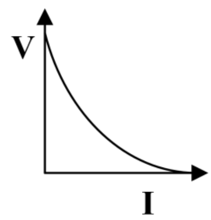
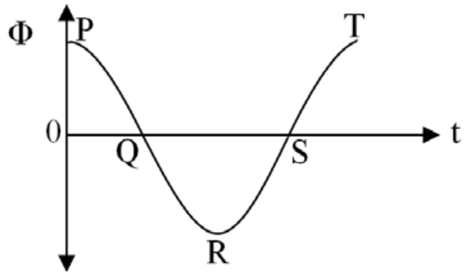


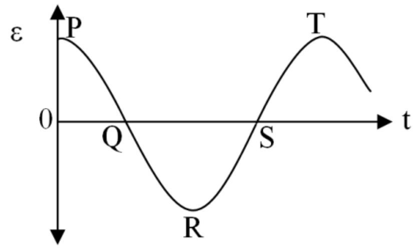
1.8 Which option correctly gives the energy conversion in the direct current motor as well as the component(s) connected to the ends of the coil?

	Energy conversion	**Component**
A	Electrical to mechanical	Split ring commutator
B	Mechanical to electrical	Slip rings
C	Electrical to mechanical	Slip rings
D	Mechanical to electrical	Split ring commutator

1.9 A coil is rotated in a magnetic field. The graph shows how the magnetic flux (Φ) changes with time for one complete rotation of the coil.



Which one of the following graphs shows the corresponding changes in the induced emf (ε) with time for one complete rotation of the coil?

A


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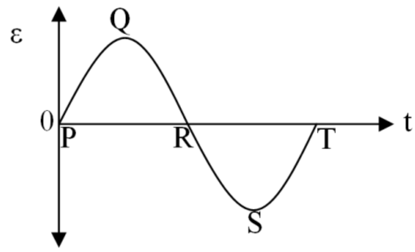
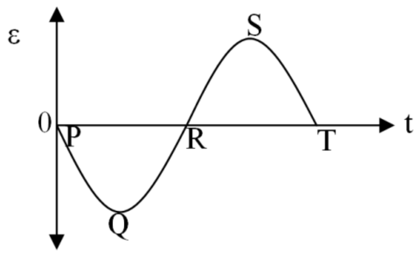


C


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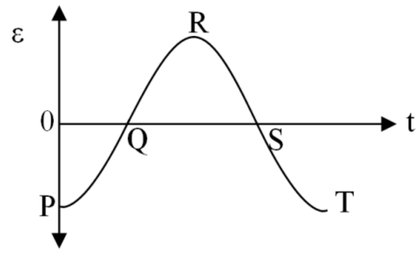
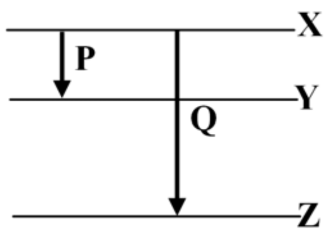


1.10 The diagram represents 3 energy levels, X, Y and Z, in a certain atom. The energy difference between levels Y and Z is twice the energy difference between levels X and Y. If the wavelength of a photon emitted as a result of transition P, from level X to Y, is λ, then what is the wavelength of the photon emitted during transition Q, from level X to Z?



A 2λ

B 3λ

C $\lambda/2$

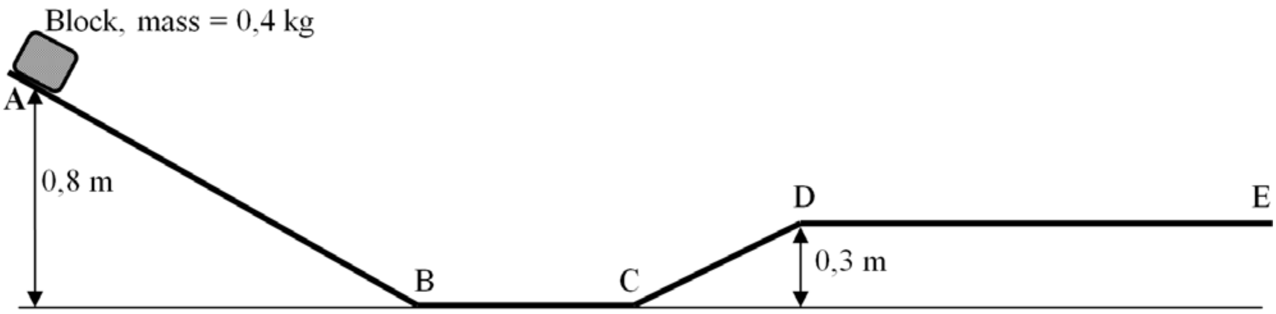
D $\lambda/3$

[20]

QUESTION 2 KINEMATICS

2.1 A small block of mass 0,4 kg is released from rest at position A on a track as shown in the diagram. Position A is 0,8 m vertically above the ground. It takes the block 3 s to slide from position A to position E where it comes to rest. The length of the track from A to E is 8,1 m. Position D is 0,3 m vertically above the ground. There is no friction between positions A and D on the track but there is significant friction between positions D and E. Air resistance can be ignored. Positions A, B, C, D and E all lie in the same vertical plane.

Diagram not drawn to scale



2.1.1 Define the terms *distance* and *displacement* and hence explain why the magnitude of the displacement of the block from A to E differs from the distance travelled by the block from A to E. (4)

2.1.2 Calculate the average speed of the block between A and E. (2)

2.1.3 State *the principle of conservation of mechanical energy.* (2)

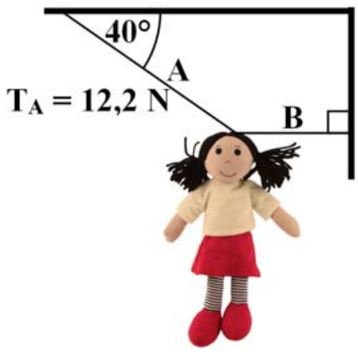
2.1.4 Use the principle of conservation of mechanical energy to calculate the speed of the block as it reaches point D on the track. (4)

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

2.1.6 Calculate the magnitude of the frictional force acting on the block between position D and E. The distance between D and E is 3 m. (4)

2.1.7 On the Answer Booklet draw a position-time sketch graph to represent the horizontal position of the block as measured from A until it stops at position E. It is not necessary to show any numerical values. It is the shape of your graph which is important. The times when the block is at position A, B, C, D and E have been labelled as t_A, t_B, t_C, t_D and t_E respectively. (4)

2.2 Lucy's doll is suspended by means of two light inextensible strings from the ceiling in the corner of her room as shown. String A makes an angle of 40° with the ceiling and string B makes an angle of 90° with the wall. The tension in string A is 12,2 N.



2.2.1 Calculate the magnitude of the vertical component of the tension in string A. (2)

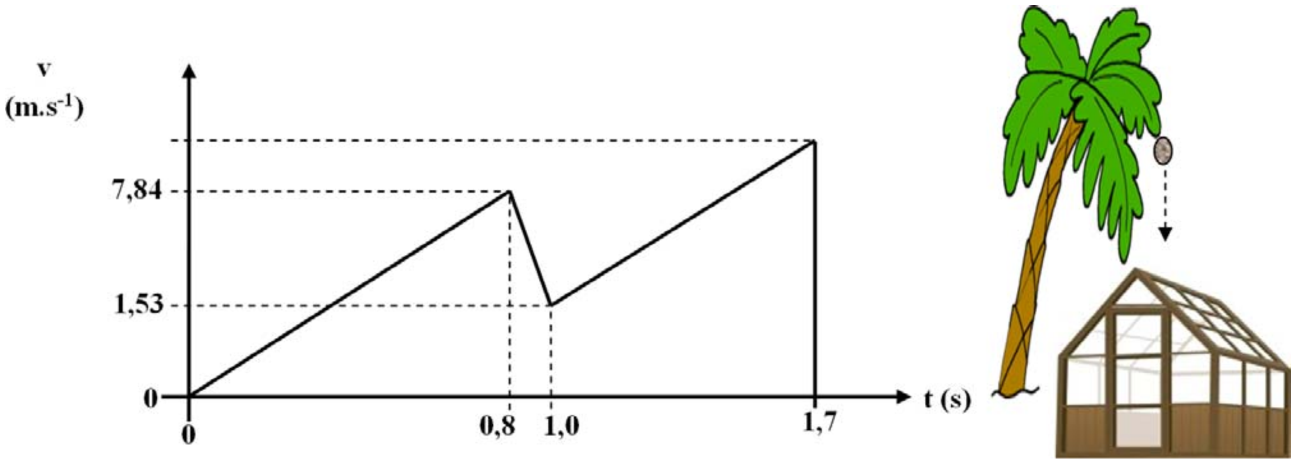
2.2.2 Calculate the mass of Lucy's doll. (4)

2.2.3 Calculate the magnitude of the tension in string B. (2)

[30]

QUESTION 3 FALLING BODIES

3.1 A coconut of mass 5,4 kg falls from a tree and breaks the glass roof of a greenhouse directly below it. The unbroken coconut continues to fall freely until it hits the ground. The velocity-time graph below represents the motion of the coconut from when it left the tree until it hit the ground. Air resistance is negligible.



3.1.1 Calculate the distance fallen by the coconut from when it left the tree until it hit the glass roof at time $t = 0,8$ s. (3)

3.1.2 Calculate the speed of the coconut at time $t = 1,7$ s as it hits the ground. (4)

3.1.3 Calculate the net force acting on the coconut while it was in contact with the glass roof. (5)

3.1.4 How does the magnitude of the force exerted by the coconut on the glass roof compare with the magnitude of the force exerted by the glass roof on the coconut? Name the law which you used to determine your answer. (2)

3.1.5 Draw an acceleration-time sketch graph to represent the motion of the coconut over the time period $t = 0$ s to $t = 1,7$ s. It is not necessary to show any numerical values. (3)

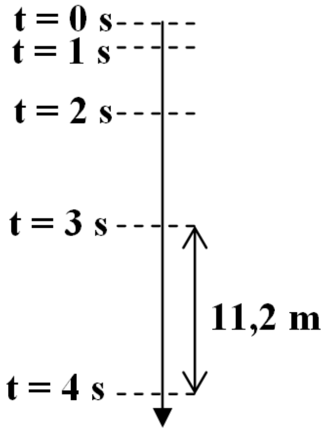
3.1.6 Consider the following information regarding two coconuts X and Y which fall from different heights:

- The mass of coconut X is greater than the mass of coconut Y.
- As they reach the roof of the greenhouse the momentum of coconut X is equal to the momentum of coconut Y.

(a) At the roof, is the kinetic energy of coconut X *greater than, less than or equal to* the kinetic energy of coconut Y? (1)

(b) Fully explain your answer to Question 3.1.6 (a) making reference to relevant formulae. (4)

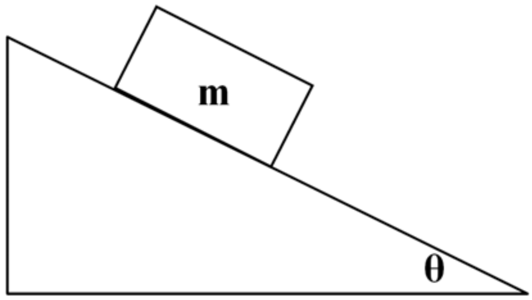
3.2 An object which is dropped on a unknown planet 'P' falls a distance of 11,2 m in its 4th second of motion. There is no air resistance on planet 'P'. Calculate the magnitude of the acceleration due to gravity on planet 'P'.



(5)
[27]

QUESTION 4 SLIDING BOX EXPERIMENT

Tom, Thuli and Tessa conduct an investigation using a box on an inclined plane. Their aim is to determine how the mass of an object placed on an inclined plane affects the maximum angle (θ) to which the plane can be tilted before the object just starts to slide down the plane.



They place an empty box on a flat horizontal track and gradually tilt the track until the box just starts to slide. They record the angle of the incline (θ) at which this happens.

They then add a 1 kg mass piece to the empty box and repeat the experiment.

They continue to increase the mass of the box by 1 kg at a time and record the angle θ each time the box starts to slide.

4.1 Name the dependent variable in this experiment. (2)

4.2 Why was it necessary to use the same track and the same box for each experiment? (2)

4.3 Draw a labelled free body diagram to represent the forces acting on the box at rest on the inclined plane. Show relevant angles and **name** the forces. (4)

Before conducting their investigation the learners make the following hypotheses:

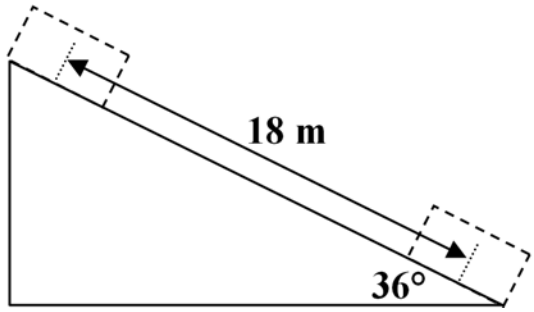
Tom: *"The greater the mass of the box the smaller the angle (θ) of the incline at which the box will start to slide."*

Thuli: *"The greater the mass of the box the greater the angle (θ) of the incline at which the box will start to slide."*

Tessa: *"The mass of the box will not affect the angle (θ) of the incline at which the box will just start to slide."*

4.4 Use your knowledge and understanding of the forces acting on the box to predict which learner's hypothesis is correct. Justify your choice by referring to relevant physics principles and formulae. (5)

4.5 In a different experiment it is found that when the angle of the slope is $36°$ a box of mass 12 kg accelerates uniformly from rest down the rough slope of length 18 m at $4{,}2\ m.s^{-2}$.



4.5.1 Calculate the magnitude of the velocity of the box as it reaches the bottom of the slope. (4)

4.5.2 State *Newton's second law.* (3)

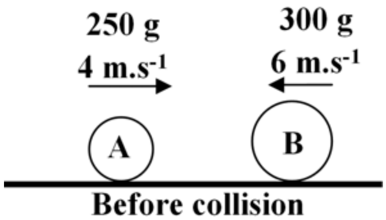
4.5.3 Calculate the magnitude of the net force acting on the box as it moves down the slope. (3)

4.5.4 Calculate the magnitude of the frictional force acting on the box. (5)

[28]

QUESTION 5 MOMENTUM

Two different balls A and B of masses 250 g and 300 g respectively have a head-on collision. Ball A is moving to the right at $4\ \text{m.s}^{-1}$ before the collision and ball B is moving to the left at $6\ \text{m.s}^{-1}$ before the collision. During the collision ball A experiences an impulse of $1{,}5\ \text{kg.m.s}^{-1}$ to the left.



5.1 Define *momentum*. (2)

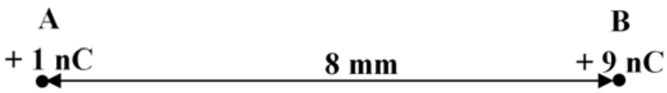
5.2 Calculate the magnitude and direction of the velocity of ball A immediately after the collision. (5)

5.3 Calculate the magnitude and direction of the velocity of ball B immediately after the collision. (5)

[12]

QUESTION 6 ELECTRIC FIELD

Two positive point charges, A and B, are separated by a distance of 8 mm. The charge on A is 1 nC and the charge on B is 9 nC.



6.1 Draw an electric field line diagram to represent the field set up by charges A and B. (3)

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

6.3 Calculate the force exerted by charge A on charge B. (5)

6.4 Calculate the number of electrons that charge A lost when it obtained its charge of 1 nC. (2)

6.5 At a distance 'x' from charge A the magnitude of the resultant electric field due to charges A and B is zero. Point 'x' lies on the straight line joining charges A and B.

6.5.1 Define *resultant vector*. (2)

6.5.2 Define *the magnitude of the electric field at a point.* (2)

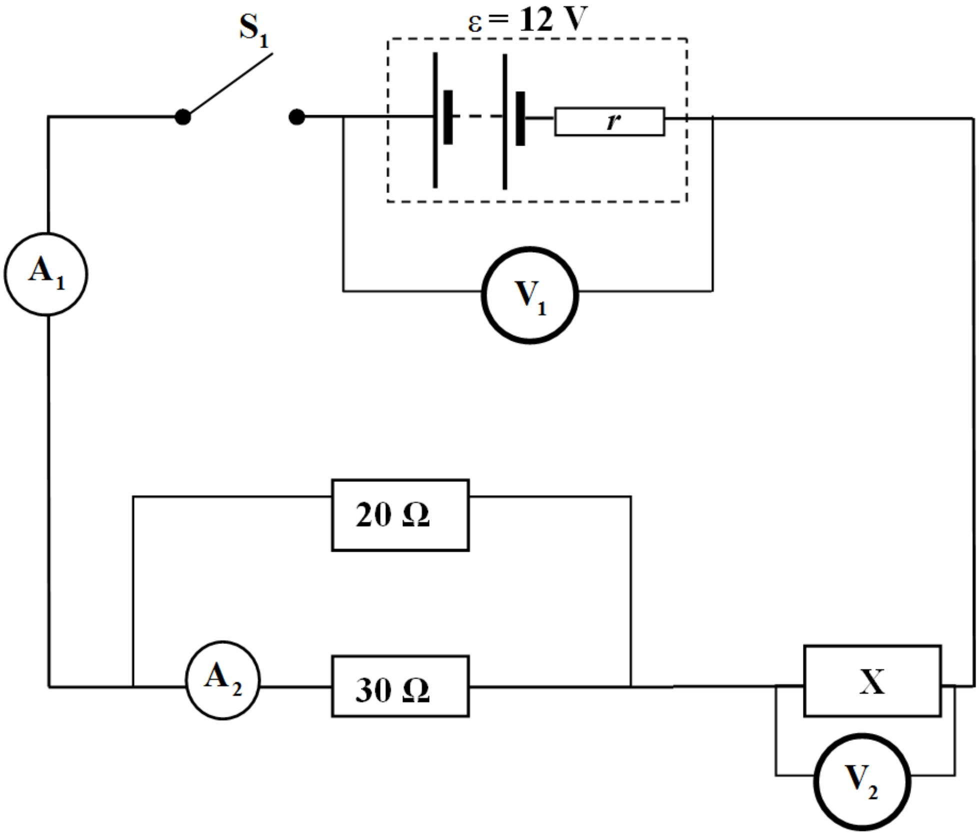
6.5.3 Determine the distance 'x' from charge A. Show all working/reasoning in support of your answer. (4)

[20]

QUESTION 7 ELECTRIC CIRCUIT

7.1 An electric circuit is set up as shown in the diagram below. The resistances of the switch, ammeters and connecting wires are negligible. The voltmeters have very high resistance.

The battery has an emf (ε) of 12 V and has significant internal resistance (r).



The switch S_1 is CLOSED. The ammeter A_2 reads 0,2 A and the voltmeter V_2 reads 5,5 V.

7.1.1 Define *emf.* (2)

7.1.2 Calculate the reading on ammeter A_1. (4)

7.1.3 Calculate the resistance of resistor **X**. (3)

7.1.4 Calculate the total external resistance of the circuit. (3)

7.1.5 Calculate the internal resistance (r) of the battery. (4)

7.1.6 Resistor **X** is replaced by a new resistor of greater resistance than that of **X**.

(a) Will the reading on the voltmeter $\mathbf{V_1}$ connected across the terminals of the battery *increase, decrease or remain the same?* (1)

(b) Explain your answer to Question 7.1.6 (a), making reference to relevant formulae. (4)

7.2 An electric kettle is rated 240 V; 1 800 W.

7.2.1 What does 'rated 240 V; 1 800 W' mean in regard to how this kettle works? (2)

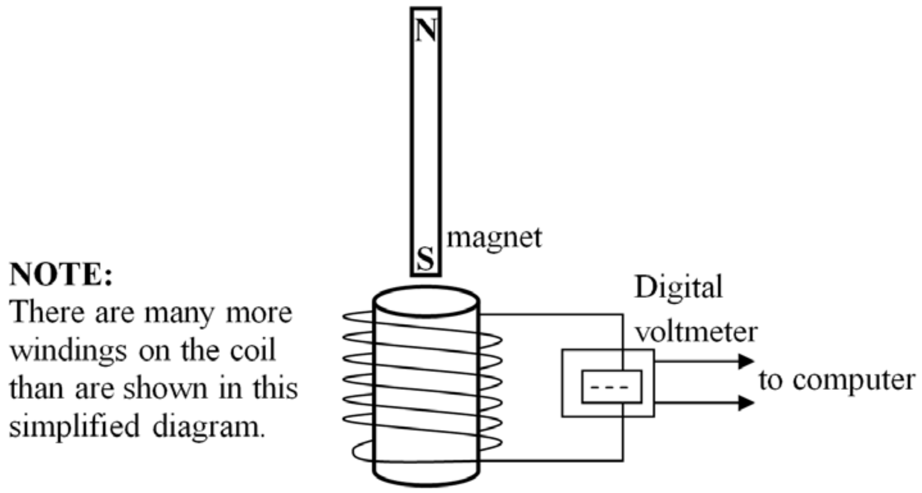
7.2.2 Calculate the current drawn by the kettle when connected to a 240 V source. (3)

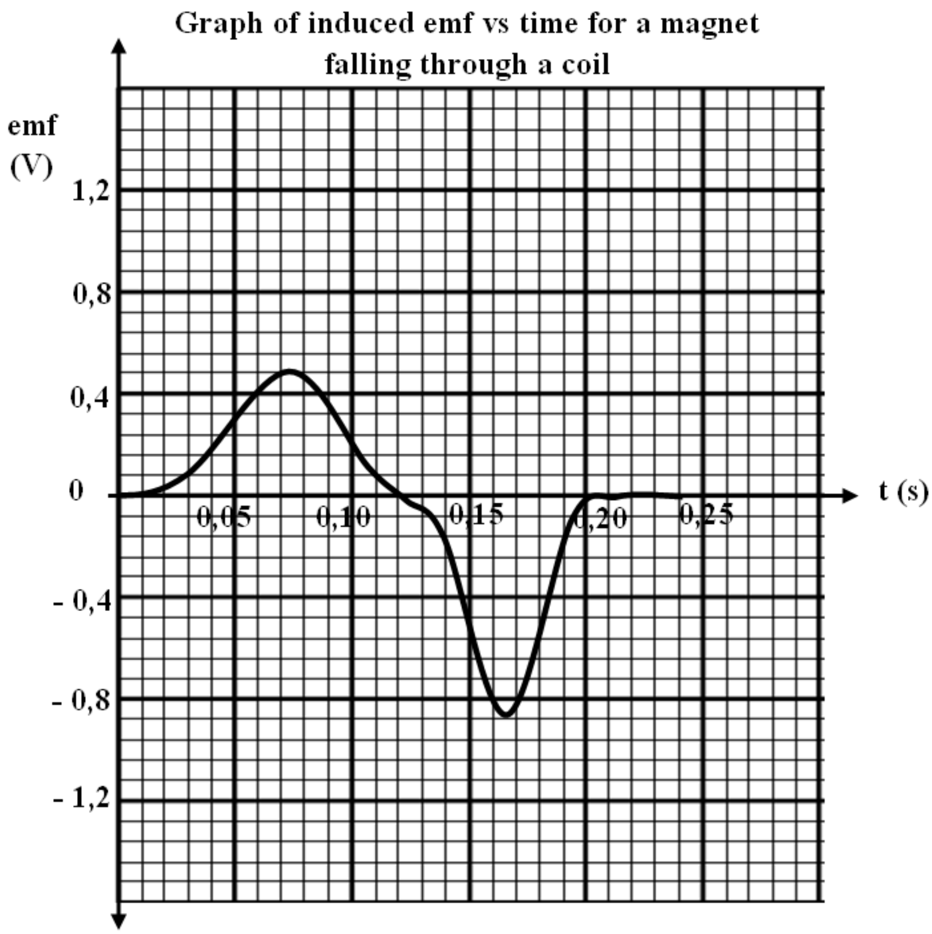
7.2.3 Calculate the cost of using the kettle for 15 minutes if electricity costs R1,40 per kWh. (3)

[29]

QUESTION 8 ELECTRODYNAMICS

A bar magnet is dropped through a coil attached to a digital voltmeter as shown in the diagram. As the magnet falls through the coil it induces an emf in the coil. The voltmeter is connected to a computer which plots a graph of the induced emf against time.





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

8.2 State the polarity (*north* or *south*) of the **bottom of the coil** as the magnet **exits** the coil. (2)

8.3 Draw a labelled free-body diagram to represent the forces acting on the magnet as it exits the coil. Air resistance can be ignored. (3)

8.4 Define *magnetic flux linkage*. (2)

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

8.6 State *Faraday's Law of electromagnetic induction*. (2)

8.7 Why is the magnitude of the maximum induced emf greater as the magnet exits the coil than when it enters the coil? (2)

8.8 The graph of induced emf vs. time for a magnet falling through the coil has been reproduced for you three times on your Answer Booklet. On each of the axes provided on your Answer Booklet, draw a graph to represent the induced emf against time when each of the three following changes are made to the **initial** experiment respectively.

8.8.1 The same magnet is dropped from the same height through the same coil with the NORTH pole entering the coil first. (2)

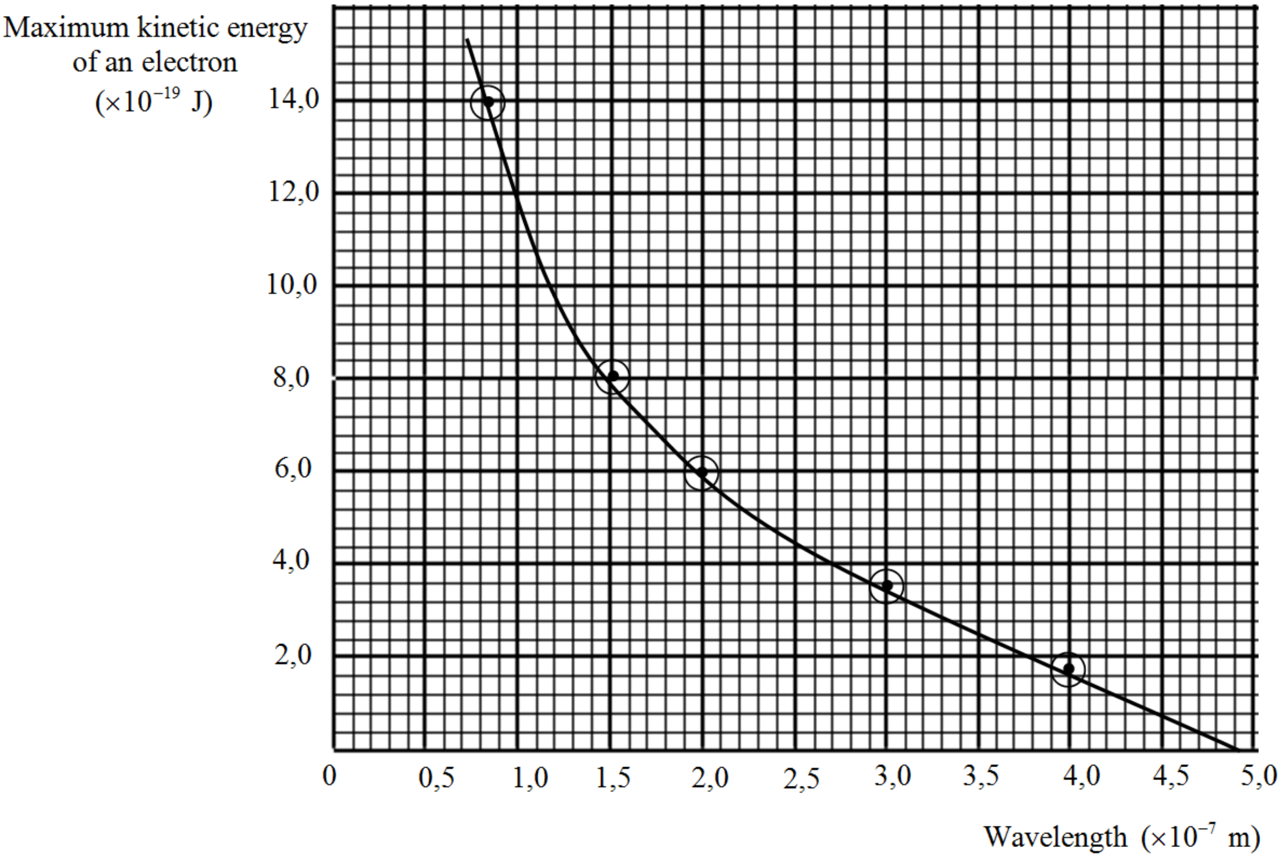
8.8.2 A STRONGER MAGNET of the same mass and length is dropped through the same coil from the same height with the south pole entering the coil first. (2)

8.8.3 The same magnet is dropped from the same height through a coil of the same length but having LESS TURNS. The south pole enters the coil first. (2)

[21]

QUESTION 9 PHOTONS AND ELECTRONS

The graph below shows how the maximum kinetic energy of an electron emitted from the metal cathode of a photoelectric cell varies with the wavelength of the incident radiation.



9.1 Use the graph to determine the maximum kinetic energy of the electron emitted when the wavelength of the incident radiation is $1,0 \times 10^{-7}$ m. (1)

9.2 Describe the relationship shown in the graph. (2)

9.3 Use your knowledge of the photoelectric effect to EXPLAIN the relationship shown in the graph. Support your answer with reference to relevant formulae. (3)

9.4 Use the graph to calculate the threshold frequency of the light needed to emit electrons from the metal cathode of the photovoltaic cell. (4)

9.5 Calculate the work function of the metal used for the cathode of the photovoltaic cell. (3)

[13]

Total: 200 marks